Interreg BSR

Baltic Blue Biotechnology Alliance project:

Supporting Blue Biotechnology Product Development in the Baltic Sea Region:

Findings from the Baltic Blue Biotechnology Alliance and Recommendations on future actions

Main Authors:

Efthalia Arvaniti[1], Martina Blümel[2], Anne-Mari Luhtanen[3], Hermanni Kaartokallio[3], Deniz Tasdemir[2] and Angela Schultz-Zehden[1]

- *with the support of the entire Baltic Blue Biotechnology Alliance community -*

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[1]SUBMARINER Network; [2] GEOMAR Helmholtz Centre for Ocean Research Kiel; [3] Environmental Institute of Finland

Preface / Foreword

Blue Biotechnology is a key enabling technology for sustainable blue growth. Although the sector has experienced considerable advances in the past years, development of market-ready blue biotechnology products and services still needs viable transnational and transdisciplinary cooperation along the entire value chain, from R&D to marketing. **The aim of this report is** to show the future steps considered as necessary to further support and accelerate blue biotechnology product development in the Baltic Sea Region (BSR), based on evidence provided by three years of cooperation within the Interreg BSR project Baltic Blue Biotechnology Alliance (*Alliance*). It relates to setting the future research agenda as well as the needs for a continuous supporting structure.

With this report we want to provide information and recommendations to the related future innovation policies as well as national and European funding programmes (ERA-Net, Interreg, BANOS CSA) as to take the right steps in advancing blue biotechnology as a key enabling technology for blue bioeconomy in the BSR. Finally, we aim to help R&D institutes and other support institutions throughout the Baltic Sea Region to strategically position themselves within the overall Baltic Sea region cooperation structure based on best complementarity and synergies.

For developing this set of recommendations, we analysed R&D capacities in the BSR (within the Baltic Blue Biotechnology Alliance but also relevant capacities beyond that), as well as the political framework. We took into account the profiles and needs of blue Biotechnology SMEs (cases) enrolled in the *Alliance* from the BSR and also monitored the *Alliance* response to the service requests of cases. Finally, we recommend other solutions to enhance regions innovation capacity, and finally present the role of the *Alliance* beyond the end of the project (April 2019).

List of abbreviations

BSR Baltic Sea Region

HELCOM

IMTA Integrated Multi-Trophic Aquaculture

RAS Recircular Aquaculture Systems

R&D Research and Development

UN SDGs United Nations Sustainable Development Goals

WP Work Package

OECD

FDA U.S. Food and Drug Administration

EMA European Medicines Agency

EC European Commission

EU European Union

RIS3 Research and Innovation Smart Specialisation Strategies

DG MARE EU Directorate General for Maritime Affairs and Fisheries

PA INNO Policy Area Innovation

BSAP Baltic Sea Action Plan

BBI-JU Bio-based industries Joint Undertaking

ERA European research Area

ERA-MBT The Marine Biotechnology ERA-NET

EMBRC BioBank (EBB)

TRL Technology Readiness Level

NL Netherlands

LV Latvia

DE Germany

EE Estonia

FL Finland

MIRRI - Microbial Resource Research Infrastructure

access and benefit sharing (ABS

EEIG European Economic Interest Grouping

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1. Introduction

1.1. Blue Bioeconomy in the Baltic Sea Region: The *Alliance* as part of the SUBMARINER roadmap

Blue Bioeconomy, an economic sector relying on the "use of renewable aquatic biological resources to make products"[1] is a highly promising sector also with regard to the Baltic Sea Region (BSR). Blue Bioeconomy has the capacity for sustainably providing a plethora of biobased products and services, thus developing blue growth by simultaneously maintaining and protecting the natural marine and freshwater ecosystem. Key blue bioeconomy sectors include besides aquaculture and fisheries the emerging field of blue biotechnology.

The potential of blue bioeconomy in the Baltic Sea Region (BSR) was first assessed in the SUBMARINER project (Interreg BSR 2010-2013). In the SUBMARINER compendium (published in 2013), an overarching assessment was carried out on available marine resources in the Baltic Sea Region with regard to state of knowledge, available technologies and maturity, natural resources, and political support, in connection with a number of marine economic activities including blue biotechnology and aquaculture. As a result of this assessment, the SUBMARINER Roadmap was developed and agreed, which showed the complementary series of actions required as to achieve the ambitious SUBMARINER blue bioeconomy vision. According to this vision, **by 2030, biobased innovations and integrated uses of blue-green solutions should have secured the maintenance of the Baltic Sea Region's natural capital, made marine resources an important part of the region's smart energy and biomass production, and improved human well-being.** To realise this vision, the SUBMARINER Roadmap suggested initiatives in the field of innovative and sustainable uses of marine resources that require joint efforts in the Baltic Sea Region in the coming years.

In order to realise these actions, the SUBMARINER Network for Blue Growth European Economic Interest Grouping (EEIG) was founded by a core group of seven public and private institutions encompassing all Baltic Sea Region countries.

The SUBMARINER Roadmap (2013) was organised along eleven strategic action fields and eight topics. In the Roadmap, blue biotechnology is featured both as one of the strategic sectors and as a strategic action field, in terms of making efficient and effective use of blue biotechnology research capacities in the BSR. Other SUBMARINER sectors captured at that time are macroalgae harvesting and cultivation, mussel farming, large scale microalgae production, and sustainable fish aquaculture.

[1] European Union (2018). BLUE BIOECONOMY. Situation report and perspectives. European Market Observatory for Fisheries and Aquaculture Products (EUMOFA), Update 2018. Luxembourg: Publications Office of the European Union, 2018. doi: 10.2771/053734

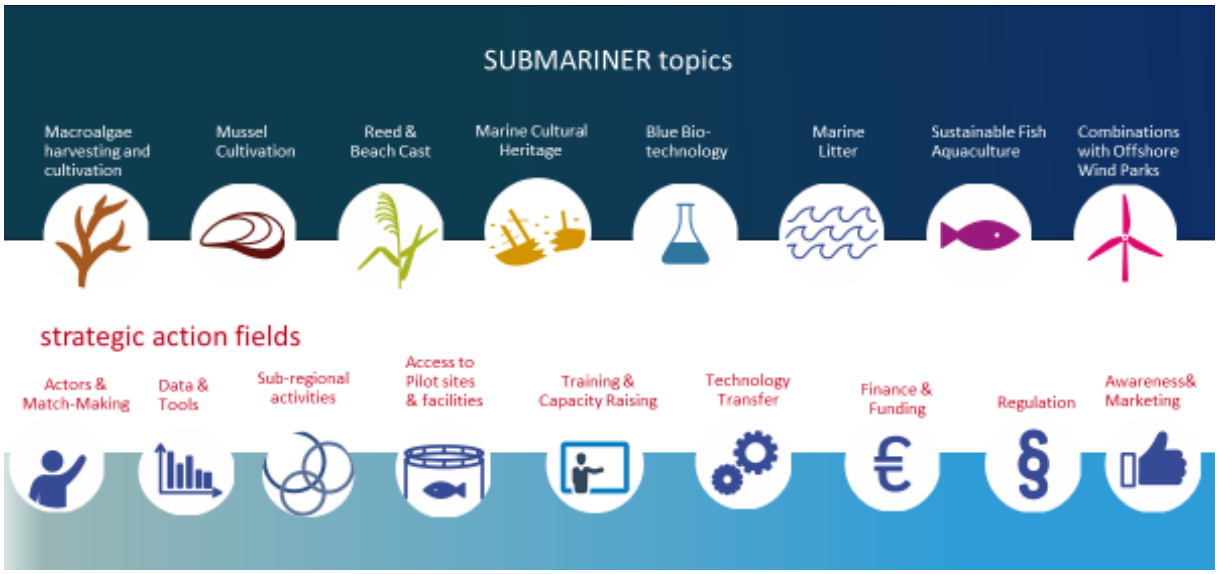


Figure 1 SUBMARINER Topics, as updated in 2019, based on topics 2013 of SUBMARINER Roadmap (2013)

Within blue biotechnology, the Roadmap suggested the following actions:

- systematic mapping of research capacities, research fields and infrastructure across the BSR and
- analysis of BSR priorities and needs for Blue Biotechnology applications for
- development of national (blue) biotechnology strategies and a pan-Baltic research agenda
- creation of pan Baltic research groups
- identify and test Baltic Sea organisms for various applications and
- establish a BSR centre for bioprospecting of Baltic Sea microorganisms.

By that moment the idea for the Baltic Blue Biotechnology Alliance project was incepted, but it took two years more to be shaped as a project before it was finally funded under Interreg BSR in 2015. During the time of its development, its focus shifted from creation of a research network into a fully-fledged science-business cooperation. Emphasis was laid on accelerating the development of actual blue biotechnology products and services – in order to showcase the real business potential inherent in the sector. Although blue biotechnology was a sector with great potential for EU biobased economy, there was one great barrier in getting blue biotechnology products market ready: **resources and expertise along the value chain were mostly scattered in the BSR and it was difficult to complete the journey from idea to finished product on a (sub-)regional or national scale. The Baltic Blue Biotechnology Alliance (*Alliance*) wanted to bridge this gap by developing and implementing optimal transnational product development chains**. These would enable efficient use of and comprehensive access to the whole variety of facilities, (bio-)resources and expertise available within the entire region and beyond, therefore pooling national capabilities.

The *Alliance* aimed to present at least **five successful case studies** in which project partners have helped a small or medium enterprise (SME) or start up to significantly progress towards a fully developed product. These cases would serve as role models for the functioning of how blue biotechnology value chains across the BSR. Moreover, by working with these cases, network partners would right from the start be informed about the real needs of current and prospective companies; ensuring that the network would put emphasis on those services, which are really in demand.

In this report, we present our findings from the Baltic Blue Biotechnology Alliance project, including the fully-fledged blue biotechnology accelerator programme developed in the project and requirements for its future continuation and development. Furthermore, we present the bigger picture of blue biotechnology in the region, by mapping research and development capacities, analysing the R&D needs of the sector in the

region with the aim to work towards creating a pan-Baltic research agenda, in order to reach the SUBMARINER vision.

1.2 Blue biotechnology innovation

The World ocean economy value creation is estimated by the OECD (2016)[2] to be USD 1.5 trillion annually. This encompasses all ocean economy sectors including e.g. shipping, tourism, offshore energy, fisheries and aquaculture, the two latter being crucial for livelihoods and world supply of animal protein. Ocean economy is projected to grow up to USD 3 trillion in year 2030. International cooperation in marine science and technology, improved ocean governance and enhanced foresight capacity for ocean industries are seen as key areas for fostering growth.

The exceptional biological diversity of the oceans is estimated to range from 700,000 to 1 million eukaryotic species and millions more prokaryotic and viral taxa [3]. Blue biotechnology is a highly promising key enabling technology that unlocks the potential for conquering new frontiers in research and innovation, and can increase prosperity and stability, and if used wisely can protect the natural capital of the oceans. Blue biotechnology is an emerging sector of the ocean economy both in North America and the European Union. The overall market worldwide for bio-based applications of blue biotechnology, is estimated to reach over EUR 6 billion by 2025[4] and major growth for the sector is predicted based on increasing consumer demand for sustainable products incl. a great potential for discovery of new drugs, biodegradable materials and enzymes for industrial processes.

The blue biotechnology product portfolio spans from low-price bulk commodities to high-value sophisticated products. Marine derived biotechnological products can be used in low-price-high volume base commodities such as fuels or in added-value commodities such as polymers or fatty acids as precursors or raw material for bio-based products. On top of the pyramid are the specialty products and molecules that are most expensive, profitable and promising category of marine bioresources. They cover a wide range of substances searched and developed for cosmetics, nutraceuticals and finally drugs or medical devices.

There is a tremendous unprecedented demand for new protein sources for human consumption and also new sustainable feed sources (e.g. fish feed). In response, new products from e.g. macroalgae, are entering the market. Aquaculture farming is the new frontier in food production, yet challenges are related to high nutrient loads and excess use of antibiotics. These can be solved e.g. by development of Recirculating Aquaculture Systems (RAS) minimalizing water exchange and nutrient input into the natural environment and improved feed quality including use of pro- and prebiotic additives designed by blue biotechnology.

Natural products play an important role in the development of drugs and many of them have been found to originate from marine sources. About 30,000 marine natural products have been described, and ca. 1000 are newly published each year.[5]Compounds isolated from the Caribbean marine sponge *Cryptotethya crypta* provided the basis for development of the anti-leukaemia drug cytarabine already in the 1960s and to the HIV

[2] OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris,https://doi.org/10.1787/9789264251724-en.
[3] Appeltans et al. 2012; Curtis, Sloan, and Scannell 2002; Suttle 2013; as quoted in the World Bank and United Nations Department of Economic and Social Affairs. 2017. The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries. World Bank, Washington DC.
[4] Smithers Group *The Future of Marine Biotechnology for Industrial Applications to 2025* (2015), quoted in EU Blue Growth Strategy (2017)
[5] Lindequist U. Marine-Derived Pharmaceuticals - Challenges and Opportunities. Biomol Ther (Seoul). 2016;24(6):561–571. doi:10.4062/biomolther.2016.181

drug Azidothymidine (AZT) in the 1980s, while a toxin purified from a cone snail from the Pacific Ocean[6] led to the development of an FDA (2004)[7] and EMA (2005)[8] -approved medication for chronic pain. So far, there are several clinically approved marine-sourced drugs against cancer, viruses, chronic pain and several more are in late stages of clinical trials[9]. Moreover, cold-adapted enzymes mostly produced by extremophilic microorganisms have been applied to industrial use to reduce process temperatures (stonewashing, meat tenderizing). Blue biotechnology can also be used for environmental bioremediation.

Currently the application of biotechnology to marine resources is still at a nascent stage even on a global scale. However, numerous forecasts predict major growth of this sector based on ever more rising consumer demand and correspondingly large markets for blue biotechnology products in the fields of medicine, cosmetics, food and feed supplements as well as environmental and industrial applications.

Furthermore, large industry, like Bayer, Dupont, Fuji, FMC Biopolymer, DSM, CP Kelco, Novozymes, producing commodities, fine chemicals, enzymes, food ingredients etc., are using algae, marine bacteria or jellyfish, while popular labels are branding consumer products containing marine-derived ingredients, e.g. cosmetic lines, snacks etc.

[6] McIntosh M, Cruz LJ, Hunkapiller MW, Gray WR, Olivera BM (1982). Isolation and structure of a peptide toxin from the marine snail *Conus magus*. Arch. Biochem. Biophys. 218: 329–34. doi:10.1016/0003-9861(82)90351-4

[7] https://www.accessdata.fda.gov/drugsatfda_docs/nda/2004/21-060_Prialt.cfm

[8] https://www.ema.europa.eu/en/medicines/human/EPAR/prialt

[9] Alejandro M. S. Mayer, Keith B. Glaser, Carmen Cuevas, Robert S. Jacobs, William Kem, R. Daniel Little, J. Michael McIntosh, David J. Newman, Barbara C. Potts, Dale E. Shuster (2010). The odyssey of marine pharmaceuticals: a current pipeline perspective. Trends Pharmacol Sci 31:255-65. *doi: 10.1016/j.tips.2010.02.005.*

Figure 2. Popular brands containing aquatic-derived ingredients [Sources of pictures: GARNIER, APIVITA, ESTEE LAUDER, BIOTHERM, LAY's, Pringles, KitKat, Jellagen, Calicos, THALGO, WHOLE EARTH]

1.3 Blue biotechnology in the Baltic Sea Region

The blue biotechnology potential in the Baltic Sea Region was first investigated by the SUBMARINER project Compendium report in 2013.

According to this report, out of the Baltic Sea countries, Germany is most advanced in the field of blue biotechnology. The German federal states Schleswig-Holstein and Mecklenburg-Vorpommern both have established regional blue biotechnology clusters involving both research institutions and the private sector. In addition, and in parallel to the following pan-Baltic SUBMARINER Blue Biotechnology roadmap, in 2013Schleswig-Holstein had developed a regional development strategy for blue biotechnology[10] , to form part of its "Sea our Future" initiative.

[10] Norgenta North German, DSN. MARINE BIOTECHNOLOGY SCHLESWIG-HOLSTEIN. Kiel and Hamburg 2012. http://www.submariner-project.eu/index.php?option=com_content&view=article&id=148:masterplan-marine-biotechnology-schleswig-holstein-germany-&catid=55&Itemid=395 (07.04.2019)

Also, Denmark has set a national strategy for blue biotechnology,[11] which is supported by a first-class bio and pharma industry. Equally Sweden possesses substantial biotechnology capacities with considerable interest towards marine biotechnology R&D (see also the Europa bio report on Swedish Industrial Biotechnology[12]) and in Finland there is some interest and activity towards marine biotechnology research and innovation, too.

In the background study to the EU Baltic Blue Growth Agenda (2013) almost all Baltic countries, including those with only very limited activities yet in the field of marine biotechnology (e.g. Poland), rated the sector with the highest potential among maritime economic activities. A high growth potential was attributed to the area of blue biotechnology (valued 5 out of a scale from 0 to 6) in the BSR. The high ranking was a result of advanced R&D capacities, a functioning innovation ecosystem in the BSR, and a common regulatory framework (EU, BSR, Nordic).

In the Sustainable Blue Growth Agenda for the Baltic Sea Region (EC, 2014)[13] it was concluded that blue biotechnology has a medium potential among other maritime economic activities in the region. Yet, in the Implementation Strategy for the Baltic Blue Growth Agenda (2017) [14], the importance for further development of blue biotechnology was ranked highest among the four development fields in an online survey of more than 230 stakeholders from the Baltics.

Furthermore, in almost all Baltic countries there are research and development centres with specific expertise in different blue biotechnology and they are operating equipment and infrastructure for blue biotechnology (Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**).

Finally, many Baltic Sea-neighbouring regions, including non-coastal regions, have selected Life Science & Blue Medicine to form part of their RIS3 Smart Specialisation Strategies under Blue Growth. In **Fehler! Verweisquelle konnte nicht gefunden werden.** we observe RIS3 and selected fields of Blue Biotechnology among the Life Science & Blue Medicine sub-categories (yellow dots on the map).

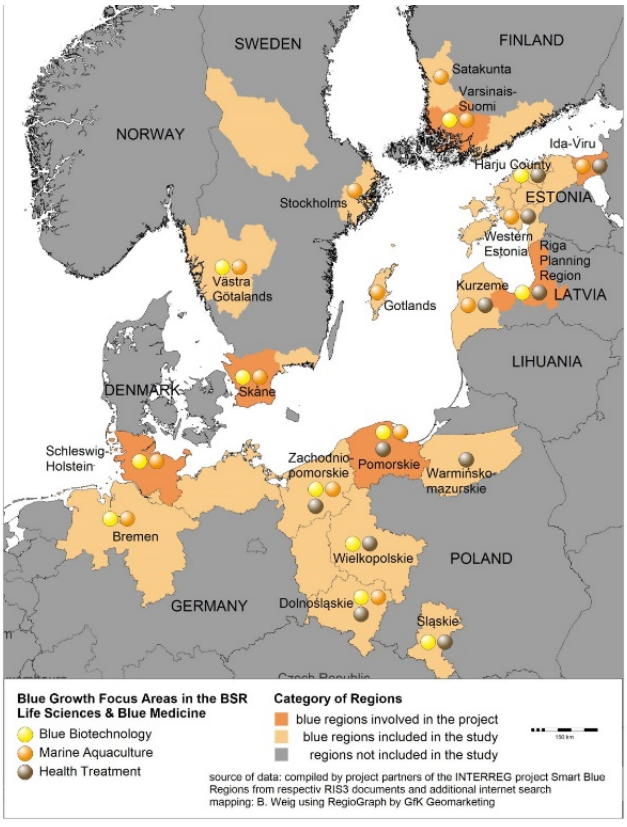


Figure 3 Blue Growth Focus Areas in the field of Life Sciences & Blue Medicine, based on an analysis of regional/national RIS3. Source: Smart Blue Regions project (Interreg BSR, 2019)

In conclusion, Blue Biotechnology has so far played a minor role in the BSR, even though its marine biodiversity provides a great

[11] Havet - en uudnyttet ressource Fødevareministeriet 2010 (in Danish) https://mst.dk/media/91729/havet_en_uudnyttet_ressource.pdf

[12] European Union (2018). BLUE BIOECONOMY. Situation report and perspectives. European Market Observatory for Fisheries and Aquaculture Products (EUMOFA), Update 2018. Luxembourg: Publications Office of the European Union, 2018. doi: 10.2771/053734

[13] A Sustainable Blue Growth Agenda for the Baltic Sea Region (Commission staff working document adopted on 16 May 2014). https://ec.europa.eu/maritimeaffairs/content/delivering-sustainable-blue-growth-agenda-baltic-sea-region_en

[14] Beyer, Schultz-Zehden et al. (2017): Towards an implementation strategy for the Sustainable Blue Growth Agenda for the BSR, Publications Office of the European Union, 2017

potential for exploration. With a smart use of the RIS3 tool and with good knowledge management and collaboration, many BSR regions can reach their development and innovation potential.

The Baltic Sea is a semi-enclosed, marginal sea connected to the North Sea only through two passages - Belt Sea and Sound - between Denmark and Sweden. Due to the narrow and shallow nature of these connections and only sporadic inflows of saline waters from the North Sea and at the same time a high freshwater flux from river runoff, the Baltic Sea is characterised by a low salinity compared to other seas. Hence, the Baltic Sea is recognised as the largest brackish water sea area in the world. Excessive (man-made) nutrient input, and high seasonal primary productivity result in an increased organic matter flux to the seafloor and high decomposition rates (microbial respiration which consumes oxygen), which cause stagnant anoxic conditions especially in the deep basins (e.g. Eastern Gotland Basin). Although the low salinity conditions in the Baltic restrict marine biodiversity to a certain extent, it nevertheless harbours a unique variability of biodiversity due to its specific settings (salinity gradient, high habitat type variability)[15]. The Baltic Sea is considered as a marine area largely suffering from eutrophication[16] and moreover, hazardous substances incl. heavy metals have been identified as a major problem in many Baltic Sea areas. [17] At the same time, maritime industry and coastal tourism are the main maritime economic activities aggravating the non- "Good Environmental Status" of the sea. Sustainable use of the Baltic Sea resources carefully combining ecosystem services and protection of the unique environment by realising blue bioeconomy concepts are therefore of highest interest.

1.4 Strategies overarching blue biotechnology in the Baltic Sea

Blue bioeconomy and blue or marine biotechnology are receiving growing attention and focus in recent years, along with increased awareness of economic feasibility and need for sustainable growth. Blue biotechnology is being addressed in current and future initiatives and strategies, some exclusively devoted to blue biotechnology. Below the most influential strategies are addressed from global to regional scope:

1.4.1 UN Sustainable Development Goals

According to the Paris Agreement (2017) and the United Nations´ 2030 agenda for sustainable development goals, the most important tasks connected to blue biotechnology on global scale are 1) to find new nutritious and secure food sources, 2) to develop affordable and clean energy sources, 3) to build resilient infrastructure and promote innovation and sustainable industrialisation, 4) to ensure responsible consumption and production, 5) to combat climate change, conserve and 6) to sustainably use the marine resources for sustainable development and 7) revitalise the global partnership for sustainable development.

Highly relevant to blue biotechnology is the Sustainable Development Goal 14: conserve and sustainably use, manage/conserve and protect the oceans, seas and marine resources for sustainable development.[18]

1.4.2 EU Blue growth strategy

Blue growth (2017) is a long-term strategy launched by the European Union to support and stimulate sustainable growth in marine and maritime sectors. It aims at an innovative, knowledge-based and inclusive growth fostering of a high-employment economy. It is also a response to challenges in the context of climate change and over-exploitation of natural resources. Blue growth encompasses five main sectors: aquaculture, coastal and maritime tourism, renewable energy, exploitation of marine mineral resources and **blue biotechnology**.

[15] http://stateofthebalticsea.helcom.fi/biodiversity-and-its-status/
[16] http://stateofthebalticsea.helcom.fi/pressures-and-their-status/eutrophication/
[17] http://stateofthebalticsea.helcom.fi/pressures-and-their-status/hazardous-substances/
[18] https://sustainabledevelopment.un.org/sdg14

The strategy has three main focus areas: 1) Development of sectors that have a high potential for sustainable jobs and growth; 2) Identification of essential components to provide knowledge, legal certainty and security in the blue economy; 3) Sea basin strategies to ensure tailor-made measures and to foster cooperation between countries, with emphasis on growth in regions, macro-regions and peripheral areas.

1.4.3 Marine Biotechnology Strategic Research and Innovation Roadmap

The ERA-MBT research and innovation roadmap (2016)[19], according the website, "highlights research and innovation as spanning scientific, technological, economic and societal challenges and sets a marine biotechnology research and innovation agenda towards 2030". The roadmap identifies five thematic areas; the first three enable exploration of the marine environment, support biomass production and processing, and contribute to product innovation and differentiation. Two other themes, policy support and stimulation, and the provision of enabling technologies and infrastructure provide the foundation to support growth in the blue bioeconomy.

National and European policy organisations were supposed to use the roadmap for developing measures to maximise the sustainable contribution of the ocean's biological resources to bioeconomy and societal welfare, and funding agencies to identify marine biotechnology related research topics. The ERA-MBT survey of research infrastructure identified opportunities to improve the research environment by providing better access and strengthening collaboration. In the short term, focus was placed on **building national and industry networks, clusters and public-private partnerships that will become a foundation for long-term improvements**. These include the creation of self-sustained marine biotechnology research and innovation networks that are closely associated with and facilitate the integration of expertise from currently unconnected areas of enabling technologies[20].

" A lasting challenge is the dissemination of knowledge about marine bioresources, research capabilities, equipment and facilities, all of which are essential in realising the benefits from increased marine biotechnology activities. The current and largely informal information and knowledge infrastructures could be developed into a dedicated marine bioresources/biotechnology knowledge portal." – ERA-MBT[21].

1.2.1 Blue Bioeconomy Roadmap

The Blue Bioeconomy Forum was an 18-months-long (2018-2019) project commissioned by the European Commission (Directorate General for Maritime Affairs and Fisheries (DG MARE) and Executive Agency for Small and Medium Enterprises (EASME) and implemented by the Technopolis Group together with Wageningen University (NL). In this period, the forum brought together a partnership of industry, public authorities, academia, and finance in order to strengthen Europe's competitive position in the emerging blue bioeconomy sector.

Aim of the forum was to develop a shared understanding of the current status of the blue bioeconomy and to collectively identify strategic developments, market opportunities, appropriate financial assistance, regulatory actions and research priorities to advance the blue bioeconomy in Europe[22]. The output will be a Blue Bioeconomy Roadmap which has the objective to identify "the sector's future regulatory, research, financial assistance and product needs"[23]. It should identify critical enablers and barriers to cross with regard to further

[19] Hurst, D.; Børresen, T.; Almesjö, L.; De Raedemaecker, F.; Bergseth, S. (2016). Marine biotechnology strategic research and innovation roadmap: Insights to the future direction of European marine biotechnology. Marine Biotechnology ERA-NET: Oostende. http://www.marinebiotech.eu/launch-marine-biotechnology-research-and-innovation-roadmap

[20] *ibid*

[21] *ibid*

[22] https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1349

[23] https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1355

market development. It should therefore also describe the steps required to transfer projects in the pipeline to marketable applications.

