SUBMARINER NETWORK

Baltic Blue Biotechnology
Alliance project (2016–2019)

Findings from the Alliance mentoring and accelerator programme

RECOMMENDATIONS
ON FUTURE ACTIONS
WITHIN BLUE BIOTECHNOLOGY
IN THE REGION

The Baltic Blue Biotechnology Alliance project was co-financed by INTERREG BSR (2016–2019).

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PREFACE

Blue Biotechnology is a key enabling technology for sustainable blue growth. Although considerable advances have been made in the sector in recent 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 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 contributes to setting the future research agenda as well as outlining the need for a permanent support structure.

With this report, we provide information and recommendations for the formulation of related future innovation policies as well as national and European funding programmes (ERA-Net, Interreg, BANOS CSA) in order to take the right steps in advancing blue biotechnology as a key enabling technology for blue bioeconomy in the BSR. We also aim to help R&D and support institutions throughout the Baltic Sea Region to strategically position themselves within the overall Baltic Sea region cooperation structure to achieve maximum complementarity and synergies. Finally, we recommend other cross-cutting solutions that enhance the region's innovation capacity, and we present our vision of the future of the *Alliance*.

In developing the set of recommendations, we analysed R&D capacities in the BSR (within the *Alliance* but also relevant capacities beyond it) as well as the current political framework. In doing so we took into account the profiles and needs of the variety of the more than 30 blue biotechnology SMEs and start-ups as well as infrastructures, which had enrolled in the *Alliance*, seeking assistance, and the ability of the current *Alliance* partners to respond to the service requests of these cases.

EXECUTIVE SUMMARY

The Baltic Blue Biotechnology Alliance project (*Alliance*) was developed in response to the 'EU Sustainable Blue Growth Agenda for the Baltic Sea Region'. Adopted by the European Commission in May 2014, the agenda provided the blueprint for harnessing the region's strengths to boost innovation and growth in its maritime sector.

Whilst it recognised the significant potential of blue biotechnology for the region, it also showed that the sector was still immature. Actors, expertise and resources within R&D were scattered across the region, working in isolation, with hardly any tangible products on the market.

A more strategic approach for development across the Baltic Sea Region was needed.

As will be shown in this report, the *Alliance* has achieved this.

By pooling the available national capabilities, not only has it enabled start-ups, spin-offs and SMEs access to the variety of facilities, resources and expertise available throughout the region and beyond. Most importantly, the systematic transnational science-business cooperative approach has led to many new product developments. They bear witness to the enormous business potential inherent not only within the specialised field of blue biotechnology, but also the wider sphere of the blue bioeconomy. Still more, the products showcase the contribution of the sector to the sustainable development of the Baltic Sea Region.