This report aims to inform undergoing work on state-of-the-art research and innovation capacities, recorded innovation barriers from real cases and make validated recommendations for action.

Previously, DG MARE had funded a study called "Study in support of Impact Assessment work on Blue Biotechnology" (2014)[24]. The study compiled a review of the status of blue biotechnology within the EU, construction of a stakeholder database and a patent profiling across the field, and finally development of a stakeholder workshop in order to obtain direct inputs from participants regarding the sector´s most relevant challenges and opportunities. **Among the barriers perceived to be the most important in Blue Biotechnology were a lack of coordination and collaboration along the value chain**, lack of access to finance, lack of knowledge and issues regarding access to resources.

1.2.2 EU Bioeconomy strategy

Since bioeconomy and blue biotechnology development are closely related, the European Commission aligned some objectives between the EU Bioeconomy Strategy and the EU Blue Growth strategy. The aim of the bioeconomy strategy is to combine the EU's efforts in the right direction for development of sustainable legislation and actions for economic development. After five years implementation of the bioeconomy strategy, the EU funding for activities supporting bioeconomy has doubled.

An update in the bioeconomy strategy[25] was released in 2018, and oceans and the role of blue bioeconomy are recognised to have strategic importance. Oceans are seen to play a huge role as biomass supplier, e.g. food and other resources, to cover the needs for an increasing global population. However, knowledge on marine ecosystems and their dynamics is limited compared to what is known about terrestrial ecosystems. According to the Strategy, "the EU is stimulating actions to provide better knowledge, ecosystem-based, cross-border and integrated spatial planning, management and surveillance. A better understanding of ocean resources and the marine environment is necessary to underpin sound policies and will allow to better assess and weigh opportunities and potential risks inherent to marine bioeconomic activities". [26]

1.2.3 EU Strategy for the Baltic Sea Region

In 2014, European Commission adopted a "Sustainable Blue Growth Agenda for the Baltic Sea Region" (EUSBSR), which has three main objectives: 1) Save the sea; 2) Connect the region; 3) Increase prosperity, which focuses on environmental challenges of the Baltic Sea. These challenges have been addressed and the potential solutions have been looked for by jointly EU-funded BONUS program and by HELCOM and also, they have been funded by Interreg BSR, that also directly supports coordinating activities of macro-regional cooperation. The progress of the EUSBSR and project results are presented as flagships, which serve as a pilot examples for desired change. In the absence of an overarching 'blue' priority action, the SUBMARINER Network for Blue Growth EEIG was selected as the flagship umbrella project under Policy Area Innovation; but is *de facto* also closely cooperating with other Policy Areas and Horizontal Actions such as PA bioeconomy, nutria and maritime spatial planning. The EUSBSR is currently under revision and an update is expected to be launched in 2020.

1.2.4 HELCOM Baltic Sea Action Plan

The Commission for the protection of Baltic Marine Environment HELCOM is an intergovernmental cooperation forum for the Baltic Sea area. The HELCOM Baltic Sea Action Plan (BSAP) is an ambitious programme to restore the "good" ecological status of the Baltic marine environment by 2021. The plan, adopted by all Baltic coastal

[24] Study in support of Impact Assessment work on Blue Biotechnology (2014) EC EMFF https://ec.europa.eu/maritimeaffairs/publications/study-support-impact-assessment-work-blue-biotechnology_en
[25] https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy
[26] *ibid*

states and the EU in 2007, provides a concrete basis for HELCOM work. It incorporates the latest scientific knowledge and innovative management approaches into strategic policy implementation, and stimulates goal-oriented multilateral cooperation around the Baltic Sea region. The BSAP is regularly updated in ministerial meetings. The BSAP can be relevant specifically to blue biotechnology for bioremediation applications. The BSAP is currently under revision and an update is expected in 2021.

1.2.1 Nordic Bioeconomy Programme

The programme aims to create new industries and value chains and to facilitate and guide the transition of bio-based industries into technology advanced industries, and to optimise the production and value creation of biomass. The programme sets out a vision for the Nordic bioeconomy based on four pillars: - competitive bio-based industries - sustainable resource management - resilient and diverse ecosystems - inclusive economic development. To reach this vision, the programme defines 15 action points under three thematic areas: Innovate – Accelerate – Network. The focus is on development of new policies on regional, national and Nordic level, for increased funding, better education, labelling and certificates, bioeconomy clusters and several other areas. The strategy reflects the R&D and innovation needs of many technological fields including aquaculture, blue biotechnology, biorefining and recycling.

In conclusion, blue biotechnology is mentioned and supported by important strategies both on EU and BSR level.

The upcoming Blue Bioeconomy Roadmap (2019) will pave the way for unlocking the potential of the EU blue bioeconomy.

1.6 Activities and strategies of funding programmes within the BSR

Public funding schemes are traditionally supporting research, development and innovation at early stages, and for a knowledge-intensive field like blue biotechnology, this is particularly crucial. The above-mentioned strategies are supported by several funding programmes available both at European as well as national level. In the following we show the most important currently available funding streams and previously funded projects relevant to blue biotechnology.

Horizon 2020 is the biggest EU Research and Innovation program ever realised with nearly € 80 billion of funding available to be spent in a 7 years period (2014 to 2020).[27] H2020 is a financial instrument, which aims to drive economic growth and create jobs. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. **Blue Growth call**(H2020-BG-2018-2020) is part of the Horizon 2020 work program (2018-2020) on Societal challenge 2 “food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy” with a financial volume of more than € 166 million. According to the website, “the Blue Growth call aims at sustainably harvesting the potential of resources from seas, oceans and inland waters for different uses and across the range of marine and maritime industries, while protecting biodiversity and enhancing climate resilience.” Some funded blue biotechnology Horizon 2020 projects are: **MacroFuels** (2016-2019)[28] aiming to produce ´advanced biofuels from seaweed or macro-algae. The targeted biofuels are ethanol, butanol, furanics (chemically mediated conversion of sugar to fuel) and biogas. **GOJELLY** (2018-2021) offers ´a gelatinous solution to plastic pollution'[29] aiming to use jellyfish as source of innovative solutions to combat marine litter.

[27] https://ec.europa.eu/programmes/horizon2020/what-horizon-2020
[28] https://cordis.europa.eu/project/rcn/199672/factsheet/en
[29] https://cordis.europa.eu/project/rcn/214293/factsheet/en

The Bio-based industries (BBI-JU) Initiative is an ongoing, industry-driven Public-Private Partnership (PPP) between the European Commission and the Bio-based Industries Consortium (BIC). The PPP is a Horizon 2020 instrument to support industrial research and innovation, to overcome the innovation 'valley of death', the path from research to the marketplace. It focuses on three major aspects: supply of sustainable feedstock biomass , development and demonstration of efficiency as well as economic viability of (large-scale)biorefineries, and market developments and optimisation of policy frameworks for bio-based products.[30] Some funded blue biotechnology projects are: The **MACRO CASCADE** (2016-2020)[31] project aims to prove the concept of the cascading marine macroalgal biorefinery, covering the entire technological chain for processing sustainable cultivated seaweed into highly processed value-added products. **AQUABIOPRO-FIT** (2018-2022)[32] has the objective to convert residual biomass and industry side streams, such as fish heads, backbones and intestines, into ingredients for food, feed and other high value markets. **BIOSEA** (2017-2020)[33] aims to validate and scale up an entire production process of ingredients from the lipid, protein, carbohydrates and minority compounds fractions of four algae, including upstream and downstream steps. **WaSeaBi (2019-2022)[34]** is working on the development and testing of high-quality new products and ingredients from by-products coming from aquaculture, fishing and the fish processing industry.

The LIFE programme[35] is managed by the European Commission through its services DG Environment and DG Climate Action, and its Executive Agency for Small and Medium-sized Enterprises (EASME). The LIFE multi-annual work programme is updated biannually. Within the 2018-2020 programme a total of € 1,24 billion are attributed for work on nature conservation and environmental protection, and additional € 413.25 million for projects focusing on climate action. One of the objectives of the LIFE programme is to support the transition towards a resource-efficient, low carbon and climate resilient economy, improve the quality of the environment and halt and reverse biodiversity loss, including marine species and ecosystems conservation. The **SUNALGAE[36]** is a project of a Swedish SME called Swedish Algae factory. The project's main objective is to demonstrate a new, innovative algae material that can provide enhancements in the efficiency of silicon based and thin film solar panels.

The EMFF BlueEconomy 2018 call[37] had a total budget of € 18.7 million, aiming at accelerating development and implementation of the EU Maritime Policy and the sustainable development of the blue economy across Europe. This overarching aim is further divided into specific objectives as described under each of the 3 topics that are part of this call for proposals: 1) Blue Labs: innovative solutions for maritime challenges, 2) Blue Careers in Europe, and 3) Grants for the Blue Economy: investing in innovation. 108 calls were submitted in total.

Blue Economy Investment Platform (DG-MARE)[38] is a 3-years project contracted by EC DG-MARE and implemented by a consortium headed by PwC. The Platform aims to "improve the flow of private investment to blue growth sectors, in particular by helping small and medium-sized enterprises (SMEs) to improve their

[30] https://www.bbi-europe.eu/about/about-bbi
[31] https://www.macrocascade.eu/
[32] http://www.aquabioprofit.eu
[33] http://www.biosea-project.eu
[3434] https://cordis.europa.eu/project/rcn/222679/factsheet/en
[35] https://ec.europa.eu/easme/en/life
[36] https://swedishalgaefactory.com/project/eu-life-sunalgae/
[37] https://ec.europa.eu/easme/en/news/blue-economy-call-187-million-available-funding
[38] https://webgate.ec.europa.eu/maritimeforum/en/node/4388

investment readiness". The project started in July 2019 and in the next 3 years, "a number of services and activities will be implemented, including the creation of a community of interest (involving the organisation of 12 events in the next three years), provision of investment-readiness coaching services to selected SMEs (application based), creation of a financial instrument funded by the European Union and private investors that will be targeted at the blue economy sector, and scouting and identification of projects and SMEs which can be prepared for raising of investment in the market."

The Marine Biotechnology ERA-NET (ERA-MBT) has been a key initiative for blue biotechnology. Previously funded under the FP7 ERA-NET scheme, it was a consortium of 19 national funding agencies seeking complementarities between national activities by pooling resources to enable joint funding of transnational projects in the area of marine biotechnology. It launched three thematic funding calls for marine biotechnology (mainly academic research), actively sustained stakeholder dialogue and research networking and published a strategic roadmap for European marine (blue) biotechnology development (see above). The final conference, held in Oslo on 20-21 November 2017, was used as ultimate occasion to showcase all 16 funded projects, while creating discussions on other project achievements, including the five thematic areas identified in the **Marine Biotechnology Strategic Research and Innovation Roadmap**. The initiative ended in 2017.

The subsequently launched ERA-NET COFUND on the Blue Bioeconomy - Unlocking the Potential of Aquatic Bioresources (BlueBio)[39], is a collaborative effort of JPI Oceans, ERA COFASP and ERA-MBT. The participation from 16 countries (incl. BSR countries Denmark, Estonia, Finland, Germany, and Sweden) has already resulted in a total commitment of € 23 million, which adds to a total of € 30 million available when taking into account an EU contribution in the range of € 6,5 million. The cofund, launched in September 2018 and first call for pre-proposals closed in March 2019, will address new blue bioresources, new use of traditional blue resources, improvement of existing value chains (e.g. circular economy), and cross-cutting and supportive issues/actions. The first call required consortia composed of research organisations and industry (in particular SMEs) from at least three ERA-NET member countries; maximum budget per project was limited to€ 2 million, rendering this funding instrument ideal for technology transfer and innovation by blue biotechnology SMEs. In total, 83 project proposals were submitted in the first round of the first call in 2019, half of which were submitted under Priority area 1: Exploring new bioresources. Selected pre-proposals will be invited to submit a full application with a deadline in September 2019.

The Interreg Baltic Sea Region Programme 2014-2020 supports integrated territorial development and cooperation for a more innovative, better accessible and sustainable Baltic Sea region. The programme funds come from the European Regional Development Fund (ERDF, € 263.8 million), the European Neighbourhood Instrument (ENI) and Norwegian national funding. Project partners co-finance activities in Interreg projects by also contributing a certain percentage of own resources. Partners from countries around the Baltic Sea work together in transnational projects on common key challenges and opportunities. Priority 2 'Efficient management of natural resources' supports transnational cooperation enhancing capacity of public authorities and practitioners to ensure better environmental status of the Baltic Sea Region waters and to strengthen the resource-efficient growth.

Among the projects funded in this funding programme are several SUBMARINER Network flagship projects; apart from the Baltic Blue Biotechnology Alliance[40], there are **Baltic Blue Growth**[41] on mussel farming

[39] https://bluebioeconomy.eu/
[40] https://www.submariner-network.eu/projects/balticbluebioalliance
[41] https://www.submariner-network.eu/projects/balticbluegrowth

demonstration, **Smart Blue Regions**[42] on Blue Growth RIS3 Smart Specialisation Strategies of regions and **GRASS** (2018-2021) [43] on capacity building in macroalgae production and use. Regular project calls are now closed. The **Blue Platform project** (2018-2021)[44] will integrate the innovation capacity of many sectors including blue biotechnology and aquaculture. The Blue Platform will analyse and combine results and findings of several regular blue bioeconomy projects in the BSR, and provide recommendations for alignment of funding and legislation. Other funded projects are: **CONTRA** sustainable management of beach wrack. The next programme which will cover the period 2021-2027, is not published yet.

The BONUS programme, the joint Baltic Sea research and development programme for the years 2010-2017, comprises the national research funding institutions of the EU Baltic Sea neighbouring states together with the EU. In support of sustainable development and ecosystem-based management of the Baltic Sea region, according to the website, "BONUS issues call on ecosystem research and innovation for scientific community and SMEs. BONUS funds projects of high excellence and relevance 1) to produce knowledge, scientific evidence and innovation solutions needed by policymakers and 2) to engage end-users and the society in the knowledge-based governance of the fragile Baltic Sea"[45]. Notable funded projects with respect to blue biotechnology/bioeconomy are: **BONUS CLEANAQ** (2017-2019) on Innovative nutrient and organic matter removal in effluents from recirculating aquaculture systems (RAS) and **FLAVOPHAGE** (2017-2020) on Bacteriophage based technology for pathogen control in aquaculture. The next programme, which will run from 2021-2027 will include a combined research and innovation programme for both **Ba**ltic and **No**rth **S**eas and therefore be renamed to BANOS (current Horizon 2020 CSA project to prepare BANOS framework[46]).

NordForsk - The Nordic Bioeconomy Programme. NordForsk is an organisation under the Nordic Council of Ministers that provides funding for and facilitates Nordic cooperation on research and research infrastructure. Nordic Bioeconomy Programme was mentioned in section 1.2.1. Through the financing and administration of research programmes NordForsk brings together national research groups and promotes research activities of the highest scientific quality. A notable project funded by the Programme is **NordAqua** that aimed to form a unique hub for cross-border Nordic collaboration within blue-green bioeconomy, including industrial biotechnology and life science.

To conclude, several funding programmes have funded research and innovation projects within blue biotechnology with partners from the BSR. All the above projects represent timely relevant networks, important sources of accumulated data, information and knowledge. Among them, the Blue Platform (Interreg BSR) has the strategic role to analyse and combine results and findings of several thematic BSR-related "blue bioeconomy" projects, and provide recommendations for alignment of funding and legislation.

The Blue Investment Platform is a promising new support mechanism for blue SMEs. The new mechanism will benefit most by collaborating with existing accelerators and mentors and thus building on successes and lessons learned. The *Alliance* and other accelerators would be a great potential ally for this.

Through analysing urgent needs of the relevant sectors, the Blue Bioeconomy Roadmap will inform and influence future policies and innovation support mechanisms (incl. the Horizon Europe framework program as well as Interreg and ERA-Net programmes).

[42] https://www.submariner-network.eu/projects/smartblueregions
[43] https://www.submariner-network.eu/projects/grass
[44] https://www.submariner-network.eu/projects/blue-platform
[45] https://www.bonusportal.org/about_us
[46] https://www.banoscsa.org/banos_csa

Furthermore, the updated EUSBSR expected in 2020 will influence the future ERA-Net, Interreg and BANOS funding programmes (next BONUS programme). The new Interreg programme is not released yet, however, there are ongoing discussions towards developing calls for extending project durations from 3 to 7 years. Such scenarios would have a positive impact to absorption of benefits associated to building new support structures and mechanisms such as Alliance innovation platform and SME accelerator programme and set a good potential for long term process financial support.

1.7 Parallel blue biotechnology networks and clusters

The Baltic Blue Biotechnology Alliance and its partners are members of the SUBMARINER Network that is a bottom-up-developed transnational mega-cluster in the Baltics covering many marine sectors including blue biotechnology, mussel farming, fish/ shrimp and algae aquaculture. Parallel to SUBMARINER Network other networks have evolved too with slightly different scope. The interaction with and close relationship to other networks and clusters is known to be an important success factor. For this, both the *Alliance* partners individually but also the *Alliance* as a whole and the SUBMARINER Network constantly strive for making collaborations and partnerships with other important networking actors. The *Alliance* and the SUBMARINER Network wish to collaborate even stronger in the future with other networks.

We list here a non-exhaustive list of innovation networks and clusters that lead initiatives and provide exceptional traction in the blue biotechnology sector. *Alliance* has established links to many of these organisations:

BioMarine[47] is a private organisation at the crossroads of research, business, and investment. According to the website BioMarine "operates and manages **BioMarine Business Convention**- several international platforms about marine bio resources - with a scientific, economic and societal approach, and is designed to optimise and accelerate business opportunities and the development of small innovative companies". BioMarine is also developing partnerships to extend the scope of its activities specifically in the new media, technology and finance. In 2019, BioMarine is leading a number of initiatives like the Blue BioPlastics Consortium, the Blue International Coop and the Blue Fund. The Alliance has supported the initiative and its activities by participating in the events, by financing SMEs to attend these events, and by actively promoting activities and events. The Alliance promoted and finally attended the BioMarine Business Convention in 2018 in Cascais, Portugal alongside many of our partners and cases.

The **BLUEBIOALLIANCE** (BBA) is The BlueBioAlliance (BBA) is a non-profit Portuguese association, founded in Cascais in July 2015. It includes all subsectors of the marine biotechnology value chain in Portugal[48], "ranging from raw material producers, over R&D units, to biotechnology SMEs, transforming centres and manufacturers, public sector entities and support companies, up to the final product developers". The BBA aims at "collectively organising this value chain, to foster its relations and dynamics, leveraging its SMEs growth and accelerating their internationalisation by increasing their outreach and exportations, leading to more jobs and value creation for Portugal". The BBA have so far launched two calls in their Blue Bio Value accelerator programme, and have collaborated with the Alliance by offering promotion, creating joined events, and in mentoring start-ups and SMEs. BBA is involved in many ways in the Alliance: CIIMAR in Porto represents a link between the Alliance and BBA, since it is enrolled in the Portuguese BBA and is also involved as a mentor in the Baltic Blue Biotechnology Alliance´s mentoring programme. Moreover, but also Alliance has promoted the Blue Bio Value accelerator programme by encouraging Alliance cases to apply. In the first round, two Alliance cases applied to the Blue Bio Value accelerator and one of the two, Hoekmine BV (NL), won the first prize jointly with two Portuguese companies. On occasion of the European Maritime Day 2019 in Lisbon, both the Alliance and the BBA developed

[47] https://biomarine.org/page/what-is-biomarine
[48] https://www.bluebioalliance.pt/en_GB/

a joint workshop inviting four blue biotechnology cases, including the two Alliance cases, Vetik (EE) and Hoekmine (NL), where the cases elaborated on the innovation barriers many SMEs face within blue biotechnology, and what support they received from the Alliance and BBA.

European Algae Biomass Association (EABA) promotes mutual interchange and cooperation in the field of biomass production and use, including biofuels uses and all other utilisations. It aims at creating, developing and maintaining solidarity and links between its Members and at defending their interests at European and international level. EABA organises the annual **AlgaEurope Conference**.

The **EMBRC-ERIC**[49] is a "pan-European Research Infrastructure for marine biology and ecology research. With its services, it aims to answer fundamental questions regarding the health of oceanic ecosystems in a changing environment, enable new technologies to further our investigation capabilities, support life-science breakthrough discoveries with the use of marine biological models, and continue long-term marine monitoring efforts". EMBRC-ERIC is a driver in the development of blue biotechnologies, supporting both fundamental and applied research activities for sustainable solutions in the food, health and environmental sectors. Currently, there are no members of EMBRC-ERIC in the BSR. Hence, EMBRC-ERIC represents a pan-European sister cluster to the *Alliance*, which is complementary from a geographical perspective. Due to this complementarity while pursuing similar aims, close cooperation and joint actions are envisaged in the near future. To kick-start discussions and cross-network collaboration, a representative from EMBRC-ERIC was invited to join a panel discussion at the *Alliance* conference in Greifswald in 2018.

The following 4 projects are run under the framework of the EMBRC:

The project **European Marine Biological Research Infrastructure Cluster (EMBRIC)** is an EMBRC project which aims to promote new applications derived from marine organisms in fields such as drug discovery, novel foods and food ingredients, aquaculture selective breeding, bioremediation, cosmetics and bioenergy. The EMBRIC consortium comprises 27 partners of 4 different types (academia, research institutes, non-for-profit organisations and industry) from 9 countries, among which 5 partners come from Germany.

Assemble Plus is an EMBRC project that aims to stimulate European excellence in fundamental and applied research in marine biology and ecology, thereby improving our knowledge- and technology-base for the blue economy, policy and education purposes.

CORBEL is an EMBRC project that will establish a collaborative framework of shared services between the ESFRI Biological and Medical Research Infrastructures that transform the European research community from discovery of basic biological mechanisms to applied medical translation – through the provision of a unified interface, aligned services and coordinated user access to a range of advanced technology platforms.

EMBRC BioBank (EBB) is a three-years project (2017 –2020) that will set the basis for the common operation of the distributed marine biobanking facilities of the European Marine Biological Resource Centre (EMBRC). The project partnership is formed by a multidisciplinary team that comprises some of the world´s most important marine biobanks located in Norway, Ireland, United Kingdom, France, Spain, and Portugal; four clusters of marine biotechnology from Spain, France, Portugal and the United Kingdom; six companies active in the field of marine biotechnology; and the relevant government departments in Spain, Portugal and the United Kingdom responsible for access to genetic resources – the Access and Benefit Sharing (ABS) Competent National Authorities (CNAs). One of the *Alliance* mentors is the Scottish Association of Marine Sciences (SAMS) is a consortium partner in EBB, hence providing future opportunities to collaborate.

MIRRI - Launched in 2012, the pan-European Microbial Resource Research Infrastructure (MIRRI) is part of the Biomedical Science Research Infrastructure (BMS RI) ESFRI landscape. Currently, more than 40 public

[49] http://www.embrc.eu/

biorepositories and research institutes from 19 European countries collaborate to establish MIRRI as a European Research Infrastructure Consortium (ERIC) under EU law.

ScanBalt HealthRegion is a flagship in the EU Baltic Sea Region Strategy like SUBMARINER Network. ScanBalt is a Think Tank, Accelerator, Match-making agent, and communication hub. The flagship promotes Cross-Sectoral and Transnational Projects for Innovation in Health and in Life Sciences. It was founded in 2004 preceding SUBMARINER. It was a conscious move to create SUBMARINER in addition to ScanBalt – as there were concerns that making SUBMARINER as a sub-group of ScanBalt would fail to address the whole range of blue bioeconomy actions.

PILOTS4U is a BBI project (2016-2019) aims to set up one very visible, easily accessible network of open access pilot and multipurpose demo-infrastructures for the European bio-economy with Europe-wide coverage.

As the *Alliance* opens doors to more partners and cases, we strive to align activities with other BSR, European and global clusters and networks, e.g. integrate knowledge, exchange services (mentoring, service provision, promotion, lessons learned), develop joint events, send *Alliance* partners and cases to third-party pitching events, participate in accelerator programmes etc. We are open for collaborations, see more information in the open invitation to partners in Chapter 6.

Blue Generation is an EEA grant project (2018-2022)[50] to inspire and engage young people between 15 and 29 years to pursue a sustainable career in one of the following Blue Economy sectors: coastal tourism, aquaculture, ocean energy, marine biotechnology, shipbuilding, maritime transport and fisheries. SUBMARINER Network is an expert partner for marine biotechnology.

In this chapter, we introduced the Blue Bioeconomy and Blue Biotechnology in the Baltic Sea Region, analysed overarching strategies, funding programmes scoping the sector, and presented examples of blue biotechnology R&D initiatives. Finally, we introduced the Baltic Blue Biotechnology Alliance project that we will analyse in detail in the following chapter.

Blue Biotechnology is very important in Europe. Since SUBMARINER Compendium and Roadmap were released (2013), increasingly more projects and networks in blue biotechnology are funded. Also, in parallel to the *Alliance*, numerous new niche networks and specialty accelerator programmes are existing or have emerged. *Alliance* aims to team up and intensify existing collaborations, and this should be pursued by the other networks too. Networks should open up and collaborate instead of creating yet another network infrastructure.

The aim is to bridge the gap of to reach the critical mass concerning blue biotechnology activities and initiatives currently in the Baltics, but also to cross-fertilise and support the highly specialised sector throughout Europe. Towards this end, it is vitally important to jointly capitalise on knowledge generated also by other projects, especially those topic-specific ones, by integrating tools and findings into the 'knowledge base" of the *Alliance* of the 50+ partners. Thanks to the Blue Bioeconomy Forum, important innovation barriers are addressed by different actors across Europe with the aim to accelerate advancements in product development. For the *Alliance,* long-term financial support is still sought, e.g. strategic funding. The potential of extended financial schemes would be beneficial to allow absorbing of benefits by end-users.

[50] https://www.submariner-network.eu/projects/blue-generation

2 Lessons learned from the Baltic Blue Biotechnology Alliance (2016-2019)

In the course of the project (2016-2019), the *Alliance* consortium has developed a new structure that provided a broad spectrum of services that were offered to its client cases. The recording the lessons learned from this 3-years project is important given that *Alliance* operations continue beyond the end of the project's lifetime.

This chapter aims at summarising collected experiences and findings of the project activities, including the mentoring programme and the service offer. Furthermore, an effort has been taken to analyse the capacity of R&D actors beyond the *Alliance* consortium partners. In the last part of the chapter, an analysis of identified barriers is included.

2.1 Baltic Blue Biotechnology Alliance project

The Baltic Blue Biotechnology Alliance was a 3-year project (2016-2019) funded by Interreg BSR, with the aim to match end-users to the services, facilities and experts they need to take their product idea to the next level. The concept of the *Alliance* is based on a **transnational approach**, coming from the recognition of the fact, that blue biotechnology expertise is present but fragmented in the Baltic Sea Region.