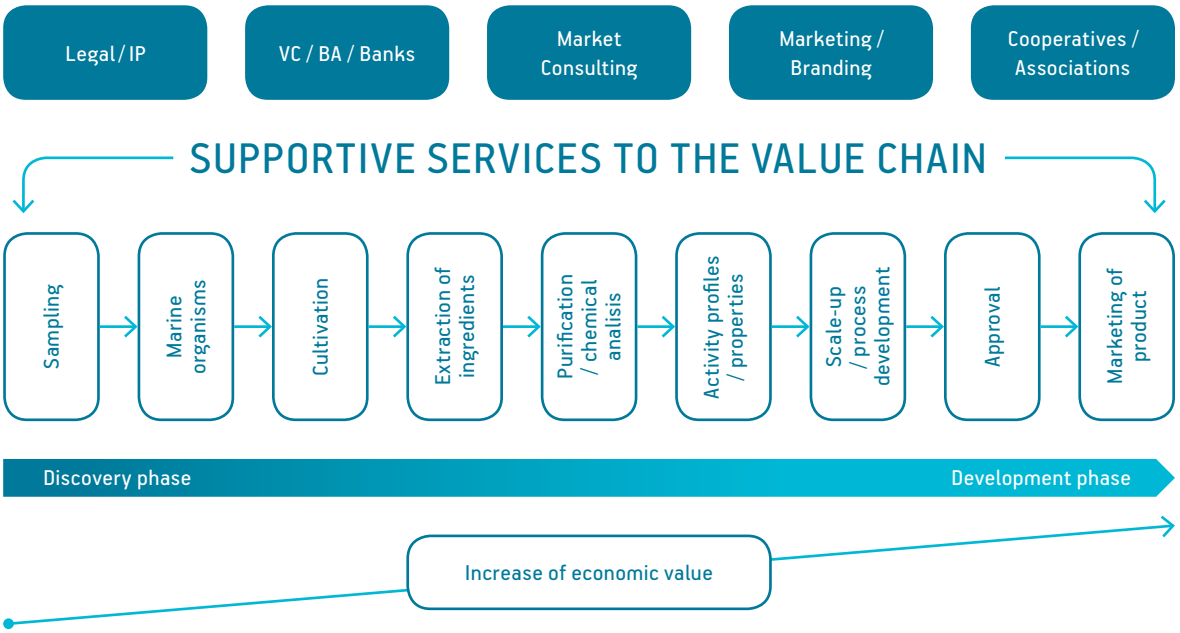

Figure I Blue biotechnology value chain – SUBMARINER Network.

This report presents the setup and the achievements of the past three years of work within the Baltic Blue Biotechnology Alliance (Interreg BSR 2016-2019) project, the associated lessons to be learned and recommended next steps.

In addition, the report comprises **recommendations for a future pan-Baltic research agenda**. These are based on the **analysis of the competences, resources and interests of the region's major blue biotechnology RGD institutions**; their **projected RGD needs and foresights** within blue biotechnology in the region as well as the **recorded innovation barriers** experienced during the *Alliance*'s **work with real client cases**.

The set of recommendations is intended to serve as a useful guide for the development of macro-regional innovation strategies; the respective (national and macro-regional) future RGD funding programmes such as BANOS as well as for national academies of science and individual RGD institutions considering their own strategic positioning in the region.

Background and motivation for initiating the Baltic Blue Biotechnology Alliance project

Overall, the Baltic Sea region is well placed in using blue biotechnology as a driver for its blue economy development:

- Blue biotechnology is part of many high-level strategies and policies, such as UN Sustainable Development Goals, the EU Blue Growth Strategy, the Marine Biotechnology Strategic Research and Innovation Roadmap, the EU Bioeconomy Strategy or the European Blue Bioeconomy Roadmap. The Nordic Bioeconomy Roadmap as well as many national strategies throughout the Baltic Sea Region build on these strategies.
- The marine biodiversity of the Baltic Sea region – with its considerable salinity gradient, shallow waters and ice-cold winters – provides great untapped potential for exploration.
- Local – and global – markets already display a demand for products based on aquatic resources in various economic areas such as food, cosmetics, and pharmaceutical products. Moreover, sustainable, climate-smart, fact-based innovation is becoming the new norm for blue biotechnology start-ups and SMEs.

- The BSR has strong R&D expertise in the fields of blue and industrial biotechnology, marine biology, chemistry, and chemical engineering and is pioneering in basic and applied science as well as technological development. Baltic Sea Region research institutions have been partners in at least 17 transnational EU research and innovation projects (Horizon2020, EASME, ERA-Net, BONUS or Interreg).
- To meet the educational demands of a changing economy, there is increased interest within BSR institutions to develop and offer advanced education programmes for future scientists and bioentrepreneurs.

However, in the highly specialised and research-driven blue biotechnology sector, individual Baltic Sea Region countries still do not have all the capacities and resources required to form the complete value chains needed in turn to realise full-scale commercial product development (Figure I). This was first observed in the SUBMARINER Roadmap (2013). The BSR needed a networking platform to create the critical mass of actors to converge and convert science outputs into marketable products.

As a response to this need, the *Alliance* project was set up under the auspices of the SUBMARINER network. Led by GEOMAR Helmholtz Centre for Ocean Research Kiel, the consortium originally consisted of 26 project partners. These included some of the major research institutes of the region, business and technology parks, an initial group of SMEs as well as the SUBMARINER Network secretariat as the main communication and coordination hub.

Over the course of three years, these partners developed an **accelerator programme** that carries out the continuous search for "cases"[1]; pitching and matchmaking events as well as a **mentoring programme with a flexible service offer**, which was piloted with all 26 case studies.

As a matter of fact, one of the most important elements of work in the *Alliance* was that all partners acted as "**blue detectives**". They continuously and proactively looked for interesting potential actors with disruptive blue biotech ideas. As a result, 16 more cases applied and were admitted to the mentoring programme – **resulting in a total of 26 cases**.

1 Service receivers, i.e. companies, spinoff projects of universities, municipalities etc. with a new business idea.

Among the 26 *Alliance* cases, 17 were companies, five were affiliated with research institutions and four belonged to other organisation types such as municipalities. Cases originated from all around the Baltic Sea Region (and beyond, with one case coming from the Netherlands). This highlights the overall success of the recruitment strategy and the plethora of innovative blue biotech ideas (see Figures II, III, IV and V). Cases enrolled in the *Alliance* joined at all stages of the value chain, from bioprospecting to full commercialisation. 66% of cases used algae as a biological resource for developing their products. Products targeted a broad spectrum of market applications, from food and food supplements to healthcare and cosmetics, bioremediation, materials, and energy.

Beyond the general mentoring support, specific support was given to cases in communication and promotion (22 cases) and scientific/ technical support (20 cases). This shows the high 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 at different types of events (13 cases). The least frequently requested support category was legal advice (7 cases).

Findings from three years of *Alliance* mentoring practice

Without 'blue detectives' – no new cases:

- In contrast to the world of IT start-ups, the community of potential new blue business cases with people behind them who really want to act as entrepreneurs rather than researchers, is very small. Before being able to assist any kind of new blue business ideas, all *Alliance* members had to intensively and **pro-actively search for good potential cases**.
- The experience of the various recruitment activities showed that even in times of border-crossing interdisciplinary social networks, **individual personal contacts are indispensable to lower barriers and create mutual confidence**.

Finding the right mix of mentors is crucial:

- Cases were always assigned to **two mentors: one main mentor acting as the national contact point to the**

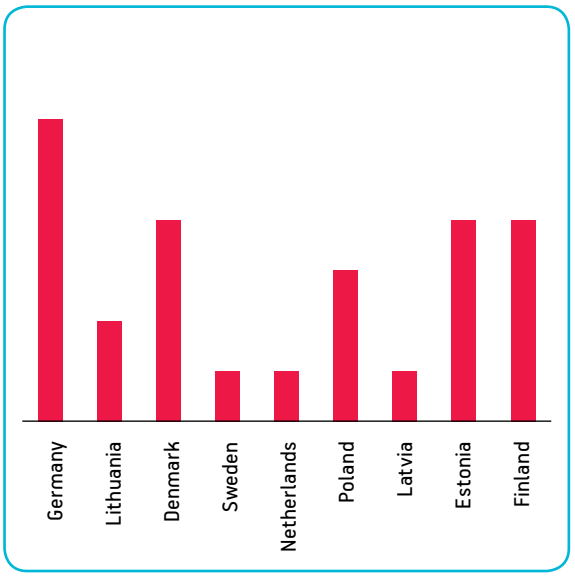

Figure II Country of origin of cases.

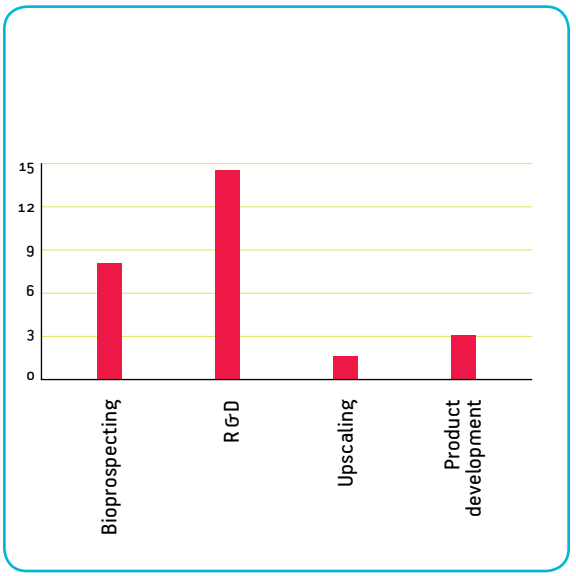

Figure III Value chain stage of the cases when entering the Alliance following the simplified value chain stages.