Biotechnology is a research-intensive sector and thus technological innovation and product development can be a long, tricky and challenging route. Crossing all the research and development steps from bioprospecting (TRL 1) to commercialization (TRL 9) can be a copious, often expensive and in many cases serendipitous process, and for this we typically see blue biotechnology developments being supported by public grants.

Research institutes exist in all BSR countries with combined expertise in all the fields of blue biotechnology. Figure 4 depicts all necessary steps across the value chain starting from the discovery phase towards the development phase and finally to product market launch. Each step is pivotal and requires involvement of different processes and stakeholders.

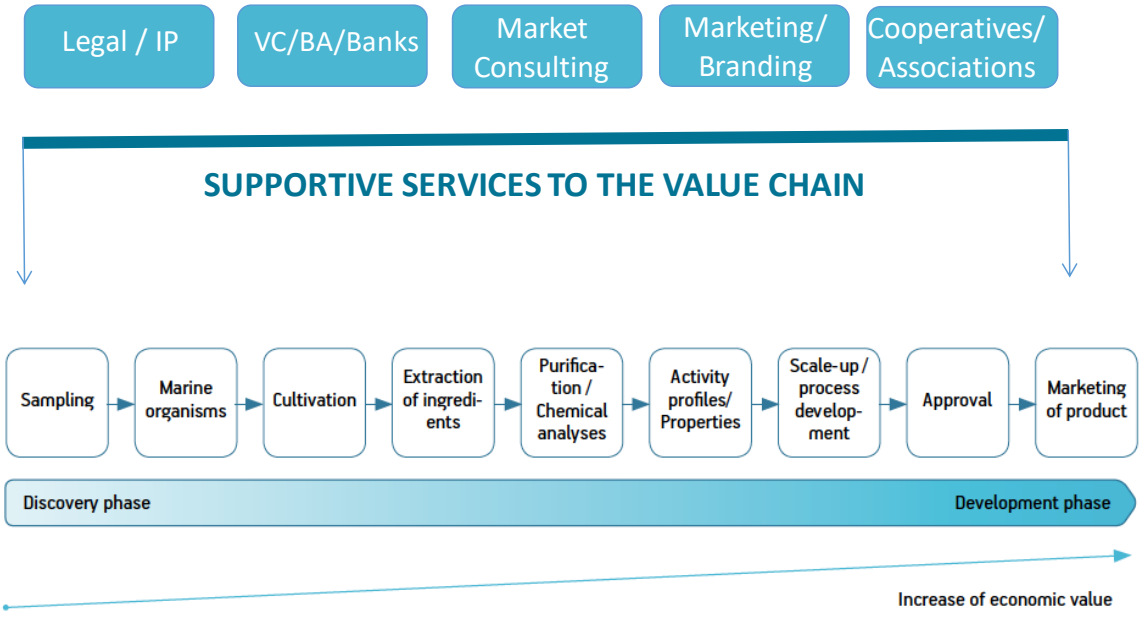


Figure 4 Blue Biotechnology value chain

The *Alliance* consortium originally comprised 25 project partners, of which 15 partners were offering services and 10 partners were service end-users. The end-users were typically start-ups and small-medium enterprises (SMEs), which served as case examples for establishment and optimisation of structures and services and hence

were called "cases". The 15 'institutional' partners are presented in Table 1 along with a short overview of the services offered by each of them. Each partner has a distinctive portfolio of services to offer in line with their expertise, competencies and resources. The portfolio and expertise of *Alliance* partners was presented in detail within the "Baltic Blue Biotechnology Alliance - Service Offer Brochure" [51].

Table 1. Alliance project partners and their expertise, competencies and resources offered in the Alliance service offer brochure in 2016.

	Mentoring	Scientific research	Research infrastructure/ equipment	Bio-resources	Business develop-ment	Commu-nication	Legal advice
GEOMAR Helmholtz Centre for Ocean Research Kiel	x	x	x	x			
SUBMARINER Network for Blue Growth EEIG	x				x	x	
BioCon Valley GmbH	x				x	x	x
Royal Institute of Technology Sweden (KTH)	x	x	x	x	x	x	
University of Gothenburg	x	x	x	x			
Finnish Environment Institute (SYKE)	x	x	x	x			
University of Gdańsk	x	x	x	x	x		
Pomeranian Special Economic Zone Ltd.	x				x	x	
Public institution Coastal Research and Planning Institute (CORPI)	x	x	x	x	x		
Danish Technological Institute (DTI)	x	x	x	x			
Klaipeda Science and Technology Park (KSTP)	x				x		
CleanTech Latvia	x	x	x		x	x	
Tartu Biotechnology Park	x				x	x	x
Svanvid Sp. z o.o.	x				x		
Scottish Association for Marine Science (SAMS)	x	x	x	x	x		x

The *Alliance* services are divided roughly into the following categories: Mentoring, Scientific research, Infrastructure access, bioresources supply, business development, communication and networking and legal services.

In the course of the 3 years *Alliance* project, in total 26 cases were enrolled in the mentoring program as end-users, 21 of which were recruited during four recruitment rounds which were operated as calls for ideas.

By the end of the project, some cases that joined at early stage, offered their services to "new coming" cases including mentoring in a case-to-case collaboration. The cross-case *Alliance* collaborations, that mostly involved start-ups and SMEs, were very potent in terms of accelerating business developments and elevating the

[51] https://www.submariner-network.eu/projects/balticbluebioalliance/about-the-balticbluebioalliance

collaborative spirit of the whole *Alliance* family. Some examples of cases are shown in Table 2, see CRM, SFTec and *Furcella* that offered mentoring as well as other skills and resources to other cases.

Table 2 Cases that offered mentoring support and competencies to other cases by the end of the Alliance project

	Mentoring	Scientific research	Research infrastructure / equipment	Bio-resources	Business development	Communi-cation	Legal advice
CRM - Coastal Research & Management	x	x		x			
Biovento Sp.z o.o.					x		
Furcella Oü	x				x		
KosterAlg				x			
SFTec Oy	x		x				

In beginning of 2019, a core-team of the *Alliance* project consisting of 7 *Alliance* consortium partners applied for the project extension of 1,5 years with a separate group of activities and outputs, but based on existing successes and aims. In April 2019, the application was evaluated positively by Interreg and thereby the Alliance+, the project extension of the Baltic Blue Biotechnology Alliance, will be funded until January 2021. Alliance. More information on the future of the *Alliance* is presented in Chapter 6**.**

2.2 The *Alliance* mentoring and support service programme

During the project implementation phase, the *Alliance* consortium has developed a broad spectrum of services which were offered to 26 client cases (Table 1). The following section provides an overview of the mentoring programme and the types of support used by the *Alliance* cases, including transnationality aspects. Cases analysis are presented separately in section 2.5.

When joining the *Alliance* mentoring program, each case was attributed two mentor organisations, one reflecting a national contact point and the second often coming from the field of expertise of the case. The mentors were responsible for guiding the case owner, introducing the various possibilities of support offered by the *Alliance* and acting as a mediator between the case owner and the consortium. However, for many cases, the mentors were also the crucial contacts helping in actual implementation of the respective case.

In the course of the mentoring process, the business plan was evaluated and updated always in close collaboration and upon mutual agreement of the mentors and the case owner. Communication between case owners and mentors was defined by the parties themselves, and was monitored by the ***Alliance* mentors' forum**. In many occasions, case owners were advised to change focus in the business plan, like e.g. investigate other market applications or technologies. The mentor's forum was an important link between the mentors and the cases and the surrounding innovation ecosystem. More information on the mentors' forum is given in Chapter 2.6.

All 26 selected cases received this mentoring support offered by *Alliance* partners. Moreover, 11 selected cases received financial support by being assigned project partner status. The other 15 cases did not receive financial support from the *Alliance*. However, the support provided for advancing the cases´ product development can be grouped in different categories such as scientific/technical, business, legal (IPR/patent research, national implementations of EU regulations), networking, and promotional support. In sum, these various support types

constitute the *Alliance* service offer. In total, 14 R&D institutions and 3 cases acted as mentors in the *Alliance* (Table 1 and Table 2).

From the case perspective, beyond the mentoring support that all 26 cases received, the most frequently provided types of support were networking (22 cases) and scientific/technical support (20 cases, incl. planning, setup and conduction of experiments, data analysis, providing equipment for analysis etc., Figure 5). This impressively shows the need for scientifically sound data and proven concepts for advancing blue biotechnology product development in the BSR. This was followed by business support (17 cases) and promotion of the cases on different types of events (13 cases). The least frequently requested support category was legal support (7 cases). On average, the cases received 4 different support categories, with Biofisk (DK) being supported in all 7 categories while in the other end, the cases Maresome and Enzymicals (both DE) requested only networking support beyond the mentoring. Notably and intendedly, the *Alliance* succeeded in its ambition to form a sustainable network connecting blue biotechnology actors on a transnational scale. Apart from the established collaborations between cases and mentors and service providers (project partners), *Alliance* developed also cases-to-case collaborations that was a serendipitous add-on in the *Alliance* partnership. In total, we recorded 12 case-to-case collaborations (CRM-Organic Seaweed, CRM-LoondSpa, CRM-Vetik, CRM-Koster-Alg, KosterAlg-SFTec, KosterAlg-Organic Seaweed, KosterAlg-DoS, Furcella-Vetik, SFTec-Vetik, Kalundborg-PowerAlgae, PowerAlgae-PhytoBox, EHP-Kalundborg) that either exchanged services and/ or resources, or conducted joint experiments to advance their product development.

2.3 Recruitment of cases (Source: WP4)

Cases joined the mentoring programme either through the recruitment process during the implementation period or as reserved partners from the start of the project. The latter statement applied to five cases, i.e. CRM (DE), Biovento (PL), Geoterma (LT), Baltic Probiotics (LV), Kalundborg (DK), whereas the other 21 cases joined after being accepted through the recruitment process.

The case recruitment process encompassed a three-step process.

Initially, "**blue detectives"** promote the support service and the potential benefits of the *Alliance* and also scout and spot for cases "in situ", i.e. in research labs, on conferences, pitching events, and accelerator programmes. The "blue detectives" are very good at discovering novel cases. It turned out as a project result, that the strategy blue detectives play a huge role for overall *Alliance* impact.

Twice a year, a structured "**call for ideas**" was launched, to which potential case candidates could apply online. The *Alliance* recruitment strategy encompassed in total 4 of these calls for ideas within the project lifetime.

At this step, crucial role played the proper **national contact points**, that can answer the various requests of different potential case candidates, and respectively guide the prospective applicants towards application submission after establishing the initial contact. National contact points have been allocated on a voluntary (but continuous throughout the project lifetime) basis and they have been key structural elements in the recruitment process, since they

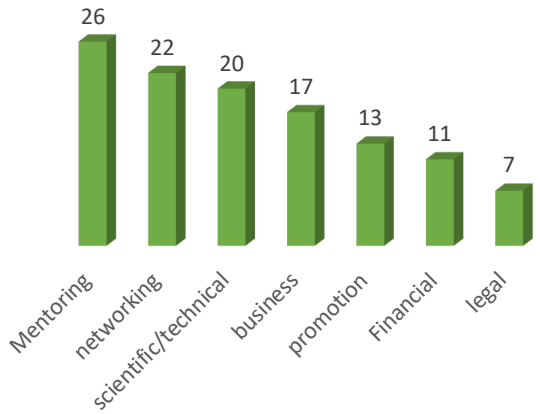


Figure 5 Different service categories delivered to cases by Alliance in frame of the mentoring program. All 26 cases received mentoring.

serve as facilitator and entrance gate to *Alliance* for newcomers, both cases and partners.

Submitted written applications to the calls for ideas were evaluated by a panel of chosen experts. The pre-decided and publicly known evaluation criteria for acceptance of cases were: 1) relevance for the Baltic Sea Region, 2) sustainability, 3) feasibility, 4) market potential and 6) fitting of applicants' needs to the competences of *Alliance* mentors and service providers.

Applicants, who passed the first level of the recruitment process, were invited to the second stage, in which they presented their idea on a dedicated pitching event against a panel of experts as evaluators. During the *Alliance* project lifetime, in total three pitching events (which were organised back-to-back to project partner meetings) took place in different BSR countries:

- Helsinki, FL/October 2016 which included evaluation of the applications to the 1st call for ideas (11 cases accepted, 6 as project partners and 5 for mentoring)
- Gothenburg, SE/April 2017 with evaluation of applications received in response to the 2nd call for ideas (4 cases accepted for mentoring)
- Berlin, DE/November 2017 including evaluation of applications from the 3rd call for ideas (2 cases accepted for mentoring).
- Copenhagen, DK/April 2018 A pitching session was realized in response to the 4th call for ideas; both 2 cases applying to this call for ideas were accepted for mentoring.

The call material was developed jointly in the *Alliance* core team (GEOMAR, Submariner, DTI) and shared with all project partners, and it was of course published on the *Alliance* website; yet **the recruitment strategy** was structured nationally. Hence each project partner was entrusted to spread the call in the respective networks as well as to actively search and address potential cases on a national level. Thus, all partners acted as blue detectives. Partners used different approaches and channels to promote these calls. When summarising the different recruitment actions, it can be concluded that the most promising and effective recruitment strategies were:

- disseminate on online media by advertising the calls on own websites, newsletters and among own networks
- approach several channels e.g. reaching out to own networks and local authorities
- direct contact to selected stakeholders
- organise dedicated events to promote the *Alliance* project and network while at the same time attracting potential case candidates
- approach candidates among own colleagues, e.g. at the university.

As expected, utilisation of direct contacts turned out to be the most effective recruitment strategy. Countries with strong *Alliance* presence, with multiple partners proactively scouted for cases, and promoted the *Alliance* via the above-mentioned recruitment strategies were more successful. When the *Alliance* recruitment was less proactive and used few and poor strategies, e.g. single publishing on a thematic website, did not perform effectively and returned no cases. Thereby, promotion and case scouting via e.g. blue detectives, are key strategies for accessing future *Alliance* services.

The recruitment strategy pursued in 2016-2019 resulted in 34 cases that applied to the four calls. Since only 26 cases were finally accepted, this means also that 13 candidates were rejected. Out of these, two applied for a second time (in response to a later call) by taking into account the previously given recommendations from the expert panels and finally managed to enter the mentoring programme.

The main reasons for rejection of applications were:

- not much added value for the Baltic Sea region,
- no proper definition of the resource origin,
- unrealistic budgeting,

- very early stage (technology readiness level 1 or 2) in their business journey.

Out of 11 rejected cases in total, 8 were rejected after the 1st call for ideas which is connected to the high number of received applications (20) to this call. Five of the 11 not accepted cases came from Germany, whereas three others came from countries outside the programme area and those applications also had no content-wise connections to the Baltic Sea. By contrast, we had one case accepted by NL, but Hoekmine used technologies from the Baltic (Algae from Finland). Six of the rejected candidates represented ideas from research institutes, whereas five were from companies.

2.4 *Alliance* mentors and service providers

Mentors play a critical role in the success of their cases. During the *Alliance*, the mentors on the one hand guided "their" cases including identification of case's needs (jointly with the case owner), but they were also crucial with regard to the definition of optimal pathways for implementation and case implementation itself. This included in several occasions also a suggestion of strategic changes e.g. in business setup or idea. The mentors typically connected the case owner with the *Alliance* through the mentors' forum, but also, they represented the cases' interests e.g. for finding the right partners within *Alliance* (mentors' forum) but also outside the project environment, e.g. in conferences or match-making. As a result, the selection of mentors in the recruitment process was of vital importance for the individual case progress.

In the course of the *Alliance* project, 18 organisations from 10 countries including 8 Baltic Sea Region countries and one organisation each from Scotland and Portugal acted as mentors (Figure 6). The Portuguese mentor, CIIMAR in Porto, was assigned as an official associate partner of the *Alliance*. The majority of the *Alliance* mentors are working in research institutes within blue biotechnology or aquaculture fields (Figure 6).

The mentors were carefully coupled to the newly recruited cases by the mentors' forum, after careful selection by matching initial cases needs with the available expertise, competencies and resources of the mentors. But mentor assignment was not merely a matter of matching competencies; largely it was coming voluntarily from the mentors. The lesson which can be learned from this concept is, that mentors should also have a genuine interest and willingness to supervise and take care of a case since this turned out to be a crucial success factor for fruitful collaboration and a win-win setup for good case progress. From the experience gained throughout the *Alliance* project, one take-home message is "the stronger the collaboration the higher the case success", and several case examples underpin this, e.g. KosterAlg - Gothenburg University, Baltic Probiotics – KSTP and CORPI, Vetik – TBP.

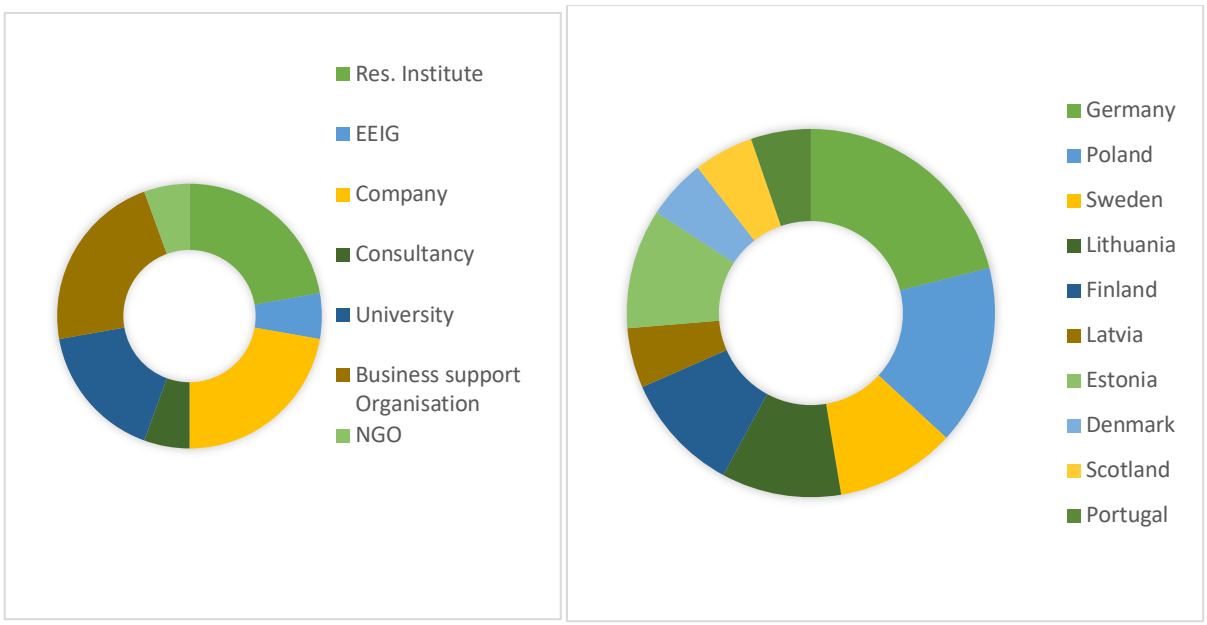


Figure 6 Country of origin among 19 Alliance mentors (left) and type of organisation among Alliance mentors (right); figures include veteran cases offering mentorship

Alliance mentors often acted also as service providers, meaning that they did not only guide their cases in the initial scoping phase, but also substantially contributed to implementation and hence case success, by providing highly specialised services on demand. Figure 7 shows the 7 different services offered by the 19 project partners (and associated partners) of the *Alliance* differentiated by service type. In Chapter 2.6, every service will be addressed separately.

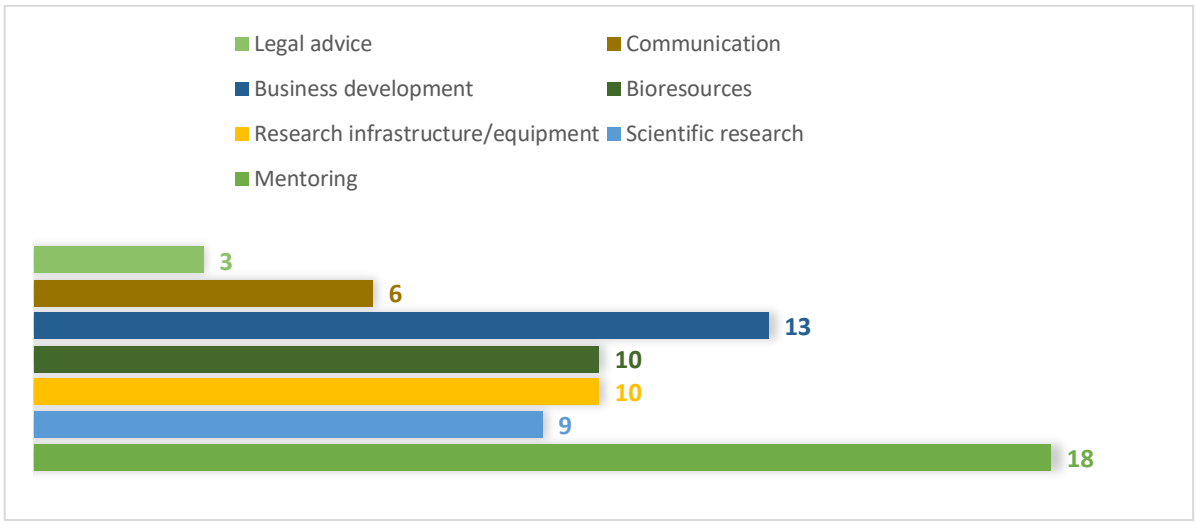


Figure 7 Services offered by the 19 project partners (and ass. Partners), including mentoring (green line). Numbers on bars indicate the number of services offered by type to equal number of cases.

In conclusion the *Alliance* mentors in 10 different countries are characterised by a high versatility with respect to professional expertise and high competencies in biotechnology innovation, as well as a service-oriented approach.

2.5 Comparative *Alliance* case analysis

The cases enrolled in the *Alliance* mentoring programme exhibited a high diversity in terms of organisation type, geographic origin, targeted products and markets, development phase, and needs. While all *Alliance* cases are listed in Table 3, the following chapter comparatively analyses key data of the cases.

*Table 3:Overview of Alliance cases, their country of origin and main market/service outline. *: partner dropped out from the project in 2018*

Case no.	Case name	Country	Product/service
1	Coastal Research & Management	Germany	Macroalgae ingredient for cosmetics
2	Biovento	Poland	Microalgae-derived antifouling paint
3	Geoterma*	Lithuania	Heat supply from thermal water
4	Baltic Probiotics	Latvia	Aquaculture probiotics
5	Kalundborg municipality	Denmark	Microalgae facility for large-scale cultivation
6	Biome	Lithuania	Mollusc shells as medical devices
7	Furcella	Estonia	Algal cosmetics
8	Biofisk	Denmark	Insect feed from beach cast
9	KosterAlg	Sweden	Baltic macroalgae as food
10	SFTec	Finland	Dryer for biomass by-products
11	UKSH	Germany	Dietary supplements from macroalgae
12	Hoekmine	The Netherlands	Structural colours from bacteria
13	JAMK	Finland	Combination of a biogas plant and a Photobioreactor for microalgae cultivation
14	Maresome	Germany	Medical product with antibacterial properties
15	PowerAlgae	Estonia	Photobioreactor for microalgae cultivation
16	Enzymicals	Germany	Novel enzymes from marine bacteria
17	Movable Biogas Factory	Finland	Biogas from beach cast
18	Organic Seaweed	Denmark	Macroalgae-derived sunscreen

19	Uni Gdansk - Biogas	Poland	Biofuel generation based on microalgae cultivation
20	EHP	Finland	Sea monitoring
21	Vetik	Estonia	Red algae extract
22	Uni Gdansk - Smart Bloom	Poland	Bioplastic from cyanobacterial blooms
23	LoondSPA	Estonia	Lake mud cosmetics
24	Phytolinc	Germany	Photobioreactor development for microalgae cultivation
25	Department of Seaweed	Germany	Seaweed platform
26	DTU - Biotrino	Denmark	Food ingredient from microalgae

In regard to the **type of organisation** (Figure 8), most of the *Alliance* cases were companies (17 cases), the remaining were research institutes (5 cases) and other organisation types, such as a municipality, an innovation team, or a platform. Majority of cases were start-ups, founded recently, or not registered yet. However, some cases were "seasoned" SMEs (e.g. CRM, Germany) with at least one product in the market prior to approaching or entering the *Alliance*.

Most case owners were based in Germany (6), followed by Denmark (4), Finland (4) and Estonia (4). This highlights the success of the recruitment strategy applied in these countries but also the plethora of innovative blue biotechnology ideas previously being dormant in a small country like Estonia. The remaining cases come from Poland, Lithuania, Latvia, Sweden and the Netherlands. The *Alliance* cases represent the whole basin of the Baltic Sea Region (except Russia, Figure 8), the established value chains prove transnationality and a transdisciplinary character for the development of products.

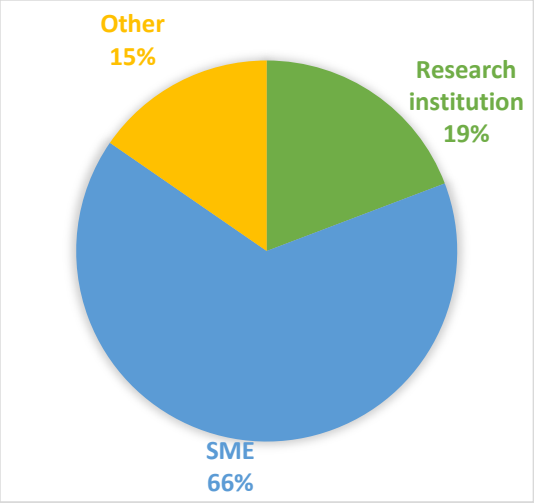


Figure 8: Alliance cases with regard to type of organisation (left) and country of origin (right)

The concept of *Alliance* is based on a **transnational approach**, coming from the recognition of the fact, that blue biotechnology expertise is present in the Baltic Sea Region but fragmented (see chapter 1.1). Therefore, the transnational approach for advancing cases in their product development was key to implementation of the

Alliance mission. Figure 9 shows the transnational bonds within the *Alliance* consortium. On average, 3,5 transnational connections/collaborations were made per case throughout the mentoring program of *Alliance*. Most international connections were realised by Hoekmine (NL), followed by Biome (LV), SFTec (FL) and Movable Biogas Factory (FI). During the *Alliance*, a tight transnational network was formed between blue biotechnology actors in the BSR which reflects the highly important transnational aspect for the mentoring program in particular and the project in general.

Figure 9 Number of transnational connections for all Alliance cases. Country of origin of the case owner is included in the calculation

As foreseen, various types of **products** were in the scope of product development in frame of the *Alliance.* This did not only include direct blue biotechnology products for sale such as cosmetic products, but also services and/or energy products. Out of the 26 cases, 21 developed biotechnological products, 4 cases developed technical devices and 3 aimed at providing alternative bio-based energy supply solutions. The devices aimed to enable production, its control or valorisation of blue biotechnology relevant biomass.