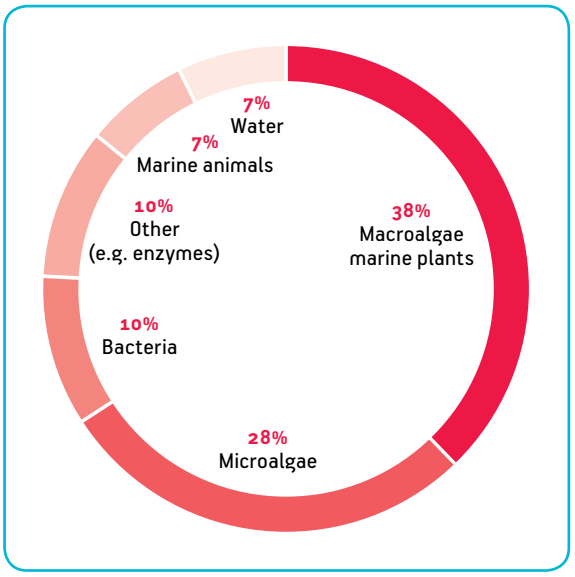

Figure IV Used biological resources for product development.

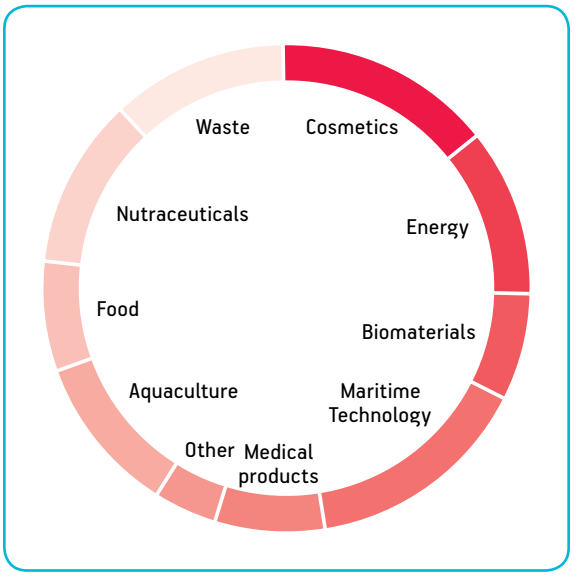

Figure V Target markets of offered products.

case and the second coming from the most relevant field of expertise for the case. One of these two mentors conducted an initial assessment of the respective scientific, technical, and business potential and the related needs of the case. Following this, the main mentor introduced the case to the various possibilities of support offered by the *Alliance* and acted as mediator between the case, the other mentors from the *Alliance* network (the mentors' forum) and the other cases.

- **Mentoring works best when the mentor is genuinely interested in the cause of a case,** leading to a win-win situation for both parties.
- Often **cases can best help each other**. Rather than seeing each other as competitors, cases gain from collaboration with fellow entrepreneurs throughout the region in order to jointly create the market conditions necessary for their individual success.