The cosmetic sector was the **target market** for most products in development by *Alliance* cases, followed by the food sector (incl. nutritional supplements) and feed, and specialty products for use in aquaculture, such as sensors, filters and fish health boosters (Figure 10). More than one market or diverse applications were targeted by 4 cases (e.g. Vetik developing red-algae based products for application in the cosmetic but also the food colorant market). Only 2 cases targeted the development of products for the pharma sector, which promises high revenues but the way to this market is spiked with high regulatory hurdles as well as expenses and requires long development times. As the cosmetic sector promises comparably quick revenues opposed to much lesser costs for product development and lesser regulatory hurdles, it is probably the most attractive market for the *Alliance* cases, most of which (14) are start-ups with limited financial resources.

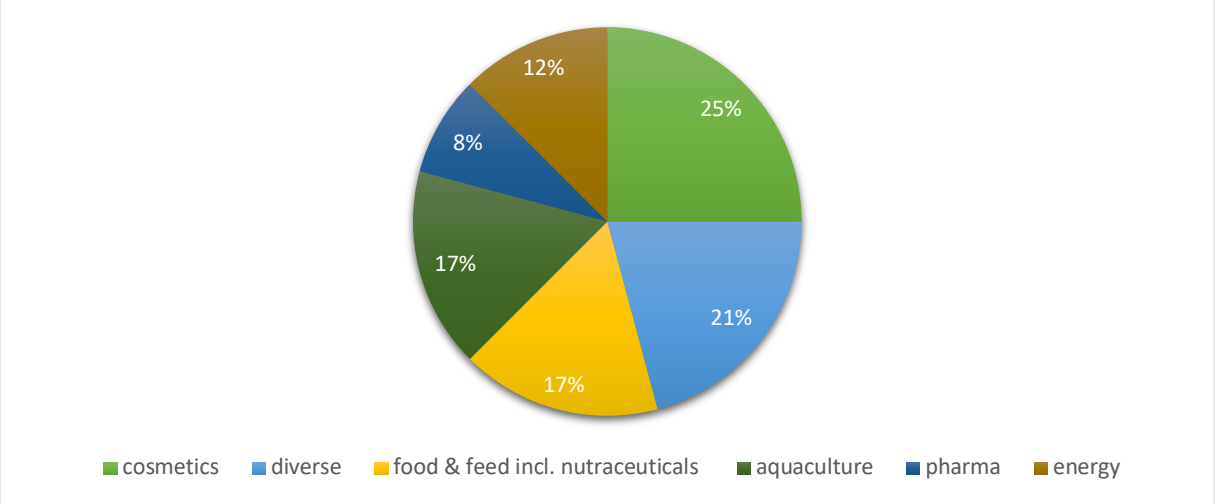


Figure 10 Target markets of the offered products

When it comes to **target customers**, the business to business (B2B) sector is clearly the most crucial for the products and services developed by the *Alliance* cases (56%), followed by the business to consumer (B2C) with 24% and the public sector with 20%.

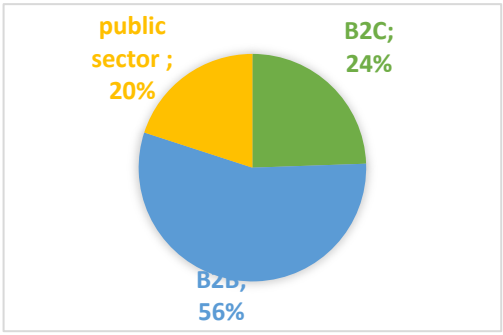


Figure 11 Client sectors the cases target

The *Alliance* case owners used different **types of biological resources** for advancing their blue biotechnology-based product development. As Figure 12 shows, most cases used different Baltic macroalgae (38%) and microalgae (28%) species as biological resources, both knowingly featuring valuable ingredients (e.g. phlorotannins, phycoerythrin or fucoidan omega-3-fatty acids in macro- and microalgae) with high biotechnological application potential and consequently, also high potential to be integrated in circular economy concepts. Microorganisms, which are also scientifically recognised as versatile producers of a variety of natural products and easily lend themselves for blue biotechnology since they are cultivable in large quantities, are only used as biological resource in 10% of cases. Notably, fungi are not used as a biological resource by any case. Moreover, only one case, Biome, is using an animal-derived product, mussel shells, for product development.

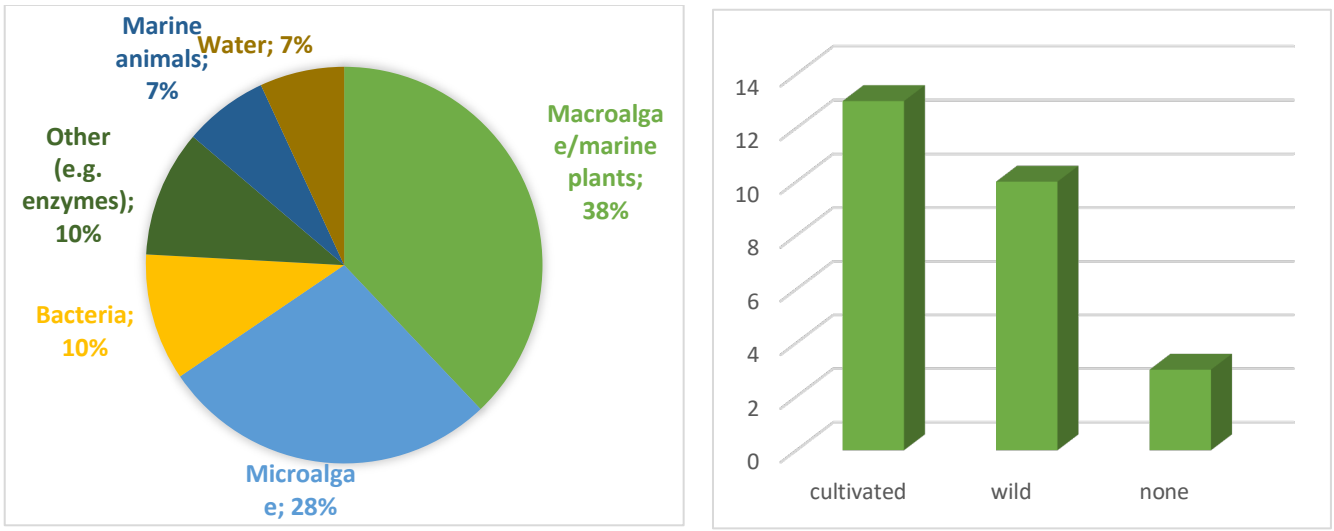


Figure 12 Used biological resource for product development (Left) and sourcing of biomass (right)

With respect to blue bioeconomy, notably 5 cases focus on the development of products using biomass generally considered as waste. This is true for Biome (mussel shells), Biofisk and Movable Biogas Factory (both: beach wrack / beachcast consisting of macroalgae and seagrass), SFTec (drying technology for bioslurries) and Uni Gdansk - Smart Bloom (algal blooms for biopolymers). Also, novel cultivation methods of well-known organisms (i.e. heterotrophic cultivation of microalgae, case DTU-Biotrino) may receive increasing attention with regard to future circular economy concepts. The biological resources used for product development were mostly obtained by cultivation (13) and 10 cases used wildly collected biological resources. 3 cases (Geoterma- hydrothermal water, EHP-water, LoondSpa-Water/Mud) did not use any biological resource. Notably, the Swedish KosterAlg case represents a specialty with respect to the resource used, since it relies on macroalgae cultivated in an offshore algal farm in the Koster Fjord in Sweden.

Sustainability was a criterion for accepting cases for the mentoring program. But sustainability is a criterion which is hard to measure. It was primarily assessed with respect to the mode of acquisition of the biological resources used for product development (e.g. cultivation, licensed harvesting from wild). It has to be noted that sustainably obtained biological resources are key to a sustainable blue biotechnology. Hence, during in frame of the *Alliance*, new partnerships were formed to safeguard sustainable supply of biological resources. Moreover, in other cases, the mentors performed sustainability and feasibility assessments in frame of case implementation, e.g. with respect to energy input in form of light and heat needed for microalgae cultivation in relation to the expected revenues. Finally, each case was categorised according to the **UN Sustainable Development Goals** (SDG), displayed as matrix in Figure 13.

Figure 13 Number of cases contributing to the different UN Sustainable Development Goals (SDGs)

All cases contributed to SDG17-Partnerships for the goals, since they formed partnerships with other actors in the blue biotechnology sector to achieve product development in a sustainable way. Naturally, in a consortium focused on marine or blue biotechnology, many cases (17 out of 26) contributed to SDG14-Life below water. This was followed by SDG9-Industry, Innovation and Infrastructure. On average, each case contributed to 4 SDGs, and all cases contributed to >1 SDG, thus showing the high respect towards sustainability in the *Alliance*.

2.5.1 Progress in product development

When joining the *Alliance*, each case was assessed with regard to the respective stage in product development via a simplified value chain shown in Figure 14. The majority of the cases were assessed to be at R&D level, followed by those in Bioprospecting stage (Figure 15). At the end of the project, this assessment was repeated to evaluate the progress in product development due to *Alliance* contribution.

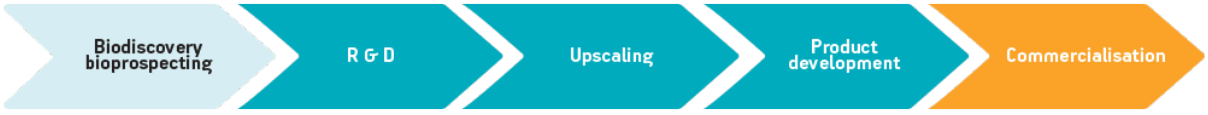


Figure 14. Simplified value chain used for assessing the TRL stages of cases applying to the Alliance

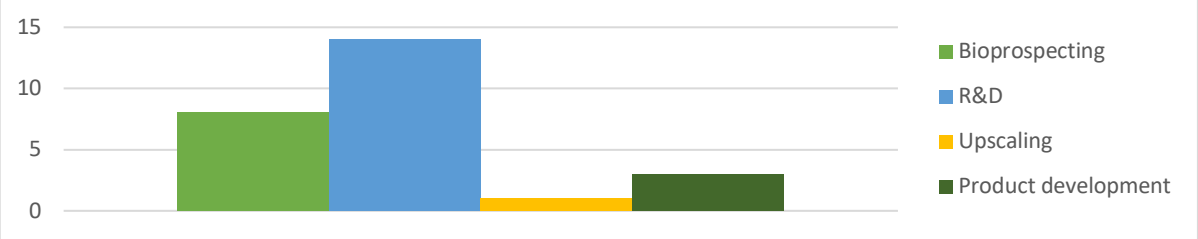


Figure 15 Value chain stage of the cases when entering the Alliance, following the simplified value chain stages in Figure 14.

On average, due to the *Alliance* support, the cases advanced 1 step in their product development (

Figure 16). This is an average calculated over all cases; since they were recruited in 5 different cohorts, the progress naturally differed between the cohorts due to several factors, i.e. establishment of the mentoring program and process, implementation, duration of experiments, type of support etc. However,

Figure 16 hardly reflects the real success of the *Alliance* cases, since it cannot take into account all the interwoven side aspects leading to significant mutual progress in many cases. For example, CRM signed a bilateral agreement with Organic Seaweed for provision of a sustainably harvested biological resource for CRM, which generated revenues for Organic Seaweed.

At the same time, several cases changed the direction or broadened their product development activities as a result of the feasibility analyses performed with the help of their mentors. This is a major contribution by *Alliance* to the case development and case owners (e.g. PowerAlgae, Uni Gdansk - Smart Bloom) as it meant a diversification with specific regard to feasibility and marketability of products. However, this diversification or change in direction is not reflected by a step forward (Figure 16) in the value chain, since intensifying e.g. R&D or bioprospecting activities with regard to product development for another sector takes time, although these cases were characterised by substantial progress towards their new aim.

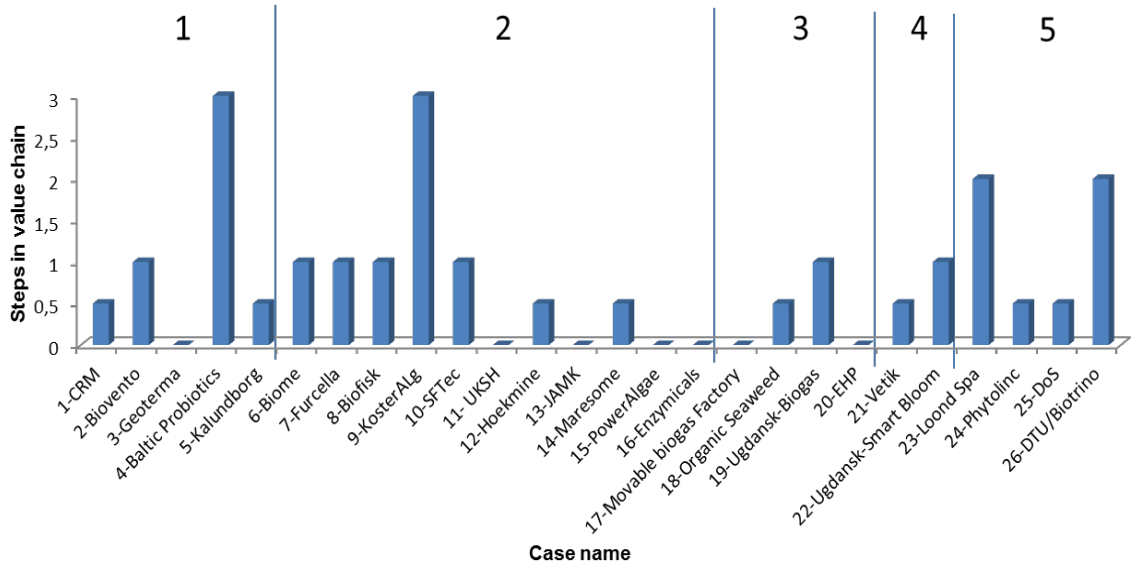


Figure 16 Individual progress of cases in the value chain. Numbers above diagram reflect different case cohorts. 1. Reserved partners represent cohort one (from March 2016), 2. Cohort recruited at pitching event in Helsinki (October 2016), 3. Cases recruited at pitching event in Gothenburg (April 2017), 4. Cases recruited during partner meeting in Berlin (November 2017), 5. Cases recruited during pitching event in Copenhagen (April 2018).

The most pronounced progress was achieved by one case each from Latvia and Sweden. Case 4-Baltic Probiotics developed two probiotic products for application in aquaculture to improve fish health proceeded from R&D to commercialisation of their products. Both newly developed products carry the Alliance/Interreg label. The

Swedish KosterAlg case which advanced also from R&D to commercialisation has succeeded in selling macroalgae grown in an offshore farm on the Swedish West Coast (Koster fjord) for food purposes.

Figure 17 Pictures show Koster Alg harvest on the offshore farm (left), Baltic Probiotics "Smart Fishery" probiotic solution to improve fish health for aquaculture fish (right)

Figure 18 shows the different progress steps made by *Alliance* cases. Notably, most steps still involve R&D aspects underlining the importance of knowledge-based product development and proof-of-concept studies for blue biotech-based product development. Six cases, which were in bioprospecting stage before joining *Alliance*, have moved forward to R&D in frame of the project *Alliance* and 5 advanced from R&D to upscaling, which nicely underlines the success of *Alliance* in taking blue biotechnology development in the BSR one step further. By the help of Alliance, commercialisation of newly developed products started in 3 cases (Baltic Probiotics, Furcella, KosterAlg) and prototypes are ready from 2 more cases (CRM, Biome).

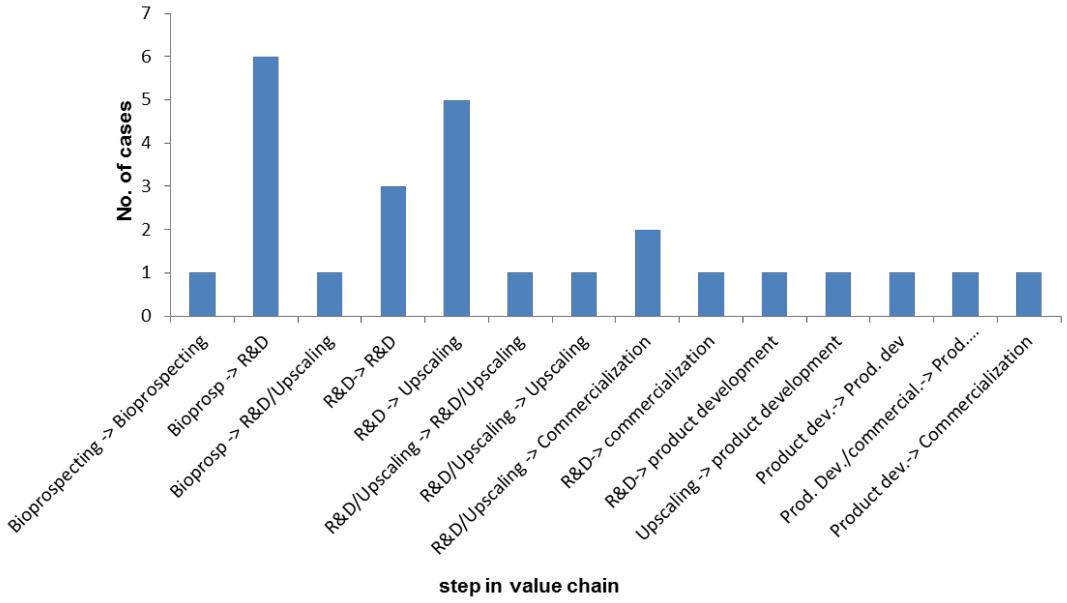


Figure 18. Progress of Alliance cases in the value chain with respect to different steps.

2.6 Service provision

Entangled in the mentoring programme, the *Alliance* service offer described the technical support offered to the cases. In Table 1 the *Alliance* partners were presented alongside the services they were able to offer in the course of the project. When converted into a percentage distribution of **available services** (Figure 19), an even distribution of different types of expertise and services can be observed. Business development, and a strong mix of scientific research, access to infrastructure and biological resources were on offer. Furthermore, communication, and legal advice was offered by few partners, although this was not the main focus in the original *Alliance* partners´ portfolio. Additionally, legal advice was offered by specialists sub-contracted by the project.

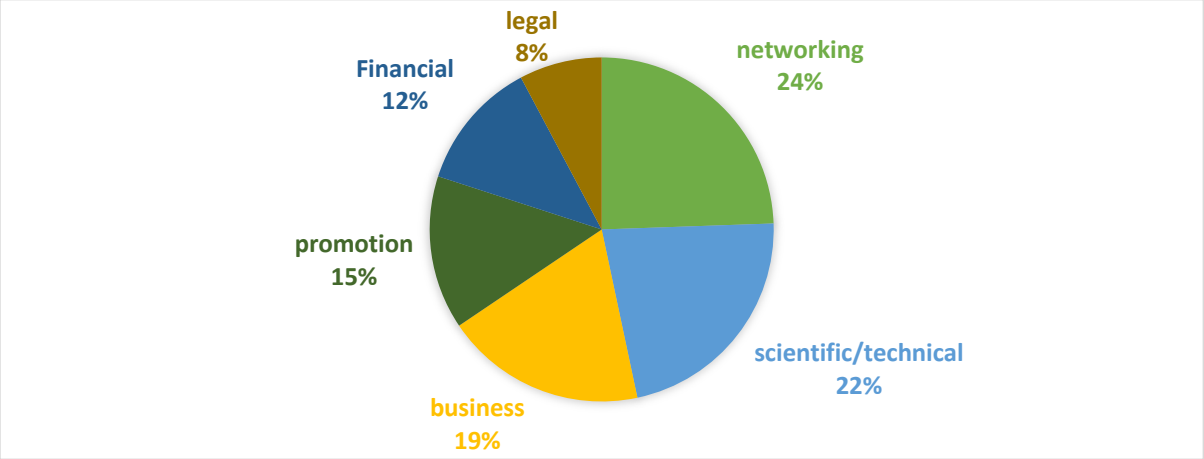


Figure 19 Distribution of available services from Alliance service providers (adapted from Table 1)

The *Alliance* delivered different **support services** to cases (Figure 5). Beyond the mentoring support that all cases received, the most frequently delivered types of support were networking (22 cases) and scientific/technical support (20 cases). This was followed by business support (17 cases) and promotion of the cases on different types of events (13 cases). The least frequently requested support category was legal support (7 cases). Evidently, in the *Alliance*, all mentors were also service providers, but the offered services varied by provider. Therefore, the service offer displayed a slightly different picture after correction (removal) of mentoring service (Figure 20). It reveals, that the majority of services were of scientific/technical nature (extraction know-how, access to equipment or infrastructure, propagation/cultivation of biomass, chemical analysis etc.), although services to many cases were also related to business development (i.e. development of business plan, market analysis), and promotion (matchmaking). Financial services also include those 11 case partners that received funding support from the project.

Networking and promotion service are difficult to measure (detailed analysis in chapter 2.6). Most of cases were profiled on the *Alliance* website and also, they were represented in match-making events in which partners, e.g. SUBMARINER, participated or cases accessed *Alliance network* events (e.g. participation in external events such as BioMarine convention, BlueBioValue accelerator etc.). So, promotional service may be underestimated.

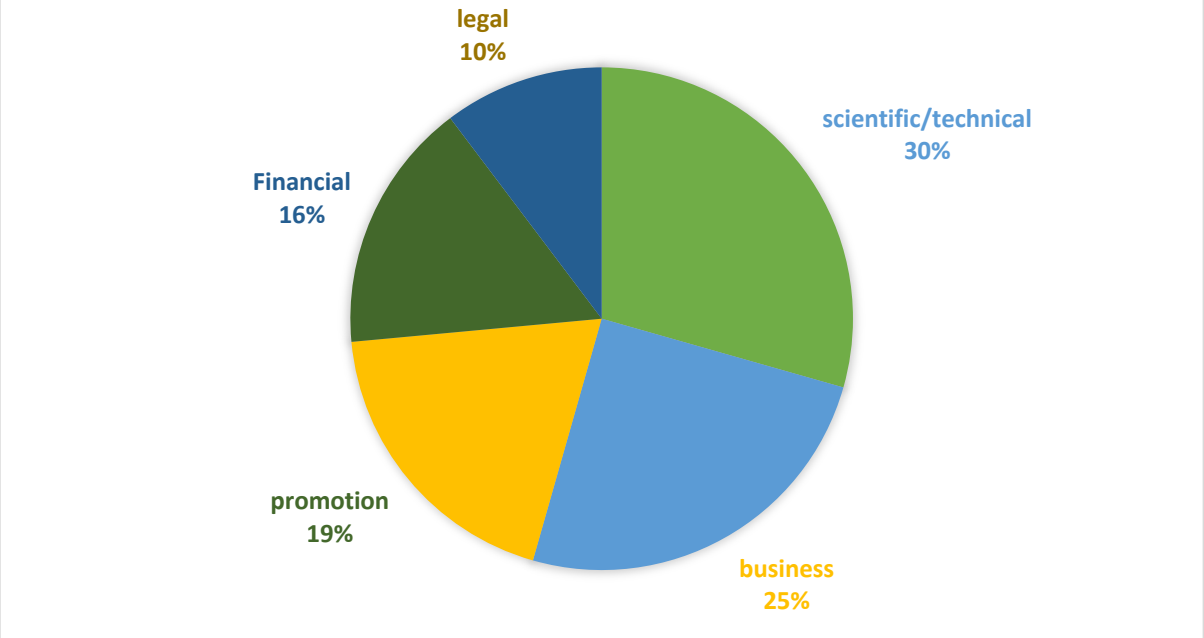


Figure 20 Distribution (percentage) of services delivered to cases, apart from mentoring (adapted by Figure 5)

In the Alliance, the delivered services were carefully matched to the **case requests for support** – hence generating a demand driven service offer which is considered as one prerequisite for success. One of the main criteria during the *Alliance* recruitment process, was the assessment of suitability with regard to available expertise within *Alliance* consortium. In practice, this included a careful a priori analysis of expertise present in *Alliance* and matchmaking with needs specified in the applications, and a negative result of this evaluation could also be a reason for rejection.

What makes the *Alliance* unique, among different networks and accelerators, is the needs-oriented service provision. The *Alliance* is a flexible accelerator that provides a basic case mentoring package allowing cases to analyse their needs and co-design with the mentor a case development strategy. At a second level, actors, data and actions are aligned to the strategy and support the development of the case. But in essence, there are many degrees of freedom in doing so, and there is no curriculum to be followed. Cases are free to participate to the degree they wish, and based on their requests, the consortium responds to match the case needs, through the mentors. This is important approach given that the cases are unique; they are very early in the development stage and their development pathways, and thereby needs can be very different.

Case needs were agreed with the mentors and precisely formulated at the initial phase of the mentoring programme in a joint effort of case owners and their respective mentors. These needs were then circulated by the mentors via the mentor´s forum to the entire *Alliance* consortium to find the right partners to support the case owners finding optimal pathways and during implementation.

The most frequent (24%) service requests was related to networking, i.e. the aim to find new partners (suppliers, clients, etc., Figure 21). This was followed by scientific/technical support such as lab analysis and extraction methods (combined 19%), business support for designing business plans (16%), marketing (combined 14%), and expertise in regulations e.g. for product standards or regulations for food law (11%) and finally IPR advice (6%). This list of requests evidently describes the needs of blue biotechnology actors, when approaching *Alliance* for support in product development.

Figure 21 Needs of cases approaching Alliance for support.

Analysis of service requests and correlation with the service offer is very important since it allows useful conclusions and lessons learned for improvement, innovation capacity of the region and the impact of the *Alliance*. By simply comparing (quantitatively) the requested (Figure 21) with the delivered services (Figure 20), networking (promotion, match-making, outreach) is a very important service to cases. This also means, that coordinated efforts will likely increase the impact or integrated approaches can be used to transfer knowledge to client cases, e.g. training material.

The comparison of requested and delivered services also leads to the conclusion, that there is a good match between supply and demand. This can be partially expected as cases were selected also with regard to the available expertise or in other words – suitable service providers. However, the expertise pool to cover multiple types of case needs is considered to be strong. Marketing was not the strongest point of the *Alliance*. Although product branding was offered to cases by an external specialist in nutraceuticals, some cases requested marketing data, which *Alliance* could not provide. Instead the *Alliance* provided to cases information on where to access the data.

In the occasions service requests could be fulfilled by Alliance, for example when a service was highly specific or beyond the expertise of the *Alliance* service providers, a case mentor addressed the need towards the mentor´s forum and on a second level, asked to activate the mentors´ networks as another multiplying factor. In some cases, *Alliance* partners subcontracted external service providers to deliver certain services. For example, Biofisk needed a heavy metal analysis of the beach cast. This could not be provided by the mentors. The primary mentor reached out for help, but they did not find the expertise within the consortium. Analysis was finally done by subcontracting an external company. As *Alliance* was intended to serve as a blue biotechnology network, expertise in legal issues including intellectual property rights, business development and product branding related requests could not be met by *Alliance* partners. In those occasions external experts were subcontracted, providing their services to the *Alliance*. These specialists are now associates of the *Alliance* and are contactable on demand.

The ***Alliance* mentors' forum** was an important structure developed within the *Alliance*, pivotal to its operational success in regard to mentoring and service provision (see Figure 22). The *Alliance* mentors' forum was realised by regular meetings organised virtually or physically. All mentors participated in a bottom up approach, coordinated by the Lead Partner (GEOMAR). The purpose of the forum was multi-fold, i.e. the forum allowed

mentors to participate and exchange by sharing case progress, discuss and find joint solutions for challenges encountered during case implementation, announce events and exchange news, and also ask for expertise among the consortium to match service requests articulated by case owners. For example, when a service could not be delivered by the assigned mentors (since often mentors were also service providers and hence were absolutely crucial for case implementation and success), then these mentors reached out to the forum to address a service request and search of other service providers to satisfy the request. Usually, the case needs were satisfied when reaching out to the forum, reflecting the high agility and flexibility of the mentoring programme to meet differential needs and, moreover, the diversity and versatility of expertise available within the *Alliance*.

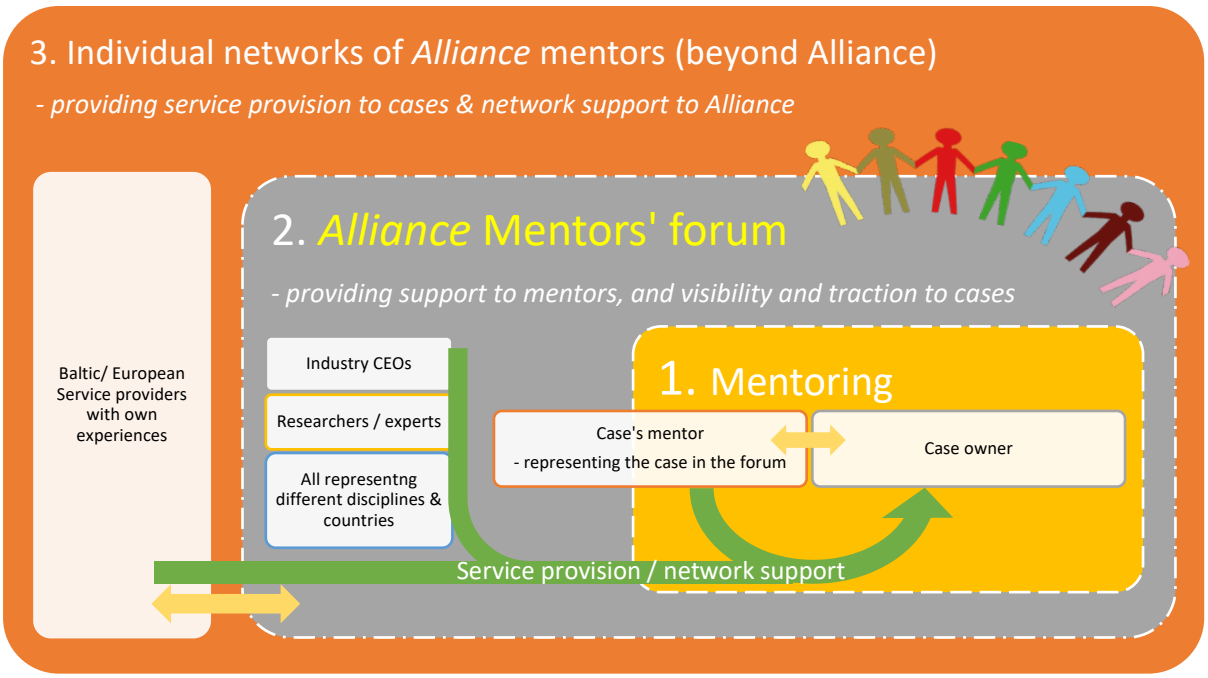


Figure 22 Scheme presenting the Mentors' Forum of the Alliance, and relationship with a case

As discussed earlier, when a requested service could not be met by the existing *Alliance* partners, the mentors supported by other *Alliance* partners reached out to their respective external networks for support. As an example, when case BIOME needed a new supplier of blue mussel shells, SUBMARINER Network reached out to partners (mussel farmers) from the INTERREG (BSR)-funded Baltic Blue Growth project, who could provide blue mussel shells. This is a good example for the **need for a supercluster** – such as SUBMARINER Network which is operating beyond borders (transnational) and, moreover, across different blue bioeconomy sectors, e.g. in aquaculture of algae, fish, shrimp or mussels. Moreover, these examples also show the success of the *Alliance* to unite actors from different value chain stages and thus to create the critical mass for supporting blue biotechnology product development on transnational scales in the BSR.

In the next section all the service offer elements were analysed.

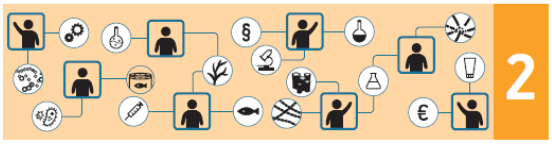
2.6.1 Networking, match-making, communication and lobbying

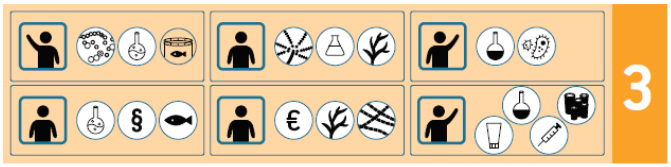
Networking and match-making is a standard package, offered in combination by *Alliance* and SUBMARINER Network hub to ALL partners, associates and cases through the innovation and communication platform. The objective was to promote collaboration and project development with the aim to advance transnational product development value chains. On top of that, the *Alliance* responded to case needs by matching them with services,

facilities and expertise to take their idea to the next level. The following scheme describes the match-making process.

All *Alliance* partners and cases have been given several opportunities for networking, match-making and promotion via an accessible address book of actors, workshops, match-making events, and ongoing search and training of new cases and mentors and also reach out and advertise their cooperation requests via our SUBMARINER e-newsletters and website.

All cases were offered to receive **online promotion** in the website and the offer was well-accepted. Hence, 25 case profiles are published online on the by SUBMARINER Network. The online profiles promoted the business idea of case, the team behind it, and the *Alliance* partners supporting the case by implementing the service offer. Furthermore, the cases had **access to SUBMARINER community** to reach out and make requests for partners, both directly and through a professional e-newsletter released by SUBMARINER regularly. The newsletter has been open access and subscribers are able to respond to calls for collaboration.





The role of the mentors included promotion of from different angles: 1) for finding the right partners (i.e. matchmaking facilities), 2) *Alliance* through the mentors' forum exchanges and 3) on events externally organised events such as BioMarine Business convention, BlueBioValue accelerator programme.

Networking was the most frequently service offered to cases. In addition to the promotion, match-making and networking services offered to all cases by the *Alliance*, communication training and lobbying was provided to few cases under request.

Promoting of members and cases in events

Promotion of *Alliance* members and cases was facilitated by participating in events on different scales. Cases participated in events, either physically, or by being represented by other members of the *Alliance* (e.g. mentors or service providers):

- Promotion of cases to other national and international accelerator programs such as the participation of Hoekmine and Vetik in the Portuguese BlueBioValue accelerator program in 2018
- STARTUp day, a regional event in Tartu, Estonia, co-organized by *Alliance* partner Tartu Biotechnology Park, contributed to the promotion of Estonian cases at regional level
- DoS case prepared an art exhibition at Tjärnö, Sweden, co-organized by their mentor Royal Institute of Sweden, KTH, and University of Gothenburg
- European Week of Cities and Regions 2018, where Furcella products and Biome prototypes were presented by SUBMARINER
- The European Maritime Day 2017 and 2019; in 2019 Vetik and Hoekmine case owners participated in a panel discussion on blue biotechnology entrepreneurship.
- Blue Invest 2018 in Brussels have actively promoted cases interests, by 1-to-1 matchmaking meetings and distribution of marketing material; Hoekmine attended the event.

- BioMarine Convention 2018 have actively promoted cases interests, by 1-to-1 matchmaking meetings and distribution of marketing material; CRM, Furcella and Movable Biogas Factory attended the event.
- International Baltic Blue Biotechnology *Alliance* conference 2018 in Greifswald Germany, on which R&D partners and selected cases gave a pitch talk or presented their case on a poster (7 cases: CRM, Furcella, UKSH, Biofisk, Uni Gdansk Smart Bloom, Phytolinc, Hoekmine).

In conclusion, networking and promotion was the most important service request by cases. The networking platform enabled cases to efficiently present themselves, interact with peers and search for partners, while physical match-making and pitching events created opportunities and confirmed deals. The *Alliance* promoted cases in a wide range of events, from international events to regional and local events. A good mix is necessary to attract the right partners. While international events are beneficial for start-ups to understand the trends and meet large industry and centralised investors, regional events can effective for clustering activities that can be more supportive for start-ups. The SUBMARINER Network and the *Alliance* are seeking to continue good collaboration with other blue bioeconomy networks and innovation support organisations e.g. clusters and accelerators, as synergies have been very beneficial to *Alliance* cases. To this end, SUBMARINER is inviting other networks join our effort in promoting and networking activities to increase and benefit from the region's innovation capacity.

2.6.2 Placement and training opportunities

The *Alliance* as an innovation platform connected talent with open training opportunities in blue biotechnology and blue bioeconomy. This was realised by installing a section on the project website where job placements, exchange of staff, internships, apprenticeships, in-job-training, courses and other important opportunities were announced. All relevant opportunities offered by *Alliance* and third parties are published and fully updated online.

2.6.3 Lobbying for blue biotechnology

The *Alliance* supported the development of national and macro-regional research agendas for blue biotechnology of the Baltics, taking into account evidence provided by the Baltic Blue Biotechnology Alliance project (Interreg BSR project). Using the voice of SUBMARINER, the *Alliance* is aiming to unlock the potential of blue biotech, by informing the Marine Bioeconomy Forum, influencing new European funding programmes (ERA-Net, Interreg, BANOS, Horizon Europe) as wells as innovation policies. Finally, we aim to help R&D to strategically position itself in the BSR, and thus influence the research agenda of individual institutions.

In conclusion the *Alliance* has applied various types of promotional support to advance its cases to move forward and to secure funding for the next step in product development.

2.6.4 Scientific/Technical support

Scientific and technical support is an umbrella service term that pooled individual and institutional capacities and access to infrastructure offered by *Alliance* partners to cases. This type of service was actually a series of **tailor-made knowledge intensive services driven by case demand**, where *Alliance* partners shared their scientific expertise and know-how, provided access to infrastructure and equipment, analytical techniques, processes and biological resources, exchange of staff etc.

Scientific and technical support was offered by 9 project partners and 3 cases (cross-case service offer). 20 cases have received this type of support. Scientific and technical support had the most pronounced impact on collaboration among partners and cases and it resulted in new discoveries, product applications, and launched

products (see also paragraph 2.5 on progress of cases). However, even if substantial progress was made, the time and effort spent for this type of service both by service providers and cases is not reflected by the simplified product development chain. This is especially true for early-stage cases which need intensive bioprospecting or R&D effort e.g. for realising a proof-of-principle study.

Most common scientific research and analytical services offered to cases included:

- laboratory chemical analysis,
- bioactivity/toxicological tests of chemical compounds,
- chemical extraction technologies,
- propagation/cultivation of biomass,
- development of new apparatus/equipment,
- scaling technology,
- product formulations etc.

To streamline this type of service, in the course of the project **a database for cataloguing multi-purpose infrastructure and equipment** owned by *Alliance* partners was developed. This database which is publicly accessible *Alliance*[52] is a very useful asset for researchers and companies alike. The database contains laboratory equipment, analytical techniques, pilot scale facilities even research vessels that are offered by Alliance and accessible to *Alliance* partners and cases. For lab equipment alone, the database contains 86 entries. All these examples of large-scale equipment can be very useful to *Alliance* cases.

Furthermore, an effort to map all existing open access pilot and demo-infrastructures across Europe that are relevant to bioeconomy has started at PILOTS4U BBI project (2016-2019). The database categories that PILOTS4U use are both upstream and downstream technologies, which could be integrated with the database of the *Alliance*. So far, there is no collaboration between the two projects. But KTH that is a project partner in both projects will the obvious route to link the two sets of database.

In conclusion, scientific/technical support has been at the heart of the services provided by the *Alliance* and it is unique in the sense of service is 100% tailored to the needs of a case, suppliers of expertise and equipment can be transnational, accessing process is simple and it is often based on mutual trust. Connection of the *Alliance* with other relevant EU-wide networks that provide scientific expertise and access to multi-use infrastructure is still poor, such as the EMBRC-ERIC and PILOTS4U project.

2.6.5 Biological resources

One of the *Alliance* tasks was to provide an overview and catalogue of biological resources available within the *Alliance* in an integrative way. Access to and utilisation of biological resources on a transnational scale is nowadays regulated by the Nagoya protocol, which involves national focal points and is regulated on national scales and beyond influence of Alliance. However, several *Alliance* partners hosted biological resources and offered access.

The *Alliance* has developed an online catalogue on biological resources in a form of an “one-stop-info-shop” that lists the biological resources of the *Alliance* partner research institutions. The **Blue Bioresources catalogue** also

[52] http://alliance-database.eu/#/

lists the respective contacts at the partner institutions. It has been developed with support from all *Alliance* partners and coordinated by the lead partner GEOMAR. The catalogue is published on the *Alliance* website[53].

The overview created shows that, in total, a considerable diversity of biological resources is available at *Alliance* partner organisations, i.e. collections of viruses, bacteria incl. cyanobacteria, fungi, microalgae, macroalgae, crustacea, molluscs, and fish. The organisations hosting the biological resources available in *Alliance* were exclusively research institutions across the BSR located in Germany, Poland, Sweden, Finland, Denmark and Lithuania. Concerning the types of bioresources, most partners within the *Alliance* consortium have bacteria in their collections, followed by microalgae and macroalgae. This diversity of the organisms cultivated and hosted by *Alliance* partners impressively represents the necessity to have a high diversity of biological resources to account for diverse modes of utilisation in biotechnological applications.

Culture collections world-wide

Outside *Alliance*, on a worldwide basis, most culture collections host microorganisms. According to the culture collections information worldwide[54]; in 2014, 647 culture collections from a total of 70 countries have registered in the World Data Centre for Microorganisms (WDCM) having a total of 2,3 million strains in them. Asia is leading in the total number of microbial culture collections (223, 60 alone in Thailand), closely followed by Europe with 220 microbial culture collections (France leading here with 38 culture collections). The highest proportion (43%) are contributed by bacteria, followed by fungi (27%) and much lower proportions of viruses and cell lines[55]. The vast majority of microbial culture collections worldwide (78%) are hosted by governmental bodies or universities. Apparently, there are different national strategies concerning the organisation of these culture collections, which is reflected by the total number per country, i.e. France (38) is apparently following a more decentralised system compared to Germany with 13 or Sweden with 3 registered culture collections. Within Europe, Germany has the largest registered microorganism collection. The whole Baltic Sea region is reflected by 35 microbial culture collections with over 250.000 strains.

Since 1981, European Culture Collections' Organisation (ECCO)[56] exists, whose aim is promoting of collaborations and (scientific) exchange of culture collection activity. Recently, due to the rising awareness of the high biotechnological importance of these resources, international consortia have formed providing pan-European research infrastructure (**MIRRI** - Microbial Resource Research Infrastructure)[57]. MIRRI, now headquartered in Spain and Portugal and comprising 13 biobanks all over Europe, was established to support research and development in the field of biotechnology.

Microalgae cultures are apparently not so common in microorganism cultures. Often cyanobacteria (here counted as bacteria due to their prokaryotic nature) are included as algae in culture collections. Worldwide, phycology.Net[58] lists 21 culture collections of marine microalgae, most of which are hosted in the US (4) followed by France and Germany (3 each).

Outside the *Alliance*, only dispersed information of curated collections of specifically marine resources can be found. The Roscoff culture collection[59] in France harbors marine microalgae, macroalgae, protists, bacteria and viruses and the Marine Biological Association[60] in the UK is specialised on marine phytoplankton. The Australian

[53] https://www.submariner-network.eu/projects/balticbluebioalliance/one-stop-info-shop-for-bioresources
[54] Data Source: http://www.wfcc.info/ccinfo/index.php/home/statistics/#m1
[55] Data Source: http://www.wfcc.info/ccinfo/index.php/home/statistics/#m4

[56] https://www.eccosite.org/
[57] https://www.mirri.org/home.html
[58] http://www.phycology.net/Content/PNetContent.cfm?MID=135
[59] http://roscoff-culture-collection.org/
[60] https://www.mba.ac.uk/facilities/culture-collection

Commonwealth Scientific and Industrial Research Organisation (CSIRO) also hosts a collection of > 1000 microalgae cultures[61].

However, interestingly enough, access to biological resources was not among the most highly demanded services in the Alliance. Only 5 cases requested and received biological resources or access to them to *Alliance* partner institutions. Most cases (16) approaching the *Alliance* with a blue biotechnology idea already had biological resources for their product development readily available and relied on a mixed approach involving own collections, cultivation and/or sustainable harvest. Additionally, networking and case-to-case cross-collaboration within the *Alliance* also led to biological resource exchange, in case the raw material was not on offer by the regular partners for this service offer, thus enabling a diversification of raw material supply for the respective case owners and new collaborations arising from this exchange.

Finally, there were few cases, like e.g. SFTec that could not receive biological resources in the amounts they needed. By having a comprehensive Blue Bioresources catalogue such requests could be accommodated by reaching out to associated owners of biomaterial.

In conclusion, the biomaterial available within the *Alliance* represents a unique and unequalled resource due to its variability of organisms and the grade of specialisation concerning brackish/Baltic Sea organisms. However, the research institutes having these valuable resources in hand require strong collaborative power, most probably realised by an increase in personnel for technology transfer offices and probably personnel investments in the staff curating the respective collections. Moreover, substantial training is required for scientists to further raise awareness for the legal frameworks.

2.6.6 Business development

In order to successfully convert (biotechnological) inventions into marketable innovations, business development is needed, it is involved in all value chain steps starting from TRL3 (proof of principle) and playing an increasingly important role in the more advanced TRLs. To support cases and to raise awareness for this important aspect also for cases in early stages of the value chain, business development support was offered by the Alliance. The service was offered by 11 partners and 2 cases (cross-case service offer), each having expertise in different business elements, roles, market sectors, and regions. Among the service suppliers offering support in business development were science and technology parks, clusters, technological institutes, consultancies and manufacturing SMEs. Finally, services within business development were delivered to 17 cases and this type was the 4th most highly requested service (see Figure 5). The majority of requests included development of business plans, market analysis data, development of marketing strategies, and support in fund raising.

Concerning support in business development, *Alliance* recruited Gaia Consulting Oy (Finland) to develop a **quick scan business assessment tool** that assesses the business plan status of a case and recommends the immediate strategic steps to increase the business viability. The tool was accessible and used in frame of the *Alliance* mentoring programme. The quick scan tool is used jointly by mentors and case owners at the beginning of the mentoring programme and it has been very useful to both informing case owners on current status and immediate needs but also to mentors in helping them integrate knowledge and accelerate mentoring process. The tool included three joint meetings between mentors and case owners entirely dedicated to business awareness including: value and strategy, markets, management and organisation, product and process development, resources, production and logistics, funding and ownership, quality and regulatory requirements, and sustainability. A manual is available for conducting the business assessment procedure and the tool was

[61] https://www.csiro.au/en/Research/Collections/ANACC

validated by assessment of several pilot cases at different value chain stages, sectors and countries of origin. After its establishment, this business assessment tool has been an integral part of the initial phase of the *Alliance* mentoring programme.

The structure of the *Alliance* is quite unique in empowering mentors. We have created an *Alliance* of R&D tech experts and business developers from consultancies, technology parks and SMEs to act as mentors for cases. As a result, mentors in the *Alliance* had very diverse background and sometimes differential understanding in steps needed for product development value chain. Training of mentors was necessary especially with regard to business aspects. In the future, a **mentors training package** will be developed under the Alliance+ project (*Alliance* extension project funded by Interreg BSR). Tools like the quick scan business assessment tool and also through the meetings of the mentors' forum, have provided guidance and support to "new coming" mentors via peer-to-peer mentor's training, and it's been proven to have increased mentors' confidence and contributed to the success of the *Alliance* mentoring programme.

Financial support

All recruited cases received the *Alliance* service offer and mentoring programme "free of charge" in the context of the *Alliance* project, as the mentoring programme and service provision was (co-)financed by Interreg BSR (ERDF co-funding through the Interreg programme).

If external financial support of Interreg was absent, it is questionable whether *Alliance* service providers would be able or are willing to provide the service and under which conditions. It is known that *Alliance* service providers are more likely to (be able and willing to) provide services, based on "compensation". Examples of non-monetary compensation are through creating an added value by e.g. project development, joint fund-raising initiatives, access to new scientific ideas, forming spin-off companies, publications or patents.

To keep the service provision without funding "alive" in the Alliance, there must be two conditions met: Service providers' every day role must be in close affinity to the *Alliance's* role, and that service providers have a personal interest to the case. **By incorporating these two elements in the recruitment strategy of mentors and other service providers, the *Alliance* can increase the probability that *Alliance* accelerator is sustained on a long-term basis.**

In total, 11 cases received financial support by the *Alliance* after being granted with partner status. Financial support covered their salary costs (for the project), buying equipment, and travelling costs. This financial support was substantial for the *Alliance* cases, which also was reflected in the amount of applications received to the different calls for ideas. The first call for ideas, that included covering financial support for accepted cases (by granting partner status) attracted in total 20 candidates. In the 2nd call 6 candidates applied, in the 3rd call 3 candidates and in the 4th call 5 candidates. We speculate that the number of candidates declined across the cohorts, also because the case financing was not included in the offer. In the future, Alliance will also consider financing support schemes for cases that cover not only service provision but also direct financing of the case, e.g. by including salaries and capital costs.

Financial support was not a distinctive part of the *Alliance* service offer, but rather part of business development e.g. as support in fund raising. Fund-raising support was offered to 4 cases in the form of identifying and creating contact with private investors, finding public funding opportunities, co-developing new projects etc. However, it has been shown that many *Alliance* cases, e.g. Hoekmine, Vetik, SFTec, KosterAlg, have been very successful attracting financing outside *Alliance*. So, it is a matter of incorporating the right *Alliance* partners in the team. In the future, this service will be expanded by attracting public grant experts, private investor networks, business consultants and accelerator programmes that can support needs at various stages of product development chains.

In conclusion, business development is important for cases even at early stage in the product development chain. In the future, more business service providers and external consultants will be recruited by the *Alliance* to cope with the demand of this type of service. Furthermore, creating and sustaining good connections with existing accelerators, like the successful collaboration with BlueBioValue, is strategic for *Alliance*. In lieu of Interreg funding, *Alliance* is approaching future investors that will fund the *Alliance* service provision and cases. It in an activity in the Alliance+ project. Project development, equity shares or other non-monetary compensation options can be very attractive to some service providers.

2.6.7 Legal advice

Legal issues were one of the most relevant barriers cases faced and, as we saw in Figure 5), 7 cases received legal support. The needs reflected a broad spectrum of legal issues, from application of the Nagoya Protocol, Intellectual Property Rights (IPR) issues, Non-Disclosure Agreements, and Material Transfer Agreements, to information on EU product safety standards, food regulations, or certifications and product labelling.

Because many case owners had similar questions revolving around IPR issues and contractual agreements, an external patent lawyer developed a dedicated series of guideline documents on IPR issues. These guidelines responded to the common needs of cases, following workshops with cases and one-to-one case consultations, in which the respective mentors also were involved. In many occasions, mentors supported the cases in the implementation phase, e.g. running the online patent search. The guidelines included checklists for establishment of consortia, Standard Operating Practices (SOP), and also several contract templates for agreements between academia and industry, e.g. License agreement-patent and trademarks, Non-disclosure agreements, material transfer agreements, as well as R&D collaboration service agreement. All the templates and guidelines are available to and accessible by *Alliance* cases and partners.

Furthermore, 3 partners (Tartu Biotechnology Park, BioCon Valley, and SAMS) have offered expertise on legal issues, with a diverse expertise. The mentors assisted the cases to raise concrete questions, e.g. how-to setup a start-up in Sweden or an organisation in Germany, how Poland does interpret certain EU regulations, EU safety aspects with regards to using recycled biomass for food and feed sectors, rules and process for organic certification of seaweed (EU, national). With the help of the respective mentors, the cases received specific answers to their specific questions, either directly from their mentor or through the *Alliance* mentors' forum.

The recruitment of a legal expert was very beneficial for the cases and mentors. Again, customisation of service was offered case-by-case, but when case requests were overlapping, the lawyer delivered two workshops and a training material package. A expert consultant was important in this type of service, as intellectual property is a strong asset, and knowledge management is of strategic importance for blue biotechnology SMEs and start-ups. But this was also beneficial for the service providers and mentors that had also access to such resources.

2.7 Lessons learned from the mentoring programme

During the setup of the mentoring program and during implementation of the mentoring programme and the service provision to cases, both the *Alliance* consortium and the cases were able to acquire significant experience and expertise in transnational collaboration in multi-actor environments. Below we summarise the main lessons learned from the process.

While mentoring and providing unique support services to 26 SMEs and start-ups within wide spectrum of blue bioeconomy sectors, we have developed a **fully-fledged innovation platform, a mentoring programme and service offer** that can accommodate many needs at different stages in the product development chain. However, given the current consortium, capacities and resources, we mainly attracted SMEs and start-ups with a business idea at bioprospecting and R&D stages, without excluding the mentor's capabilities and case successes in more advanced stages (upscaling and commercialisation). *Alliance* has been very successful in raising confidence of cases owners, promoting and giving access to a niche networking platform for match-making, provide concrete answers to concrete questions, support SMEs to make knowledge-based decisions. In the future, if more business partners entered the *Alliance*, more development skills and resources would benefit clients. Examples of partners are: accelerator programmes in blue biotech/bioeconomy, food, cosmetics, or aquaculture, business consultancies, marketing and PR companies, business developers (CEOs of companies).

One attribute of the *Alliance* was that **veteran cases** of the mentoring programme tend to stay in the *Alliance* as partners. These are very important partners, not only because they can act as "blue detectives" and ambassadors of the *Alliance* but also, they have experience and enlarge the mentoring offer and services. The veteran cases act as role models to new clients and they can provide unique insights, capacities and resources at peer-to-peer collaborations. So far, we have had 12 very positive experiences with four cases that acted as mentors and service providers. By growing the *Alliance* and fostering company communities, this element will build up further in *Alliance*.

Transnational and cross-institutional cooperation between R&D and SMEs was necessary already at very early stages, e.g. R&D, and it has proven to be also beneficial for the research institute with regard to mediation of contacts, and focus on market-relatedness. Clear communication of aims from the case owner to the mentors proved absolutely necessary in order to enable the partners to provide the right type of support needed by the case. Equally, it was more difficult for mentors to contribute to case progress when the progress was not driven by case; as communication/mutual trust was absolutely indispensable for progress even if legal documents (NDA etc.) are existing.