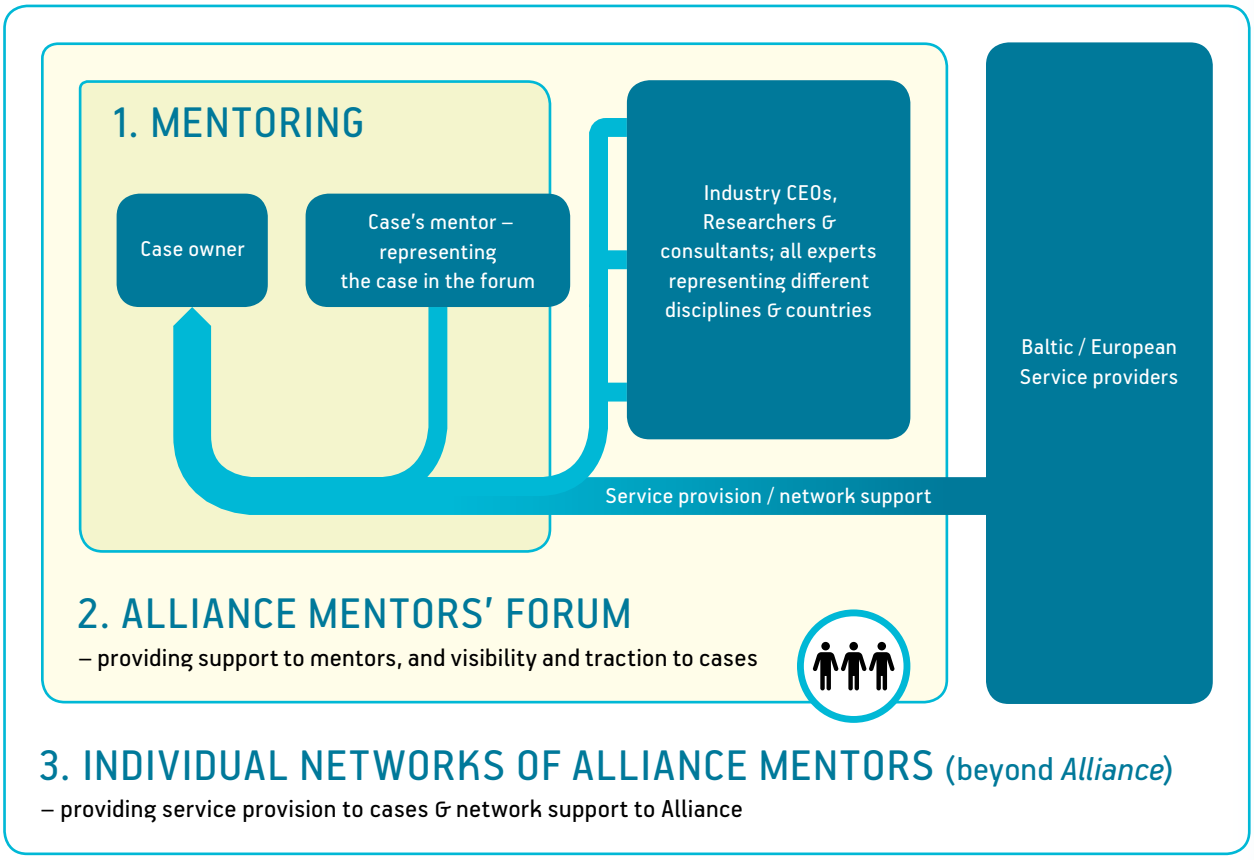

Figure VI Scheme presenting the mentors' forum of the *Alliance*, and relationship with a case.

- Even **the initial assessment often proved to be a crucial service** to cases, often initiating a refocus of their initial business idea and strategy – and thus saving them a lot of expensive 'learning' time.
- **One mentor on their own will often not be able to meet the demands of a case**; a genuine network of cross-disciplinary expertise is required as to guide a case through the entire product development value chain.

Networking and matchmaking among blue specialists are in high demand by all:

- The networking of cases and mentors facilitated by the SUBMARINER Network secretariat through **regular telephone conferences (the mentors' forum)** enabled *Alliance* cases and mentors to efficiently present themselves, interact with peers and search for partners (Figure VI).
- Whereas initial and follow-up activities could be settled through virtual communication forms; these **cannot replace physical meetings and get togethers**, which are essential for pitching, matchmaking, valid assessments and creation of true partnerships.
- **Matchmaking led to partnerships across all elements of the value chain**, from biomass sourcing to necessary equipment to market access. Against this background, it is critical to understand the *Alliance* as part of the SUBMARINER Network, offering transnational networking across all bioeconomy sectors and actors. Even though scientific/ technical support often requires specialised blue biotechnology knowledge, the matching of partners covers a much greater span.

Scientific/ technical support forms the heart of the transnational *Alliance* service:

- The most important and unique feature of the science-business partnerships, created through the match-making services, was the fact that the **scientific / technical support was 100% tailored to the needs of a case**.
- As foreseen in the needs analysis for the initial *Alliance* project, provider(s) of the scientific or technical

expertise were often **experts and infrastructures from another country**.