One critical factor for case progress was often **geographical proximity** between case owner and mentors. The setup using a combination of two mentors, one national contact point and one having expertise in the target field or market, proved to be highly successful.

Mediation of case-to-case relationships was often crucial for the case success on more than one side; all mentors should have a broad overview on all mentored cases (realised by monthly mentors´ telephone conferences) and also cross-linking of mentors is important.

Readiness of case-owners to cooperate and cross-link with other cases was also important to broaden their future customer bases. The mentors were very often not only acting as mediators, but were also crucial also for providing support during case implementation, mostly in terms of scientific/technical, networking and business support. Moreover, **joint interests of scientists/mentors** and case owners are a tremendous driving force for case progress (model example: Baltic Probiotics).

Mentors are coming from diverse background, from technical expertise, business development, technology transfer and innovation management. New mentors will need training as to fulfil own and future client expectations and feasibility assessments. The Alliance+ project (Interreg BSR) *will develop* a **mentors training package** that will make it more attractive and much easier for new mentors to enter the *Alliance* and offer their niche expertise in the pool of expertise in the **mentors' forum**.

M**entor's forum** was of strategic importance for supporting cases and mentors alike. The pool of expertise acted as a safety net for mentors and cases to operate, providing exchange of news, problem-solving, exchange of lessons-learned and also reach out to own networks to find a new contact for a case when needed. Mentor's forum was a platform for a collective memory and a pool of expertise. By this, mentors do not need to be perfect, but should be open to offer their expertise when requested.

In line with the above, the role of a mentor is efficiently support and orient case progress, following case requests. Towards this end ideal **soft skills** for becoming an *Alliance* mentor are outgoing, proactive, service-oriented. They ideally should have an expertise trespassing science and business development.

The recruitment of cases was organised at national level, recruitment strategies varied by country and returned varied success in terms of number of new applicants. The most successful tactics in recruitment were the use more than one channels for promoting the mentoring programme and especially use of personal contacts for scouting for new cases. The role of **blue detectives** was vital in the initial recruitment stage.

The R&D stage often requires costly investments and, in some cases, it was prolonged due to a change of direction or broadening of the scope of a case. However, a **sound R&D** was considered the basis for almost all blue biotechnology products. Therefore, many *Alliance* cases were constantly addressing R&D aspects, also if they had advanced to other stages of the value chain. Knowledge-based product development is a selling point which is gaining importance also in sectors like cosmetics, nutritional supplements, aquaculture. The R&D stage should also involve other aspects, such as an assessment of feasibility and sustainability, which is crucially important for sound blue biotechnology product development.

It has proven to be important, that **legal prerequisites are clarified before starting mentoring** to avoid long phases until implementation. Unclear legal situation significantly affected case progress.

National implementation of EU regulations has become highly relevant; on the one hand with regard to the transnational exchange and utilisation of biological resources (Nagoya protocol), on the other hand with regard to novel uses of organic raw materials, commonly regarded as waste for the industries related to human consumption such as food or feed.

The *Alliance* consortium has also learned during the project, that **auxiliary innovative technologies** such as drying of marine biomass were highly important. A new technique/equipment providing a technical solution for an important process which is a prerequisite for development of many blue biotechnology products was crucial for moving other cases forward.

To conclude, the improvement and fostering of future transnational cooperation between different research actors and funding institutions in the BSR can without doubt be strengthened by the experiences from within the scope of the *Alliance* project, where a platform for exchange of knowledge at a transnational level has been established and where cases have been able to benefit from experts, who have been willing to share their knowledge, competencies and infrastructures for the mutual benefit of the project and its partners. In order to continue and strengthen this collaboration, the *Alliance* platform requires, however, an anchor and realistic business model to ensure a permanent future presence on the Baltic blue biotechnology scene. The legacy of the Baltic Blue Biotechnology Alliance is passed on to SUBMARINER Network for Blue Growth EEIG that is coordinating beyond the project funding. More information on the *Alliance* legacy is presented in Chapter 6.

3. Capacities within Blue biotechnology in the Baltics

3.1 R&D Capacities

In November 2018 the *Alliance* developed a survey on research and development activities and expert capacities. Recipients of the survey were known research and development institutes with expertise in blue biotechnology in the BSR. In the table below, the responses of the 15 external R&D institutions are presented, in addition to the 9 R&D institutions of the *Alliance*. Data from 24 Baltic institutions (and departments) draw the blue biotechnology map of capacities and provided useful evidence on some of the ongoing R&D activities, interests and expertise in the region; even though – as with many other surveys – the analysis is not fully comprehensive in view of some missing responses.

There are many other institutions and relevant departments of included institutions that are not included in this analysis. This analysis aims to identify potential strengths and gaps in R&D.

Table 4 List of the 24 R&D institutes that answered the questionnaire

Country of institution	Short name	Institution name in English	Alliance partner
Germany	GEOMAR	GEOMAR Helmholtz Centre for Ocean Research Kiel, Centre for Marine Biotechnology	■
	FNR	Fraunhofer-Institution for Marine Biotechnology and Cell Technology, Department of Marine Biotechnology	
	FLEN	University of Applied Sciences Flensburg, Faculty of Energy and Biotechnology, AG Bio and food technology	
Denmark	RUC	Roskilde University, Department of Science and Environment	
	AU	Aarhus University, Department of Bioscience	
	KU	Copenhagen University, Department of Plant sciences	
	DTU	Danish Technical University, National Food Institute	
	DTI	Danish Technical Institute, Div. Agrotech, Centre of Bioresource and Biorefinery,	
		Danish Technical Institute, Div. Agrotech, Centre for Plant Technology	■
Sweden	KTH	KTH, Royal Institute of Technology, Sustainable Development Environmental Science and Engineering (SEED)	■
	UGOT	University of Gothenburg, Department of Marine Sciences	■
	RISE	RISE Research Institutes of Sweden, Department of Chemistry and Materials	
Poland	UGdansk	University of Gdańsk, Faculty of Oceanography & Geography, Intercollegiate Faculty of Biotechnology UG & MUG	■
	MIG	Maritime Institute of Gdansk, Department of Environmental Protection	
Finland	SYKE	Finnish Environment Institute (SYKE)	■
	LUKE	Natural Resources Institute Finland, Department of Value-added food and aquatic biomass products	
		Natural Resources Institute Finland, Department of Blue production	

	VTT	Technical Research Centre of Finland, Department of Solutions for natural resources and environment	
Estonia	EMU	Estonian University of Life Sciences, Faculty of Aquaculture	
	TALINN	Tallinn University, School of Natural Sciences and Health	
	UTARTU	University of Tartu, Estonian Marine Institute	
Lithuania	CORPI	Public institution Coastal Research and Planning Institute (CORPI)	■
Latvia	CTL	Cleantech Latvia	■
Great Britain	SAMS	Scottish Association for Marine Science (SAMS)	■

In regard to what **type of research** is targeted, nearly all institutions responded that were engaged in applied research, whereas only 17 out of them work more in basic research.

In the question **what type of biological resource represents the source for R&D**, algae were the most popular biomass type (in total above 40%), followed by bacteria, fish, mussels/cyprids, marine fungi and final crustacean.

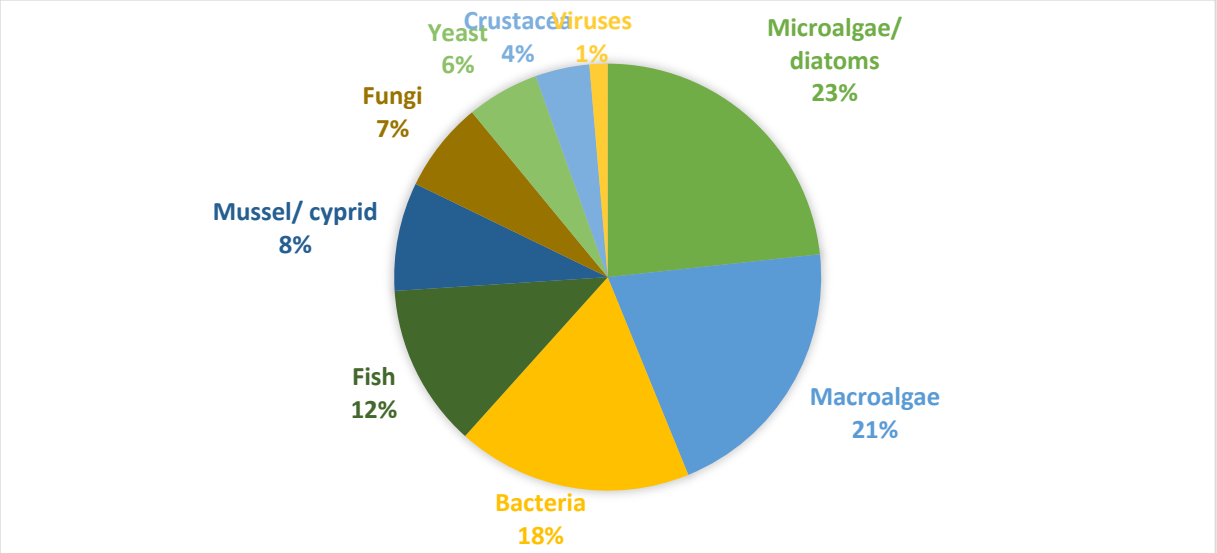


Figure 24 Type of Marine Biomaterials that is used for R&D (Right)

The **expertise of the R&D** is presented in Figure 25. In a nutshell:

- 22 institutions had the capacity to analyse chemistry, although they had variable expertise e.g. in metabolomics, biomass chemistry, water chemistry, contaminants analysis
- 18 had competencies and facilities to scale up and down technologies e.g. production, conversion and downstream processes,
- 15 institutions were experts in chemical extraction, while 11 out of 24 had the know-how and infrastructure for structural analysis and testing of bioactive compounds (e.g. pharmaceuticals, nutraceuticals, herbicides)
- 13 R&D departments had expertise in fermentation (e.g. of microalgae, marine fungi, cyanobacteria) for production of microbial biomass or for use as microbial factories for production of chemical compounds with added value e.g. commodity or fine chemicals, materials (biopolymers, building blocks), nutraceuticals,

- 13 had expertise in mathematical modelling, e.g. in computational biology and bioinformatics to determine key structures for new bioactive compounds and fine chemicals, but also calculate implications of human activities e.g. life-cycle assessment of technological applications
- 11 could cultivate microalgae in photobioreactors and 4 macroalgae on longlines and/or in tanks
- 11 departments had expertise in marine ecology, industrial ecology, ecosystems and natural habitats.
- 8 out of 24 had expertise in metabolic engineering and/or synthetic biology that unlock the potential of microorganisms by altering the genome for, e.g. increase resistance against pathogens and stress factors, improve production of target compounds incl. secondary metabolites with bioactive properties
- 6 institutions had expertise in breeding and growing fish e.g. in tanks, and also testing for animal diseases etc. and 4 had expertise in mussel farming.

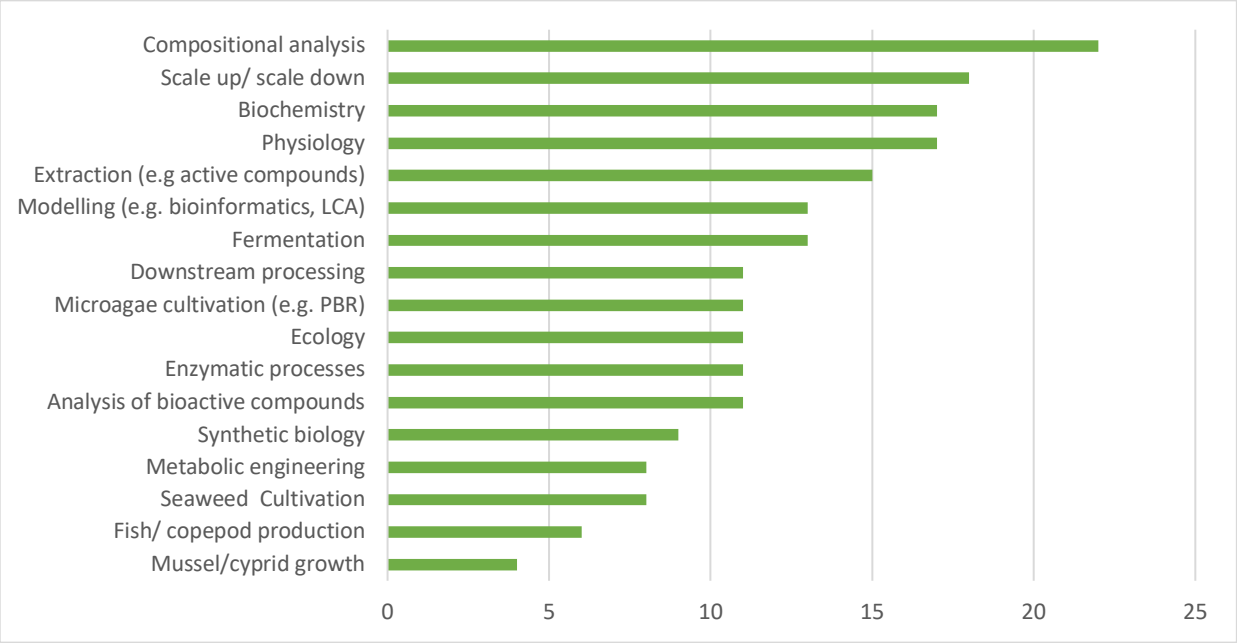


Figure 25 Expertise of R&D institutions in blue biotechnology

As for the **type of markets** the research is primarily affiliated with, the majority (in total 35%) were food and feed products (food commodities, protein, nutraceuticals, and feed applications). The second market is blue cosmetics (15%), followed by biomaterials (11%) bioremediation services (11%), and pharmaceuticals (10%). Nine institutions are developing equipment and hardware for upstream or downstream processes, e.g. bioreactors, driers, while a few are working directly with energy production or waste valorisation.

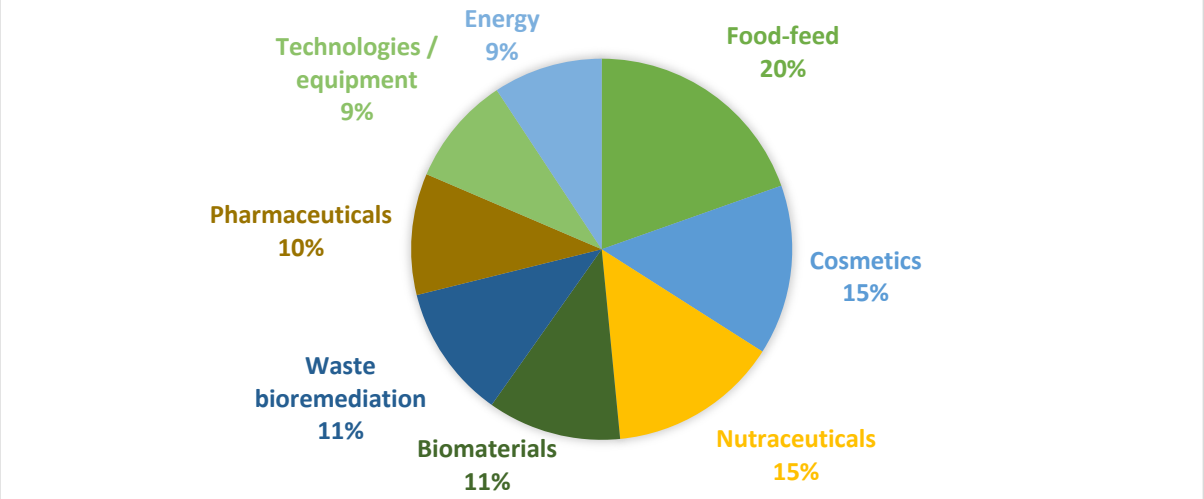


Figure 26 Blue Bioeconomy market products R&D institutions have expertise and interest on

From the analysis below an even distribution of skills and resources in chemistry, biology, ecology, maths and modelling, as well as engineering can be observed. Mussel farming, seaweed production and fish aquaculture (e.g. land-based RAS technologies) were the weakest field of expertise among 24 BSR institutions, although all three technologies are critical for sustainable local food and feed production and also for reducing nutrient inflow or nutrient load in the Baltic sea (bioremediation). This is because we selected research institutes for the survey with primary expertise within blue biotechnology and not aquaculture. On the other hand, many institutions had expertise in fermentation, microbial physiology, synthetic biology, and product development from microalgae, bacteria and fungi that are so important for production of a variety of products, such as food nutraceutical, various industrial products, biomaterial and pharmaceuticals.

Interestingly, although all institutions were engaged in applied research, many of the institutions had their primary focus in basic (marine) research. Basic research provides the basis for developing applications for future enabling technologies. From current analysis we see an even distribution of expertise within the various marine biomaterial sources.

Foresighted blue biotechnology research needs and bioresources in the BSR

A survey was conducted during the *Alliance* conference "**Blue Biotechnology in the Baltic Sea Region**" (22.-24. August 2018 in Greifswald, Germany) using the sli.do tool.[62] More than 100 conference delegates responded to this survey. Three strategic questions were asked to the delegates in order to be able to anticipate future important directions and set priorities in the field of blue biotechnology in the BSR:

What are the most important future research needs?

1) new food sources, food security and nutrition (71%),
2) more sustainable consumption and production (46%),
3) sustainable use of oceans, seas and marine resources (34%) and
4) sustainable and affordable energy sources (22%).
5) biotechnology

Can you identify the potentially highly profitable products?

[62] https://www.sli.do/

1) cosmetics and healthcare (64%),
2) food and nutritional supplements (61%),
3) antibiotics and pharmaceuticals (46%) and
4) special/valuable biocompounds (e.g. enzymes, bioplastics, fine chemicals) (39%).

What are gaps and bottlenecks for solving most important blue biotechnology challenges?

1) access to scientific techniques or services (46%),
2) access to funding (45%),
3) international, national or regional regulation issues (39%) and
4) business development support (25%).

The obtained results show there is an urgent need for blue biotechnology to open roads to new food sources, making use of waste streams for food and feed, and use of previously underutilised material (e.g. algae) for developing novel foods incl. marine superfoods. In terms of marine biotechnology-derived products generating the highest potential revenues, cosmetics/healthcare and nutrition incl. nutritional supplements were identified as the most promising sectors. However, this result should not be mistaken as unawareness about the importance of novel blue pharmaceuticals. It can most probably be explained by the easier market accessibility of the cosmetic market compared to the pharmaceutical sector, in which long trial periods are required and regulatory hurdles are much higher. Answers to the last question still reflects the existence of the "valley-of death" in product development, as the answers with almost equal percentages identified obstacles in all relevant fields for marine biotechnology.

3.2 Other capacities

3.2.1 Innovation ecosystem

The recipe of success to bring an innovative business idea to the market depends on various factors, but the innovation capacity of the system plays a key role.

Figure 27 presents key structures that comprise the entire innovation ecosystem and surround and influence any technological innovation throughout its advancement from developing a prototype, until the product saturated a market regardless of the market sector or geography. These structures are institutions (policy, regulation, laws, and norms), actors and networks. Advancement of a technological innovation is dependent on the existence and the functionality of these structures. Under good terms these structures can effectively create a fertile environment for business growth. In reality, though, there are usually bumps on the road, so important structures can be missing or present but are not functional. In this case, professional clusters, associations and networks solve part of the problem and boost business creation, by co-locating resources in a small distance, i.e. knowledge, human capital, finance and infrastructure, which can effectively advance technological innovation.

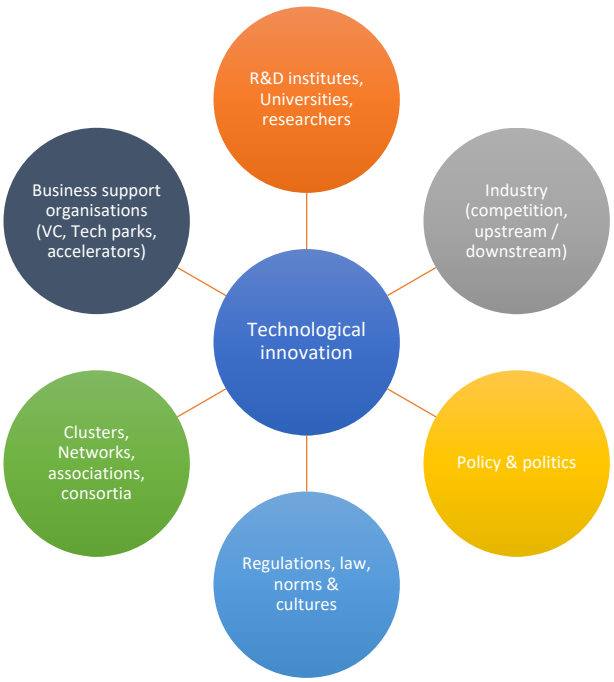


Figure 27 Structures influencing the advancement of a technological innovation throughout its lifespan from building a prototype to attaining a market saturation[63]

The status of blue biotechnology innovation capacity in BSR is a critical factor for success of the *Alliance*. Apart from the analysis of capacities presented above at R&D institution-level, a few other sources can provide an indication of the educational, research, development and innovation capacities.

The project Smart Blue Regions (Interreg BSR 2016-2019) mapped actors in the six BSR regions active in Life Science & Blue Medicine, such as 1) higher education institutions, 2) non-University research institutions and 3) business support organisations. The six regions that participated in the project were: South-West Finland, Riga Planning Region (LV), Skåne (SE), Schleswig-Holstein (DE), Ida-Viru (EE) and Pomorskie (PL). The data in Figure 28 show that there are institutions of all three types in almost all six regions, and also, we can see that institutions that be located in close vicinity to other institutions, thus forming regional clusters. Some of the universities and research institutions shown on the actors' maps in Figure 28 have been surveyed for their expertise and resources in this chapter. Some of the R&D Institutes are also *Alliance* partners. However, not all regions were mapped in the project, e.g. entire Denmark and Lithuania countries data are missing from the search, and also Småland region in Sweden.

[63] Adapted from: Bergek A. et al. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy 37 (2008) 407–429

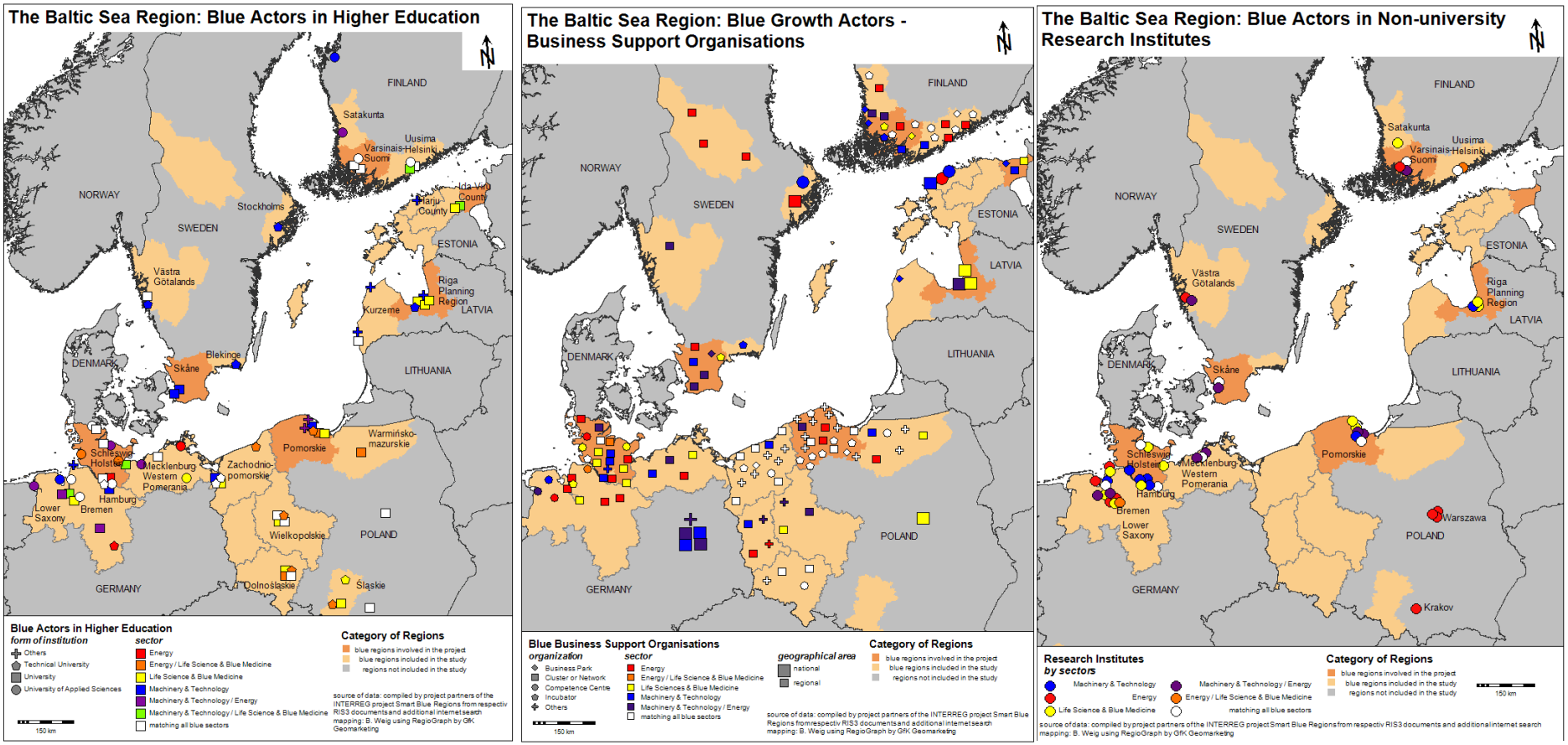


Figure 28 Maps depicting findings from 6 BSR regions (NUT2) on A) Business support organisations (Actors map), B) Higher Education institutions (Actors map), and C) Non-university research Institutes (Actors map). Source: Smart Blue Regions project (Interreg BSR)[1]

3.3 Higher Education

Education and training programmes are paramount for developing capacities among future researchers, practitioners and business developers. Blue biotechnology is a knowledge-intensive and highly specialised field. In Table 5 below we analysed the available study programmes in higher education within blue biotechnology in Northern Europe. This analysis is indication of the available programmes and courses, and are not a comprehensive analysis.

Table 5 Offered Higher Education Programmes within blue biotechnology and bioentrepreneurship in the Northern Europe

Country	Study Programmes	Stand-alone courses
Poland	University of Gdansk (Oceanography and Geography Department) offers a 2-years MSc Program in **Biological Oceanography with the specialization in marine biotechnology**. There are about ten universities offering biotechnology programmes at BSc MSc and PhD level, but mainly focusing in biomedical fields.	Biotechnology in aquaculture – invertebrates, Microorganisms in marine biotechnology, Phylogeny of marine organisms, Marine environment protection, Molecular and cytogenetic diagnostics in aquaculture, Intellectual property, Gen and genome engineering of marine organism, Bioinformatics, Blue biotechnology, Biotechnology company training.
Germany	There are about 70 MSc programs in biotechnology in general in various German universities, technical universities and universities of Applied Sciences. There are no dedicated programmes in blue biotechnology.	Several lectures, courses and seminars in biological, pharmaceutical and biochemical MSc programmes in University of Bremen, Uni of Greifswald, Uni of Kiel and Uni of Hamburg with strong blue biotechnology focus.
Estonia	There are many biotechnology programmes (BSc and MSc) but not “blue”.	University of Tartu Department of Marine Biology covers all taxonomic units and size classes of marine life, which exists in Baltic Sea, with its competence and activities. They offer courses at all levels. Also, University of Tartu offers a course named “Entrepreneurship for Biotechnology” for Biology, Biomedicine, Gene-technology and Chemistry MSc students.
Finland	Several programmes are offered like the MSc Microbiology and Microbial Biotechnology or the MSc in Chemical, Biochemical and Materials Engineering – Biotechnology, but there was no dedicated programme found.	There are many dedicated courses in marine biotechnology.[64][65]

[64] https://eliademy.com/catalog/catalog/product/view/sku/e56938e154
[65] https://eliademy.com/catalog/catalog/product/view/sku/8030f496de

Denmark	Denmark system offers many programmes in biotechnology, but not "blue". Danish Technical University (DTU) offer a 2-years MSc programme in **Aquatic science and technology**[66]. The MSc with three study specialisations: allows you to specialize in one of three study lines: Aquaculture, Fisheries, and Oceanography. DTU in collaboration with other Nordic Universities offers a 2-years joint **MSc in Aquatic food production - safety & quality**.[67] Students design their own course, within the aquatic food sector linking advanced aquatic food production, processing and distribution with issues of importance for tomorrow's consumers, industry and society. Copenhagen Business School offers the MBA programme in "Business administration and bioentrepreneurship" that is a 2-years programme advanced biology and biotechnology with business tools and methods.[68]	
Norway	The Arctic University of Norway offer a 2-years MSc programme on **Marine Biotechnology**[69] that develops graduates with advanced skills in genetic, biotechnological and molecular biological techniques.	
United Kingdom	Scottish Association for Marine Science (SAMS) in Scotland offer a 1-year MRes programme in **Algal Biotechnology, Biology and Ecology**.[70] Heriot-Watt University is offering the 1-year MSc. programme **Marine Biodiversity and Biotechnology**.[71]	

[66] https://www.dtu.dk/english/education/msc/programmes/aquatic_science_and_technology
[67] http://www.aqfood.org/
[68] https://www.cbs.dk/en/study/graduate/msc-in-business-administration-and-bioentrepreneurship
[69] https://uit.no/utdanning/program/541796/marine_biotechnology_-_master
[70] https://www.sams.ac.uk/study/postgraduate/sams-algal-biotechnology-biology-and-ecology-mres/
[71] https://www.hw.ac.uk/study/uk/postgraduate/marine-biodiversity-biotechnology.htm

Transnational joint MSc programmes relevant to Northern Europe	University of Gothenburg offers the joint Nordic 2-years MSc programme named Sustainable Production and **Utilization of Marine Bioresources** (MAR-BIO).[72] SAMS jointly with other EU Universities offers the Erasmus Mundus 2-years Master Degree in **Aquaculture, Environment and Society** (ACES).[73] BBMBC was a project funded by EASME (EMFF) that designed and piloted a transnational **Blue Biotechnology** MSc programme (2017-2018).[74] The programme focuses on blue biotechnology and dedicated to their application particularly in the health, nutrition and aquaculture domains. University of Stirling (UK) was the only partner from in Northern Europe.	

In conclusion, in the previous chapter we analysed the competencies and interests of 24 R&D institutions in the Baltic Sea Region that are engaged in blue biotechnology. The analysis is by no means exhaustive but it gave a snapshot of the capacities of institutions, on technological expertise, know-how, biological resources that are in scope or their R&D as well as their main current focus when it comes to product development and market applications. A total of 24 R&D institutions and departments (including 9 *Alliance* partner institutions) were surveyed through a questionnaire developed by the *Alliance*.

The analysed R&D institutions of the BSR have a wide spectrum of competencies, resources and interests within blue biotechnology, namely within chemistry, biology, ecology and engineering. Among the most popular fields of study were production of algae (both micro- and macroalgae) and also bacteria (e.g. marine bacteria, cyanobacteria) for a number of applications from food and feed to highly specialised markets and bioremediation. Analysis showed that auxiliary fields of study could well support food production sectors. In conclusion of the survey, all 15 non-*Alliance* partner institutions represent prime candidates to become partners of the future *Alliance* and will be contacted by SUBMARINER Network.

In regard to higher education programmes, blue biotechnology study programmes are very rare. They are considered highly specialised programmes and typically they are part of biotechnology or marine biology study programmes as specialisations or elective courses. To encourage young generation to join blue biotechnology, more high-profiled educational programmes would be needed. The inspiring success stories of BBMBC or ACES programmes can be imitated in the future in the BSR. Additionally, more bioentrepreneurship education opportunities are required for future managers and business developers. This is especially relevant for strong biotechnological clusters, like Kiel, Tartu, and Helsinki, thus copying the success of Copenhagen Business school. The Blue Generation project (EEA grant) raises awareness and mobilise groups among young people on the opportunities of blue economy, including blue biotechnology as an upcoming sector.

[72] http://holar.is/en/marbio_a_nordic_masters_programme
[73] http://www.emm-aces.org/
[74] https://www.bbmbc.eu/

4 Research & Innovation strengths and opportunities of Baltic Blue Biotechnology R&D

In this chapter we assess the strengths and opportunities of research, development and innovation capacities of the blue biotechnology. Here we consider blue biotechnology as an enabling technology of blue bioeconomy and place it in the wider framework of bio-circular economy. The assessment is focused on the Baltic Sea Region and it is analysing data gathered during the Baltic Blue Biotechnology Alliance Interreg project (2016-2019).

The analysis is organised around five thematic areas; the first three enable the *exploration of the marine environment*; support *biomass production and processing;* and contribute to *product innovation and differentiation*; whilst the remaining two, *policy support and stimulation;* and the provision of *enabling technologies and infrastructure*; provide the essential foundation to support growth in bioeconomy. This framework was first developed by the ERA-MBT project that developed the Roadmap for future EU marine biotechnology research and innovation agenda to 2030.[75] The framework of the roadmap was incorporated here in order to provide a validation and feedback from the Baltic Sea Region as well as a sense of progress after 2 years' time since the first publication. The following scheme illustrates the ERA-MBT framework, in which the thematic areas are interconnected and some overlapping is expected also in the analysis below.

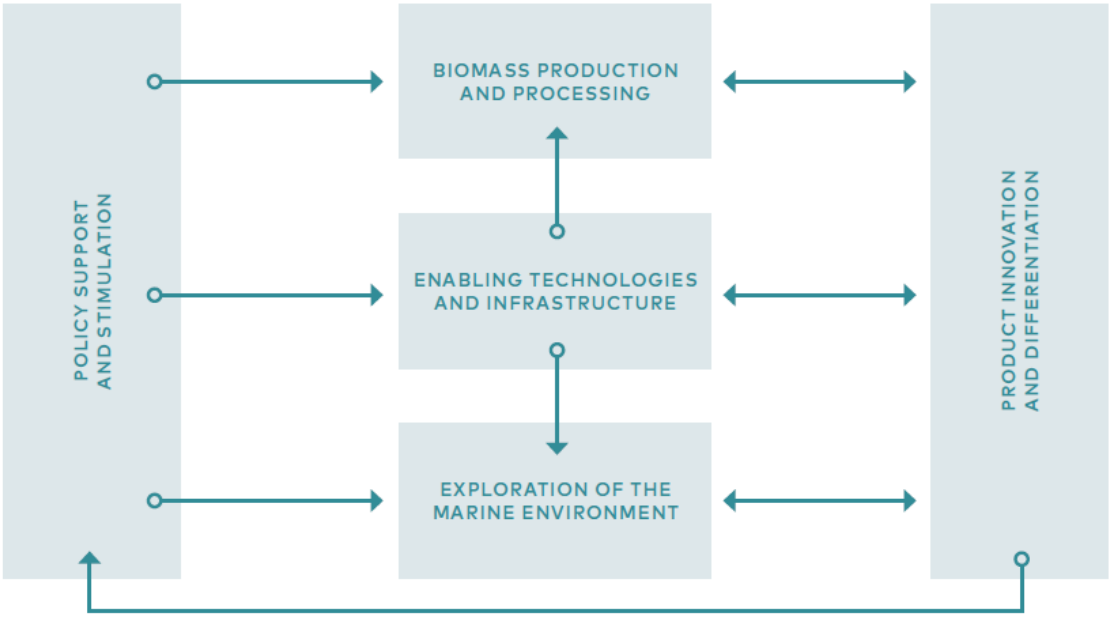


Figure 29 ERA-MBT framework of analysis of five thematic areas [76]

4.3 Exploration of marine environment

Below are the findings of the thematic area: Exploration of the marine environment.

[75] Hurst, D.; Børresen, T.; Almesjö, L.; De Raedemaecker, F.; Bergseth, S. (2016). Marine biotechnology strategic research and innovation roadmap: Insights to the future direction of European marine biotechnology. Marine Biotechnology ERA-NET: Oostende.
[76] *Ibid.*

Strengths of the BSR:

- Baltic marine and freshwater ecosystems host a special biological diversity of organisms e.g. fungi, micro- and macroalgae, bacteria, sponges, and mussels, as a result of the special condition of the Baltic Sea (see also text box 1.3). These bioresources can be used directly as biomass source (e.g. protein), they can be producers (as microbial factories) of valuable natural products, or finally can provide new knowledge or genes. Since many BSR coastal regions have enabled RIS3 within blue biotechnology and marine aquaculture-related fields (see Figure 28), it would be valuable for them to harvest the opportunity to take actions and unlock the potential of their marine and freshwater biological resources. An opportunity would be to use blue biotechnology field to support blue growth (generate and promote employment, economic and regional development, while at the same time contributing to growth and cohesion).
- A rich diversity of biological resources is available at *Alliance* partner institutions in collections of viruses, bacteria incl. Cyanobacteria, fungi, microalgae, macroalgae, crustacea, molluscs, and fish. The institutions hosting the biological resources are research institutions across the BSR located in Germany, Poland, Sweden, Finland, Denmark and Lithuania. Furthermore, outside the *Alliance* consortium, among 15 surveyed institutions in the BSR, all institutes had capacities and resources in cultivating different types of biomass, e.g. micro- or macroalgae, fermentation of fungi or bacteria, farming mussels or breeding or growing fish or copepods and are highly likely to contribute to *Alliance* Blue Bioresource database. Some of them have organised biobanks.
- SYKE and other Alliance partners own a state-of-the-art fleet of research vessels that can harvest organisms at various conditions and thereby expand the frontier of new discoveries.

Opportunities in the BSR:

- With the aim to expand the current database of 28 entries[77] and develop a central BSR-wide Blue Bioresources database on blue biotechnologies and aquaculture species, *Alliance* partners and cases have the opportunity to both contribute to the database, but also to benefit from accessing information on availability and accessibility of biological resources, in accordance with the guidelines of the regulatory framework on access and benefit sharing (ABS) on the use of marine bioresources for commercial and academic research.
- Connecting the *Alliance* with the EBB project and the activities associated with their Blue Bioresources catalogue could expand the BSR-wide *Alliance* database and also enhance co-development of new tools and processes for improving preservation of organisms, pool best practices in applying the ABS protocol across countries, alleviate innovation barriers of implementation of the ABS protocol, e.g. by SMEs. The latter is particularly important, since the EEB project does not have a Baltic partner. A connection point could be *Alliance* partners like SAMS (UK) or CIIMAR (PT) or another EMBRC member.
- To this point, there is no need to yet establishing another biobank of microbiological cultures but rather to link existing structures. More important is linking and merging the available information to find ways for regulation-compliant transnational access to available microbial resources. Therefore, the national authorities responsible for implementing the existing regulations have to be included into the calculation to enable common solutions. Project funding programmes are going into this direction - with some exceptions, with many are moving away from pure collection screening approaches (i.e. enriching the pure number of available strains). Instead, some calls change towards establishing novel microorganisms as so-called "platform organisms" which can either be genetically

[77] http://alliance-database.eu/#/bioresources

modified or have already the natural capacity to produce biotechnologically important compounds (e.g. enzymes).

4.4 Biomass production and processing

Strengths of the BSR:

- The analysis of R&D capacities revealed a broad spectrum of competencies within biomass production and processing with 205 entries of expertise from 25 BSR institutions, ranging from biomass propagation (seaweed, fish, shrimp, mussels, algae, microbial fermentation) to physiology, biochemistry, genetics, analytical chemistry and downstream processing. This demonstrated that Baltic Sea Region R&D is a strong cluster within the EU blue biotechnology landscape and enlists many listed world-scale universities and research institutes.
- By comparing the type of biomass used in R&D in the surveyed institutes with the type of biomass used for product development in *Alliance* cases, we find micro- and macro-algae were the two most prominent biomass types; 66% of cases and 44% of institutions used algae. 24% of R&D and 7% of cases worked with marine animals. Not many aquaculture production undertakings were mentored in the *Alliance* project, however 4 cases were developing technologies and solutions for the aquaculture sector, like *Baltic Probiotics*, that develops products improving fish health in tanks, *Biofisk* developing a novel feed source for fish feed, *EHP* sensing devices, and Phytolink photobioreactors for integrative aquaculture. Bacteria that are widely used as microbial factories for commercial production of a variety of fine and specialty chemicals including pharmaceuticals, were investigated by 18% of R&D institutes but only by 10% of cases.
- Among 26 cases that enrolled the *Alliance* mentoring programme, 20 cases requested and received scientific/technical support incl. planning, setup and conduction of experiments, data analysis, providing equipment for analysis etc.
- Funding programmes like the Horizon2020 (Blue Growth), BBI-JU, Marine Biotechnology ERA-NET (ERA-MBT), and more recently the ERA-NET COFUND on the Blue Bioeconomy, but also regional initiatives like Interreg BSR, BONUS and the Nordic Bioeconomy Programme enable blue biotechnology research on biomass production in the BSR. Such programmes have funded R&D with Baltic partners in biomass production such as micro- and macroalgae, marine bacteria, mussels, integrative fish aquaculture, even jellyfish, but also have funded research on valorisation of residual biomass resources, such as beach wrack and bycatch, processing side-streams and by-products, as we saw in Chapter 1.6. Majority of the projects from the BSR (having an LP from the BSR) scoped macroalgae production (cultivation, harvesting) and processing, but there were also a number of identified projects investigating alternative biomass resources e.g. jelly fish or microalgae. Notably, ERA-NET COFUND targeted developing transnational value chains within blue bioeconomy. In the first round of the first call in 2019, half of the submitted applications were under Priority area 1: Exploring new bioresources. This is an exemplary funding scheme tailored for SMEs in a niche sector. On the negative side, according the eligibility rules, participation is only possible for Denmark, Estonia, Finland, Germany, and Sweden among BSR countries; while Latvia, Lithuania and Poland cannot participate in this initiative. We need more of these initiatives tailored for SMEs. Other SME funding schemes e.g. SME Instruments are very competitive, and other sectors have been more successful.
- Environmental sustainability was taken very seriously in the *Alliance* mentoring programme. Sustainability of the bioresource acquisition was one of the main selection criteria in the recruitment phase and reduction of environmental impacts of production (incl. upscaling) was usually a parameter revisited in the mentoring process. Among the 26 *Alliance* cases, 13 cases have developed products from cultivated biomass sources (e.g. macroalgae, microalgae, bacteria) and 10 cases used wild stocks (e.g. macroalgae, algal/cyanobacteria blooms) that were harvested/collected sustainably.

Environmental sustainability is of prime interest for a region that is striving to achieve Good Environmental Status in the Baltic Sea.

- SUBMARINER Network EEIG and its Blue Platform project (Interreg BSR) aims to integrate and increase visibility of knowledge, data and actors within blue bioeconomy across the BSR. This includes project findings of the Baltic Blue Biotechnology Alliance and Alliance+ (both Interreg BSR), but also foster synergies with other regional or national clusters or pan-European R&D clusters, e.g. EMBRC-ERIC are not covering BSR.

Opportunities in the BSR:

- As mentioned, Baltic Sea is far from reaching "Good Environmental Status" caused by (among other reasons) excess nutrient (e.g. nitrogen and phosphorus) pollution, and the additive environmental impacts they cause (eutrophication, anoxia, toxic algae blooms) especially during the summer season. More and better measures are needed to reduce nutrient load in a controlled way. Low trophic aquaculture technologies like seaweed cultivation and harvesting, sustainable fishing of wild stocks, and mussel farming combined with harvesting, have been considered biological methods with high potential to improve environmental status by removal of excess nutrients accumulated via the food-chain in the harvested biomass. However, more R&D is needed to develop understanding in a systems perspective (environmental, socio-economic) but also scaling up technologies combined with entrepreneurial experimentation activities are needed in the near future to build economies of scale. More data need to be collected from large scale projects to address open questions.
- Furthermore, harvesting of algal blooms or beach wrack are also promising alternative biomass resources albeit often of lower quality. SUBMARINER Network is addressing environmental issues of the Baltic Sea and taking actions towards improving the environmental status of the sea since 2013, e.g. by lobbying and communication, project development (*Alliance*, Baltic Blue Growth, GRASS projects), developing studies and Roadmaps.

4.5 Product innovation and differentiation

Strengths in the BSR:

- The analysis of R&D institutional capacities in the BSR revealed a wide variety and an even distribution of blue biotechnology product applications of, e.g. food and feed (35%), cosmetics (15%), biomaterial and waste bioremediation (each for 11%), pharmaceuticals (10%) and hardware and energy (each 9%). This shows that there are many current blue biotechnology trends and research themes that sustain a plethora of technological platforms for product innovation and differentiation. Interestingly, blue biotechnology field is famous for drug discovery and historically many drugs are derived from marine organisms e.g. sponges, but the analysis revealed that only a small fraction of participating institutions was engaged in drug discovery (10%) while majority are engaged in research for other market applications.
- The analysis of the BSR entrepreneurial experimentation trends showed a picture different from the research R&D institutions. Analysis of 26 *Alliance* cases showed that most popular markets for business have been cosmetics (25%), followed by food and feed (17%), energy (12%) and finally pharmaceuticals only by 8% of cases. This is no big surprise, since the cosmetic sector promises quick revenues opposed to much lesser costs for product development and lesser regulatory hurdles compared to the pharma sector, it is probably the most attractive market for the *Alliance* cases, most of which (14) are start-ups with limited start capital resources. Furthermore, the sustainable cosmetics market is very much on trend in many Scandinavian countries as well as Eastern Baltic countries that are popular tourist and

spa treatment destinations. There is a very interesting trend also in developing hardware technologies and solutions for aquaculture, e.g. sensors, and filters and fish health boosters for tanks.

- The *Alliance* mentoring programme was pivotal for the advancement of cases, and also influential for the mentors. Access and development of new ideas and joint projects etc. were not uncommon in the *Alliance*. In that sense the Alliance mentoring programme was a win-win setup for both parties. Innovation was a core-element of the *Alliance* mentoring programme, as many cases had changed focus in product development in the course of the mentoring and the service offer. This was a combined result of discussions with experts but also access to new materials and data, e.g. from scientific/technical service.

Opportunities in the BSR:

- Many large manufacturing companies have a track record in investing in R&D and in participating in blue biotechnology R&D projects. Examples are companies e.g. CP Kelco, BASF, DSM, FMC Biopolymer, Novozymes have a strong innovation portfolio management systems and interest in blue biotechnology to source new biological solutions. SMEs are a useful source of new product ideas for large industry because SMEs can help them secure their position in the market. SMEs are also looking for funding and support for developing further. However, SMEs and start-ups find innovation offices of large industry were as "difficult to reach". This innovation barrier has been noticed by large industrial actors, who have tried to create a fertile environment to attract SMEs with relevant technologies. Examples of activities are: organising open innovation events by sharing their knowledge (unused patents), organising hackathons inviting SMEs to solve a challenge, pitching events, or setting accelerator programmes. Novozymes, BASF, Maersk have developed such accelerators on board. As an example, also, *SFTec* case was recruited by the 2nd accelerator programme of Stora Enso, a global-scale pulp and paper manufacturer. The *Alliance* has not collaborated in long-term with large industry, however large industry is an excellent future partner of the *Alliance* for both as sponsoring cases or events, but also to organise joint event for blue biotech innovation.

4.6 Enabling technologies and infrastructure

"The availability of a relevant and accessible research infrastructure comprising physical and human resources and capabilities is essential to continue the development and utilisation of outputs from marine biotechnology."- ERA-MBT[78]

Strengths in the BSR:

- Two *Alliance* tools, i.e. the database for cataloguing multi-purpose research infrastructure and equipment and the bioresources catalogue, aim to increase access to R&D open access equipment as well as marine biological resources, by commercial and R&D institutions, thus increasing the potential of innovation, product development and "cross-fertilisation" of new ideas and development of new knowledge both in academia and economic sector. Active dissemination of these available tools is the key for success. Mentors forum are the primary users of these two databases that acts as a map for partner networking for both R&D institutions and private users.
- A tangible obstacle in advancing blue biotechnology products in the Baltic Sea Region, as described in the SUBMARINER roadmap (2013), is that not every country alone can provide all resources and expertise necessary to complete the journey from idea to finished product. In 2017, the ERA-MBT

[78] Hurst, D.; Børresen, T.; Almesjö, L.; De Raedemaecker, F.; Bergseth, S. (2016). Marine biotechnology strategic research and innovation roadmap: Insights to the future direction of European marine biotechnology. Marine Biotechnology ERA-NET: Oostende.

suggested building of national and industry networks, clusters and public-private partnerships to form a foundation for long-term improvements in research environment by providing better access and strengthening collaboration. A concrete suggestion was the creation of "self-sustained marine biotechnology research and innovation networks that are closely associated with and facilitate the integration of expertise from currently unconnected areas of enabling technologies".[79] There was, however, no real focus on transnational aspects, which is very important for the Baltic Sea Region. In the *Alliance* project, not only have the research actors successfully transferred knowledge to each other and their cases, they have been encouraged to share physical infrastructures; e.g. laboratories, equipment, pilot facilities and research vessels, also at transnational level where possible. The *Alliance* project has set up an innovation platform and accelerator within blue biotechnology, where partners can invite their own networks reaching beyond the Baltic Sea Region, encouraging the exchange of knowledge and resources and creating reasons to collaborate by joining forces in the *Alliance* mentoring program for their mutual benefit and that of the *Alliance* biotechnology cases.

- A point of reflection regarding the improvement and fostering of future transnational cooperation between different research actors and funding institutions must be grounded in the topic of dissemination. Not only does the ERA-MBT report suggested that "the current and largely informal information and knowledge infrastructures could be developed into a dedicated marine bioresources/biotechnology knowledge portal".[80] To this point, the *Alliance and the SUBMARINER Network (as well as the Blue Platform project)* have succeeded in bringing all these actors, knowledge, data, resources and networks together since 2016 by creating a long-standing technological innovation platform within blue biotechnology in the region.
- Furthermore, cross-linkages between blue biotechnology capacities and resources will have a positive impact on research, development and innovation. Many technologies and tools used by blue biotechnology are used by other research and technological fields. Creating synergies across sectors within a region will create positive externalities, by cross-fertilising knowledge, develop, access and retain talent and skills and provide access to resources, like financial, biomaterial and infrastructure, much needed in the research-intensive blue biotechnology sectors. BSR has great prospects to be a blue bioeconomy showcase, as it was elaborated in the SUBMARINER Roadmap, that since 2013 SUBMARINER Network has set a platform for collaboration across marine sectors, including blue biotechnology, algae, mussels, and aquaculture, but multi-uses of sea and marine litter.

Opportunities in the BSR:

- In the recruitment process, we believe that the high number of incoming applications in the first call was due to high demand for such a service in the region but also perhaps because the offer was covering financial support (e.g. salary costs). In the future, when Interreg financing ends, it is questionable how the cost of mentoring programme and the service offer will be covered. BlueBioAlliance, a sister innovation platform in Portugal, has introduced an Innovation Voucher system, in which winners of the BlueBioValue accelerator programme win 45k€ that they can spend cost-effectively for "buying services" from BlueBioAlliance associates in a number of technical services e.g. scientific/technical, legal advice etc. In the Baltics, introduction of innovation vouchers is a very interesting scheme that will be examined by the *Alliance* and SUBMARINER. However, introduction of innovation vouchers is regarded more complex in the Baltics, since Baltic Blue Biotechnology Alliance is a transnational structure, unlike the BlueBioAlliance which has a national setup, and administrative and regional barriers are foreseen. Potentially, costs will be directly financed either by partners or third-parties

[79] *ibid*
[80] *ibid*

either directly, or via a "bluebio" fund with mixed sourcing, e.g. crowd-sourcing or entrepreneurial charity, sponsorships from large industry or regional development offices. A scenario foreseen in the near future is based on the assumption that mentors and service providers are receiving only non-monetary compensation, which entitles them "free-will" to act on self-interest to mentor a case. This makes the *Alliance* accessible to more cases and empowers the wider network to "adopt a case" or "crowd fund support" a case. This is particularly relevant for cases that are in very early stage in the product development stage.

4.7 Policy support and stimulation

Strengths in the BSR:

- In the *Alliance,* we have recorded a strong innovation potential from all the BSR countries. But for a small country like Estonia, the track record was a surprising discovery. This was inherently a success of *Alliance* that enabled a transnational collaboration and mobilised and provided access to resources and expertise for start-ups and SMEs of Estonia. Such examples are inspiring and show the way forward to reach the goals of the Innovation Union.[81]
- Blue biotechnology is mentioned in and supported by important strategies text both at EU and the BSR level, by many goals, overarching strategies and roadmaps. Apart from the Marine Biotechnology Strategic Research and Innovation Roadmap, it is worth mentioning the Blue Growth Strategy (2017), and the EU Bioeconomy Strategy. The upcoming Blue Bioeconomy Roadmap (2019) is expected to pave the way for unlocking the potential of the EU blue bioeconomy. However, these EU strategies for be useful in practice should be converted into National policies, e.g. Smart Specialisation Strategies (RIS3).
- Blue Growth focus areas are very popular in RIS3 among BSR countries as analysed by the Smart Blue Regions project (Interreg BSR). In particular, many BSR regions had enable Life Sciences & Blue Medicine priority fields. From the recommendations of the report "Common elements and lessons learned from RIS3 processes",[82] we highlight: more funds should be allocated for inter-regional collaboration as regions often experience same difficulties, or regions have similar projects. Thereby, exchange of lessons learned was regarded very useful for them. The role of the clusters is strategic for regional development and should be enhanced. For example, the cluster can well be the forum where private and private resources and funds converge for the same goal, so clusters should be also better supported for enabling stability and long-term planning. Finally, in regard to Blue Growth, this RIS3 focus area was not well-known, nor understood, or accepted among stakeholders, especially among the business and the regional planners.