- Whereas within the *Alliance* project duration it was possible for scientific institutions to offer such services as 'part of the project', it remains to be seen how details on service delivery or access to infrastructure and biomaterial can be negotiated between cases and the given mentor or service provider on transnational basis outside a specific project framework. Such contract negotiations often prove to take up a lot of time as they are outside the realm of responsibility of the people directly involved.
- The **biological resources** available at *Alliance* partner institutions represent a unique and unequalled resource due to the variability of organisms and the grade of specialisation on brackish and Baltic Sea organisms. As will be shown later, substantial efficiency gains can be achieved from maintaining and expanding an overview on what is available in which institution for further research.
- Those cases dealing with larger marine organisms (e.g. macroalgae or mussels) are not so much in need of such biobank samples, but **of access to large scale biomass** in view of commercial production. With the *Alliance* being part of the larger SUBMARINER Network, valuable contacts could be created between relevant biomass producers and cases in need of this biomass.

Business awareness raising and development services are also vital in early stages of the product development chain:

- There are not many experts who unite blue biotechnology expertise and business know-how in one person (and are also ready and willing to act as a case mentor). To remedy this skills gap, the *Alliance* developed a quick business assessment guide and trained its mostly scientific mentors on how to apply it in their work with cases. Thus, the *Alliance* is also important in raising capacities within universities or research institutes by sensitising their staff for potentially good spin-off ideas.
- In future, it is the ambition to recruit **more business service providers** and entrepreneurs to join the *Alliance* so as to address the demand for business development expertise by cases.
- Furthermore, the *Alliance* will continue to **create, sustain and intensify collaborations with other existing accelerators**, such as the BlueBioValue accelerator of the Portuguese BlueBio *Alliance* or the various programmes under the EU Blue Invest Platform. It is important, however, that these institutions and programmes not only recognise but also contribute towards the important work undertaken by the *Alliance* in searching for and preparing cases to become 'investment ready'.

Templates on common legal issues – but individual expertise required on case by case basis

- The recruitment of an expert for awareness raising on legal issues and development of a training material package comprising **templates and guidelines for contracts**, IPR protection, and mutual agreements were equally beneficial for cases and mentors.
- These templates now provide the basis for e.g. the basic **agreement between mentors and cases** in view of 'non-disclosure', which is the pre-condition for a good mentor-case relationship.
- Further legal support has, however, so far proven to **differ from case to case**.

The *Alliance* mentoring & service offer mix has been proven to accelerate concrete blue biotech product development

- With the help of the *Alliance*, three cases were able to **commercialise newly developed products** (Baltic Probiotics, Furcella, and KosterAlg) and two cases had ready prototypes (CRM and Biome).
- Three more cases won prestigious **innovation awards**; enrolled in international accelerators and succeeded in **securing further investments** (Vetik, SFTec, and Hoekmine).
- More than half of the *Alliance* cases have concluded **partnership agreements with suitable partners** across their value chain, within as well as outside of the *Alliance* network.
- **All partners reached the next technology readiness level**

The *Alliance* has successfully established and piloted a new niche innovation and product development support mechanism operating across borders in the BSR.

Figure VII The size of boxes corresponds to the number of *Alliance* cases contributing to the different UN Sustainable Development Goals (SDGs).

Supporting the Alliance cases means supporting the UN SDGs

- The *Alliance* has developed a set of criteria for taking cases on board, which puts strong emphasis on the factor that their new blue economy idea should be not only innovative, but also meet all sustainability criteria.
- As shown in graph VII, all cases truly contribute to advancements in reaching the UN Sustainable Development Goals.

Recommendations for advancing R&D within blue biotechnology in the BSR

In addition to working with 26 cases, **the *Alliance* surveyed 24 participating R&D institutions in the Baltic Sea Region with a view to their competencies, activities and interests in the field of blue biotechnology**. Even though non-exhaustive, the analysis provides a good snapshot of the existing technological expertise, know-how, and biological resources as well as R&D focus areas including applied science.

A wide spectrum of competencies, resources and interests are available 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 bacteria (for example marine bacteria, cyanobacteria) for a number of applications from food and feed to highly specialised markets and bioremediation.

Finally, the *Alliance* assessed the current strengths and opportunities of the Baltic blue biotechnology research, development, and innovation ecosystem according to the five thematic areas of the Marine Biotechnology Strategic Research and Innovation Roadmap.