Opportunities in the BSR:

- Whilst there is funding available to blue biotechnology related research under the EU's Horizon2020 and BBI programmes which is led by R&D Institutions, there is a lack of funding further along the value chain tailored for SMEs. The exception to this fact is the very-promising new ERA-NET COFUND on the Blue Bioeconomy that in 2018 released a SME-friendly funding call promoting technology transfer and industrial innovation within blue bioeconomy sectors. Main drawback to this is that only ERA-NET EU countries are eligible for funding. The new Blue Investment mechanism is a very interesting and promising new mechanism for "pre-seed" SMEs and start-ups and *Alliance* is looking forward to provide support in this mechanism covering the Baltic region.

[81] https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/innovation-union_en

[82] Common elements and lessons learned from RIS3 processes Analysis of Project Partner Regions. Smart Blue Regions Project Synthesis Report.INTERREG BSR (2018) https://www.submariner-network.eu/files/SmartBlueRegions_Rapport_DIGITAL.pdf

- The forthcoming Blue Bioeconomy Roadmap (2019),[83] by taking account of the urgent needs of the sector, aims to inform and influence future policies and innovation support mechanisms, incl. Horizon Europe framework program as well as Interreg and ERA-Net programmes.
- The updated EUSBSR expected in 2020 may influence the future ERA-Net, Interreg and BANOS (next BONUS programme) funding programmes. Also, the new Interreg programme (2021-2027) has not been released yet, but there are discussions towards developing calls for extending projects duration from 3 years to 7 years. Such scenario would have a positive impact to absorption of benefits associated to building new support structures and mechanisms such as the Baltic Blue Biotechnology Alliance innovation platform and SME accelerator and set a good potential for long term process financial support.
- Europe is strong in coordinating research activities in the early stages of the value chain but there is a lack of collaboration further along the value chain between those doing the research and initial product development (mainly research institutes and SMEs) and investors, larger companies with the resources to up-scale and commercialise a product and the industry within which the marine biotechnology application will be used.[84] Changes in existing funding initiatives could facilitate such developments. By building on increasing market success, support should be such that funding schemes respond to, and encourage new marine biotechnological developments, including the participation by industry in research projects. Such actions could provide venture capital funds with the confidence to recognise marine biotechnology as a central enabling technology in the creation of high-potential, enduring investment areas based on the use of marine biological resources. Other mechanisms to expand the role of marine biotechnology in the broader bioeconomy include funding to encourage open innovation and the creation of dedicated public-private partnerships (PPPs) where marine biotechnology is recognised as an enabler of enterprise activity.[85]
- In the *Alliance* mentoring programme, innovation-specific questions were addressed to mentors, in regard to regulatory and legal constraints cases face e.g. implementation of the Nagoya Protocol, Intellectual Property Rights (IPR) issues, to EU product safety standards, food regulations, or certifications and product labelling. These topics are key for promoting innovation and entrepreneurship and are clearly a concrete demand by cases within blue biotechnology sector. These are topics that innovation offices of universities and research institutes or science and technology parks deal with. Three *Alliance* partners were able to answer legal questions within the sphere of biotechnology, food innovation and IT, but not all requests could be covered. The *Alliance* needs more experts on board to diversify the pooled expertise, with the long-term aim to integrate knowledge with good practices and develop legal guidelines for cases (and R&D institutes) that will improve the *Alliance* innovation platform, train future mentors, and finally accelerate case product development.

[83] https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1355
[84] Study in support of Impact Assessment work on Blue Biotechnology, EC EMFF (2014). https://ec.europa.eu/maritimeaffairs/publications/study-support-impact-assessment-work-blue-biotechnology_en
[85] Hurst, D.; Børresen, T.; Almesjö, L.; De Raedemaecker, F.; Bergseth, S. (2016). Marine biotechnology strategic research and innovation roadmap: Insights to the future direction of European marine biotechnology. Marine Biotechnology ERA-NET: Oostende.

5 Recommendations for advancing Blue Biotechnology R&D for relevant policy frameworks and funding programmes

In the previous chapter, we presented an analysis of the strengths and opportunities of BSR blue biotechnology research, development and innovation ecosystem and the work was organised around five thematic areas. Based on the analysis, we developed 5 recommendations for advancing R&D within blue biotechnology in the BSR. The recommendations are organised in research themes and presented in a format that is relevant for funding programmes (e.g. national, BANOS, Interreg, ERA-NET, EU). In these recommendations the focus mainly on the initial R&D stages of a product development chains, although some innovation opportunities were also included in the list.

Objective 1. Access to marine bioresources

Baltic marine and freshwater ecosystems host a thriving biological diversity of organisms e.g. fungi, micro- and macroalgae, bacteria, sponges, and mussels. During the *Alliance* project it became clear that blue biotechnology field requires access to marine bioresources but those must be secured without destroying the ecosystems. This includes access to existing biological culture collections (e.g. microbial biobanks, microalgae collections), access to different types of bioresources in the nature (e.g. macroalgae) and access to yet undiscovered bioresources.

Hundreds or even thousands of different culture collections exist all around the world and not all of them are even registered. Many of the collections are maintained by research institutes or universities. Maintaining of the collections requires competent personnel and resources. To be able to use these collections, the information about them has to be easily found. The *Alliance* has created a catalogue that lists the biological resources and culture collections of the *Alliance* partner R&D institutions in the BSR as well as the respective contacts at the partner institutions. The catalogue guided mentors and cases to locate the right bioresource in another country, e.g. Hoekmine case. Having a comprehensive bioresources catalogue opens possibilities for collaboration and further advancement across the value chain.

Further integration of culture collections and **creation of a master BSR-wide catalogue** is a laborious and ambitious task that would benefit the entire blue biotechnology community in the BSR and EU-wide. Furthermore, connections of ***Alliance with* other EU Blue BioBanks** (e.g. see the EMBRC EBB project) could expand the existing *Alliance* catalogue for a mutual benefit of all parties (EEB project does not have a Baltic partner).

The **implementation of the Nagoya Protocol in regard to access and benefit sharing of bioresources, should be clarified within the BSR states to enable the access for research and sampling for organisms**. But also, for international waters outside the Baltic Sea Region in waters beyond national jurisdiction that can enrich collections and the innovation potential of the Region. In blue biotechnology, the access to bioresources is very important at early stages of the value chain, biodiscovery and bioprospecting. Since many BSR coastal regions have enabled RIS3 within blue biotechnology and marine aquaculture-related fields (see Figure 28), it makes sense for them to unlock the potential of their marine and freshwater biological resources and especially blue biotechnologies to generate and promote employment, economic and regional development, contributing to growth and cohesion.

Accessing of bioresources in the nature will benefit from mapping of the Baltic Sea marine environment to locate hot spots for sampling and **sustainable harvesting** of bioresources. New automated sampling devices could be used parallel to traditional ones. In many cases the access to bioresources could be provided by the research institutes.

Objective 2. Sustainable integrated aquaculture systems relevant for the Baltic Sea Region

Farming finfish, shellfish and aquatic plants is one of the world's fastest growing food sectors, it already provides the planet with about half of all the fish we eat. Seafood consumption in EU is expected to increase, especially in Central-Eastern Europe, while nowadays, on average one EU citizen is consuming 25 kilos of seafood[86]. However, 60% of seafood consumed in Europe is imported, and about a fourth is coming from aquaculture. Furthermore, aquatic plants and animals can provide ingredients, materials and services much needed in non-food sectors as well, e.g. ecosystem services (CO2 uptake, water purification), sources of nutrients in biofertilisers, ingredients for cosmetics, and energy sources. Aquaculture can supply blue biotechnology with primary bioresources (e.g. macroalgae, fish, molluscs) and secondary bioresources (e.g. industrial processing residues and side-streams). Blue biotechnology is involved in all steps from growing bioresources (incl. system ecology) to recycling biomaterials. Aquaculture and blue biotechnology are the two key blue bioeconomy sectors that *Alliance* have spanned operations.

From the analysis in Chapter 3, we concluded that the **R&D of the Baltic Sea Region was a strong cluster within EU blue biotechnology** enlisting many world-class universities and research institutes. Technological production platforms investigated in BSR R&D included micro and macroalgae, bacteria, fish, shrimp, crustacean, as well as new species like jellyfish. Examples of R&D needs are sustaining and further developing knowledge in production and processing of aquatic biological resources into added-value products, technology upscaling, as well biorefining technologies to minimise waste.

Recirculating Aquaculture Systems (RAS) and other integrated aquaculture systems, such as fish RAS[87] production systems combined with microalgae, vermiculture, insect production or aquaponics for closing nutrient and carbon cycles, and IMTA[88] systems of open-water fish with mussels and seaweed farming, have been suggested for recycling nutrients and reducing water pollution. Some technologies are more advanced than others, but all are relevant to the Baltic Sea for reducing nutrient load and inflow, and also for developing blue growth. In many cases we need to increase our understanding in the environmental and socio-economic benefits, risks and opportunities associated with integrated aquaculture technologies, also at scale. Further advancement of integrated aquaculture technologies prescribes collaboration of multiple scientific and technological disciplines both for applied science, but also for developing also auxiliary technologies to scale up aquaculture, e.g. harvesting technologies, sensors and optimisation, sustainable aquafeed, animal welfare and health, micro-filtration systems. Among *Alliance* cases, 28 % developed microalgae production technologies, 3 out of 26 cases developed technologies from processing waste from marine species (macroalgae, algal blooms and mussel shells), four cases developed support technologies for aquaculture sector. SUBMARINER's InnoAquaTech project (Interreg South Baltic) with 4 production pilots and many business development activities[89] had also provided insights to the innovation potential of the region in RAS aquaculture and integrated land-based aquaculture.

Further on, **marine aquaculture of low trophic species** has a tremendous unexplored potential in the BSR, and local biological resources should be mapped, and identify suitable production systems for cold shallow brackish waters, harvesting processing biorefining. We can already build upon existing knowledge on brown seaweed and blue mussels from projects like GRASS, MACRO CASCADE, SeaFarm, Fucosan, and Baltic Blue Growth and Optimus. Moreover, 38% of *Alliance* cases developed products from macroalgae, many of which had integrated

[86] https://ec.europa.eu/fisheries/6-consumption_en
[87] Recircular Aquaculture System
[88] Integrated Multitrophic Aquaculture
[89] https://www.submariner-network.eu/news/general-news/534-innoaquatech-brochure

supply chain of either cultivated or harvested macroalgae, yet production scale was relatively small and labour-intensive. Process optimisation and upscaling can really improve sustainability of a production process. Also, the possibilities to use different wastewater types in the cultivation and the impact of them on the end product needs more attention. Finally, more knowledge is needed both in the production and also in the processing side to increase ecosystem understanding impact assessment for open systems (e.g. ALFF project) and also LCA and economy.

Objective 3: Development of new materials and circular economy

On a global scale we are already **facing shortage or increased cost of many raw materials**. In addition, we are producing materials that withstand degradation over long time scales and may be harming the environment. For example, the marine plastic litter has become a significant problem in many marine ecosystems and for that reason new alternatives for plastic products are highly needed. Also, different drugs and hormones are released to marine environment every day affecting marine organisms. To observe planetary boundaries and achieve sustainable material economies, recycling and circular economy along with more responsible consumption needs to be enhanced and traditional industries developed. The life cycle of products as well as different processes needs to be controlled from the raw material to the end of the usage.

In blue biotechnology, the utilisation of discards and residues from different biomaterial processes (e.g. aquaculture, food and energy production, extraction of compounds from organisms) could be used in other processes or industries. **When carefully planned, redirected waste streams can be beneficial for the environment.** For example, nutrients from the wastewater could be used to cultivate algae or shellfish for energy or other added value products. This process could clean the water, produce energy or new chemical compounds and the excess biomass could be used as a fertiliser. All these steps still need research and technical innovations to optimise the processes and their benefit. Interdisciplinary expertise is needed to study these tasks. Nutrient circulation is one of the most important issues in sustainable production. In the *Alliance,* the need was observed by 5 cases that developed solutions for converting waste bioresources into a resource. Examples were: Biome that used mussel shells for developing bone tissue substitutes, Biofisk, Movable Biogas Factory and Uni Gdansk - Smart Bloom that used beach cast consisting of macroalgae and seagrass and algal blooms for production of feed, energy and biopolymers respectively. Finally, SFTec developed a drying technology for slurries and other wet bioresources. Beach cast and algal blooms in particular are a great “waste” resource, both in terms of contained nutrients, but also after considering the holistic environmental eutrophied condition of the Baltic Sea. More environmental, ecological research is needed to understand the removal implications, on top of techno-economic barriers (harvesting, conversion) and also development of value chain pathways. Initial steps are taken by CONTRA (Interreg BSR) and Coastal Biogas (Interreg South Baltic).

Objective 4: Lean of blue biotechnology R&D with product market trends, challenges and opportunities

Blue biotechnology is a highly promising key enabling technology that unlocks the potential for conquering new frontiers in research and innovation, and can increase prosperity and stability, and if used wisely, can protect the natural capital of the oceans. Also, within blue biotechnology there are many current trends and research themes that can sustain a plethora of technological platforms product innovation and differentiation. **Linking R&D with innovation pathways and market applications at early stage e.g. bioprospecting stage, it can accelerate product development.** It furthermore increases cost-efficiency of R&D by leaning costs and by minimising risk of failure. For blue biotechnology as a research-intensive niche sector falling under - upcoming - blue bioeconomy, this is especially important. Blue biotechnology still is much less known and “new” compared to agriculture and green bioeconomy and funding support measures are scarcer, e.g. H2020 BBI-JU. Support

structures like the Baltic Blue Biotechnology Alliance or the SUBMARINER Network bridge the gap of technological innovation and R&D at a transnational level at a "pre-seed" stage, that is a company with early stage product development of a minimum viable product (MVP). Such stage needs considerable financing for R&D e.g. develop and test a prototype.

Market trends show that blue biotechnology can supply bioresources for various market products and applications, including food, feed, cosmetics, environmental bioremediation, chemicals, materials and energy. Blue biotechnology is a traditional supply chain of drug discovery and many drugs have been discovered by doing research on marine biological resources, e.g. sponges. It is well known that **regulatory barriers** can postpone or even stop technological innovation. Regulatory factors should be clear to R&D at early stage, so R&D is fully aligned with requirements, product standards, regulations etc.

Furthermore, majority of large industry, such as e.g. food, chemicals and pharma, invests in innovation, and have both abundant resources and infrastructure to drive in-house innovation and entrepreneurship. However, to secure their position in the market, they scout for disruptive innovative ideas, which they support and perhaps integrate. It is known that SMEs and start-ups have an impressive capacity to de-risk technological innovation and produce disruptive products and they are pole of attraction for large industry. As a result, large industry tends to support SMEs and start-ups, via e.g. hackathons, sponsor think tanks and open science innovation events in universities, found accelerators with open calls etc. Since the sector is so small, it is very important to **that clusters organise match-making events, thus bridge the gap among universities, research institutes, large industry and SMEs and start-ups**.

However, the *Alliance* mentoring programme provides a long-term "investment" in cases that need guidance, access to expert niche services and resources (e.g. equipment) to advance their products supporting blue bioeconomy. Although hackathons and short-term match-making facilities are serving their purpose in boosting innovation, other mechanisms following a structured development pathway and provide the security net fostering ideation and risk-taking by start-ups and SMEs are also necessary. The *Alliance* mentoring programme supported by the interdisciplinary mentor's forum fills this gap by having developed a fully customised mentoring programme for blue biotechnology start-ups and SMEs. Although this mechanism is ready and operational, funds are needed for the *Alliance* to continue provide quality support to more cases and further enhance innovation capacities in the BSR.

Objective 5: Mapping capacities and resources to boost blue biotechnology R&D and innovation in the BSR

Blue biotechnology has a huge potential but also faces huge challenges. Because it is such a new field, much work, many new ideas and new infrastructure is needed. To be able to answer these challenges, transnational collaboration is needed. All the gathered information should be collected to platforms and shared with the actors in the field. A strong coordination could lead to more efficient use of public investment and help to direct the money to the most important targets. Networks could help in finding partners, transferring the technologies, creating innovation banks, promoting the sustainable products and attract investors.

Process optimisation and upscaling can substantially influence the sustainability of production (economy, environmental footprint), which makes it important to be able to test it in advance. Two unique tools have been developed in the *Alliance* project, that lift innovation barriers associated with limited resources in the BSR; the database for cataloguing multi-purpose research infrastructure and equipment and the Blue Bioresources catalogue. The Blue Bioresources catalogue was elaborated in detail in Objective 1, and hereby we focus on research infrastructure.

The *Alliance* analysed the expertise of 24 institutes within blue biotechnology in the BSR. Furthermore, it developed a database for cataloguing multi-purpose research infrastructure available by *Alliance* R&D institutes

and companies. This tool is currently available online. In the future it should be further enriched and expanded by adding more data on **available multi-use facilities and equipment, including pilot and demo scale facilities, that are available (on demand) by R&D institutions and private sector** across the BSR. BSR lacks multi-use open access pilot-scale facilities relevant to (blue) Biotechnologies. Testing technological innovation at large scale creates knowledge and data that allows knowledge-based decision making, affecting impact investment and product development.

Furthermore, at EU level **the tool should better connect with other similar tools** for increasing visibility and access to end-users and boosting return of capital investment to infrastructure. For example, the *Alliance* database for cataloguing multi-purpose research infrastructure could be linked to the PILOTS4U and other similar initiatives mapping open-use multi-purpose research infrastructure relevant to EU bioeconomy.

The mapping exercise of capacities and resources has started but not been completed yet. If we continue the work of SUBMARINER compendium and *Alliance* and we comprehensively **map the available capacities and resources within blue biotechnology in the BSR, we will be able to develop an R&D strategy based on national strengths** for unlocking the potential of blue biotechnology research and innovation, develop transnational innovation pathways connecting Eastern Baltic capacities and resources available in R&D institutes with product development chains in large industry on the Western Baltic region, as well as look at the most urgent technological innovation needs within the Baltic Sea Region.

Beyond mapping, the *Alliance* has proven that **tools work only when there is human network uses them**. For the Alliance, cornerstone in the success were the performance of the blue detectives and mentors that took actions actively searching for new cases and also for good partners for cases driven by the cases articulated demands. Network's functionality was a result of good tools, but also strong effort and expertise of blue detectives and mentors to reach out, expand and invite their networks in the Alliance. This was only possible because blue detectives and mentors had personal interest, availability, capacity and support for reaching out. Sponsors and concrete fund support would certainly enhance the quality of *Alliance* services and also make service available to more cases in the future. The Alliance+ (Interreg BSR) funding is providing basic funding for 18 months, but it is not supporting *Alliance* core-activities like, recruitment of cases and work of blue detectives, or service provision and mentoring. **Extra funds are currently sought by the *Alliance***.

Finally, **developing strategic partnerships among blue biotechnology research and innovation supporting structures can accelerate developments**. Both national and transnational networks are important actors in facilitating knowledge transfer and dissemination and for providing a platform for match-making and innovation in the BSR. Good practices can well be transferred to cross-fertilise other sectors or regions and this can be facilitated by networks. For example, SUBMARINER and ScanBalt BioRegion are two EUSBSR flagship programmes with many common objectives and innovation barriers to tackle with. Both programmes are boosting development and innovation across knowledge-intensive and legal-fenced sectors. An idea would be to develop a joint innovation project addressing common research and innovation barriers e.g. a voucher system that could be spent by innovative blue biotechnology SMEs and start-ups working within e.g. the medical sectors. Alternatively, a project could be to **analyse expectations and communication jams across the product development chain**, between research institutes and companies that pose innovation barriers and block advancement. The different expectations of research institutes and companies can create problems during the product development in blue biotechnology. The terminology may be totally different and the expectations on the time needed for research can be very far from each other. Researchers need to publish scientific results, but companies cannot allow that because of the patent regulations and trade secrets. These issues should be discussed and recommendations created and communicated to all actors in the field.

6 Support actions for blue biotechnology innovation

In this chapter the *Alliance* summarises other cross-cutting recommendations for actions needed that will accelerate innovation and product development in the BSR within blue biotechnology and in blue bioeconomy.

Funding

In blue biotechnology the challenges in funding are related to the high innovation costs and the long time needed to get the new applications to the market. Also, many of the funding possibilities are regional which may prevent the use of transnational value chains. A macro-regional funding pool could solve this problem. For example, regions with same RIS3 selection fields could develop a transnational-fund to use for tackling common challenges and difficulties. Reducing innovation in blue bioeconomy is an example. Furthermore, funding agencies should also be part of the blue biotechnology networks and clusters in order to align long-term strategies.

Also, different actors along the blue biotechnology value chain need different kinds of funding. These depend on the specific needs (e.g. R&D, prototype development, upscaling, etc) and on the geographical location of the actor. Therefore, a **funding guide** for the actors in the blue biotechnology would be of great value to assist the actors in finding the appropriate funding option for the specific needs.

Education

After the analysis of Chapter 3, we concluded that more education is needed for the blue biotechnology sector and the existing education should be reachable for more people. There is a lack of basic knowledge, especially connected to harvesting, purification and extraction of biomass. There are also knowledge gaps in special issues e.g. IPR and legal issues in different countries. There are not so many training possibilities for scientific fields within blue biotechnology; mainly separate courses or specialisation options as part biotechnology programmes. Joint transnational Master's and PhD programmes are needed and also guidance on how to have a career in blue biotechnology. In Blue generation project, a Blue career guide will be produced. *Alliance* is providing information on different blue biotechnology courses and education in Baltic Sea Region.

7 The *Alliance* from project to service offer: SUBMARINER Network

The Baltic Blue Biotechnology Alliance was a flagship project funded by Interreg BSR (2016 to 2019). After 3 successful project years, the *Alliance* will continue its operations as a Working Group (WG) under the SUBMARINER Network for Blue Growth EEIG.

The *Alliance* is a really unique structure within the BSR as it **serves both as a platform network for blue biotechnology researchers, as an innovation platform for blue biotechnology actors**, incl. start-ups, SMEs, business support organisations and R&D and as a business pre-accelerator program for product development. The *Alliance* is counting more than 40 actors, that are experts is blue biotechnology providing services. In the last three years *Alliance* has proven that the applied approach is exactly the right path to bridge the gap between development&D and business. We have so far mentored 26 cases at all stages of product development chains, and we are specialising in "pre-seed" cases that are developing a prototype and a minimum viable product (MVP).

The *Alliance* as **a SUBMARINER Working Group promoting and supporting blue biotechnology innovation** will have - like all WGs - its own agenda and members. For the upcoming 18 months until January 2021*Alliance* will receive continued funding from Interreg BSR, with the aim to operationalise *Alliance* services, and become sustainable.

The SUBMARINER WGs are representing action fields with long-term focus and perspective exceeding normal project lifetimes and hence usually have wider scope than a funded project. The same applies to the *Alliance* and the SUBMARINER blue biotechnology Working Group.

Alliance sees as priority the linkage **and intensification of collaborations with other important European networks** and projects, such as e.g. the Blue Bio Value accelerator, EMBRC-ERIC,[90] Climate KIC, Bio Marine organisation, Blue Investment Platform, and of course to other relevant **regional Baltic networks**, such as ScanBalt. *Alliance* services need to be better integrated with other relevant networks in order to increase innovation impact and visibility especially regarding SMEs and start-ups, and inspire even more potential partners to join us. Co-development of new blue biotechnology and innovation research projects with other networks and partners is an open possibility for the Alliance, building on the successful SUBMARINER flagship track-record.

Towards this end, SUBMARINER and *Alliance* suggest to **be included by in the data management plan of future project results** (H2020, BBI-JU, ERA-NET etc.) within marine resources & blue bioeconomy on a continuous basis beyond the end of a project's lifetime. SUBMARINER and *Alliance* believe that knowledge recording and management is vital for reaching long-term goals, setting up roadmaps and trajectories but also for aligning public funding across programmes. The aim is to outpace setting up of numerous databases of success stories, and use the gained knowledge and experience to move to dynamic strategies that will increase visibility of successes to target end-users, and provide a sense of traction at a macro-regional level. Such processes are implemented within the blue bioeconomy in the Blue Platform project (Interreg BSR), however, we believe such projects in the future should be long-term and work across funding programmes to reach maximal impact.

We welcome new cases, partners and supporters from the Baltic Sea Region but also pan-European**.** Even though the *Alliance* gathers already a critical mass of blue biotechnology actors across the Baltic Sea Region, we are aware that there are many more who we want to reach. Capitalising on the achievements and progress of the past years, we continue to search for new cases, we are organising pitching and match-making events, specialised workshops and seminars and joint conferences. Coming new in 2019 & 2020 in addition to provide mentoring to cases, *Alliance* also offers training opportunities for future *Alliance* mentors based on our experience gained in the last 3 years.

[90] European Marine Biological Research Centre (EMBRC-ERIC)

Next pitching event and mentors' training workshop will be in Helsinki Finland in November 2019. Furthermore, as SUBMARINER is organising large conferences, *Alliance*/SUBMARINER hold discussions with BioMarine organisation to jointly organise the famous **BioMarine Business Convention** in a Baltic city in 2020. Towards this end, common financing under one umbrella is currently investigated.

Applications are welcome by institutions as well as individual experts:

- Business parks as well as other accelerator and innovation programmes – in order to align *Alliance´s* efforts for creation of the most effective and attractive service offer for cases
- Specialists in business development and financing support; marketing and communication companies and experts as well as legal advisors – with the *Alliance* being the source for your new clients
- R&D institutions as well as potential spin-offs with suitable technical facilities, biological resources, scientific expertise
- Mentors, business coaches and "blue detectives" with experience and flare in biotechnology, impact of innovation, and sustainable development
- Start-ups and SMEs with a business idea within blue bioeconomy, seeking product development support in the Baltic Sea Region
- Companies with an interest in increasing their outreach and network towards blue bioeconomy R&D, accelerators and innovators
- Universities and other educational bodies interested in running and promoting summer schools, professional training as well as Masters' Programmes on blue biotechnology

Strategic partners are sought to support our *Alliance* platform and "pre-accelerator" services:

- Blue clusters and regions attracted by blue bioeconomy and Blue Growth, that can support our activities with expertise and resources
- Regional and national authorities, private foundations as well as public funding programmes interested in driving sustainable blue growth innovations

The *Alliance* seeks sponsors and supporters to fund excellent **fully-customised mentoring and service provision** to cases driven by cases' needs and thus boost innovation capacity in the region(s), create new opportunuties. Also, *Alliance* seeks for strategic **funding** to enable background operations, such as the very successful and influential ***Alliance* Mentor's Forum** that is THE blue biotechnology innovation community of experts supporting each other and the cases, and the ***Alliance* Blue Detectives** that provide visibility of *Alliance* services and scout 365-24/7 for new *Alliance* cases. Both actors played a huge role in the *Alliance* and worked so well, that we strongly aim at continuation of these services, which have become the heart of the *Alliance*.

If you are interested to hear more and support our activities, please visit the SUBMARINER Network website or follow us in the media. The updated SUBMARINER Network portal will be available from September 2019.

https://www.submariner-network.eu/

https://www.submariner-network.eu/projects/balticbluebioalliance