The resulting recommendations focus mainly on the initial R&D stages of product development chains, but some innovation opportunities are also included:

1 **Access to aquatic biological resources:** Baltic marine and freshwater ecosystems host a thriving biological diversity of organisms, including fungi, micro- and macroalgae, bacteria, sponges, and mussels. Access to existing biological culture collections (e.g. microbial biobanks, microalgae collections), different types of biological resources in nature (e.g. macroalgae) or as yet undiscovered bioresources can open possibilities for collaboration and further advancement across the value chain.

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 institution.

Recommendation: Further integration of culture collections for creation of a master BSR-wide catalogue as well as the connection of the *Alliance* with other EU blue biobanks is highly important to avoid generating parallel structures. Moreover, further training and well-trained personnel are necessary to accomplish the implementation of the Nagoya Protocol, regulating transnational access and the benefit-sharing of biological resources.

2 **Sustainable integrated biomass production systems relevant for the Baltic Sea Region:** Aquaculture and blue biotechnology are two distinct but highly intertwined sectors. Aquaculture can supply blue biotechnology with primary (e.g. macroalgae, fish, molluscs) and secondary resources (e.g. industrial processing biogenic residues and side-streams) – whereas blue biotechnology is crucial in all steps from growing biological resources (including fermentation, ecology engineering) to recovering biomaterials from process side-streams. Therefore, the *Alliance* covers both sectors.

Recommendations: Further R&D needs have been identified in sustaining and further developing knowledge in:

- Production and processing of aquatic biological resources into added-value products, technology upscaling, as well as biorefinery technologies to minimise waste.
- Recirculating Aquaculture Systems (RAS) for land-based fish production combined with microalgae culture, vermiculture, insect production, or aquaponics have been suggested for recycling nutrients and minimising water exchange.
- Integrated Multi-Trophic Aquaculture (IMTA) systems combining fish farming with mussels and/or seaweed are currently under development in many countries, but there are still numerous open questions about how to best to realise such combinations.
- Improved understanding of the environmental and socio-economic benefits, risks, and opportunities associated with integrated aquaculture technologies, also at a larger scale.

Furthermore, there is a need to foster inter-disciplinary and inter-technological collaborations both in applied science but also for developing auxiliary technologies for scaling up the aquaculture sector. In particular, suitable production systems should be identified as well as biomass harvesting, processing and biorefining technologies in cold, shallow, brackish BSR waters, also at scale.

3 **Design new materials supporting the circular economy:** On a global scale, we are facing a shortage or an increase in the cost of many raw materials. In addition, materials are produced that withstand degradation over long time scales and may harm the environment.

Recommendations: Recycling and circular economy concepts (along with more responsible consumption) need to be facilitated, and traditional industries should adapt to these challenges. When carefully planned and used, redirected side-streams can be a resource for biotechnological use. For example, nutrient-rich wastewater can be used to cultivate algae or shellfish for energy or other added-value products and simultaneously clean the water. The excess biomass could be used as a fertiliser in agriculture. Bioremediation technologies that can contribute to cleaning water or scavenge for nutrients and carbon should be studied in more detail. The political framework for providing

ecosystem services, for example in bioremediation, should also be improved.

4 **Align blue biotechnology RGD with product market trends, challenges and opportunities:** Linking RGD with innovation pathways and market applications at an early stage, for example at the bioprospecting stage, can accelerate product development. It also increases the cost efficiency of RGD by reducing costs and minimising risk of failure. Support structures like the *Alliance* are able to bridge the gap between technological innovation and RGD on a transnational level. The *Alliance* also accepts companies that are at the pre-seed stage and still need to develop a minimum viable product (MVP). This stage already needs considerable financing for RGD, e.g. to develop and test a prototype.

Recommendation: Since the sector is so small, it is very important that clusters organise matchmaking events, thus bridging the gap between universities, research institutes, large industry, SMEs, and start-ups. Although hackathons and short-term matchmaking facilities serve their purpose in boosting innovation, these have to be embedded within more long-term continuous mechanisms which follow a structured development pathway and provide a safety net that fosters ideation and risk-taking by start-ups and SMEs.

The *Alliance* accelerator programme, supported by the interdisciplinary mentors' forum, fills this gap with its 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 provision of quality support and further enhancement of innovation capacities in the BSR.

5 **Mapping capacities and resources to boost blue biotechnology RGD and innovation in the BSR:** Blue biotechnology is an emerging field with great potential. However, it is still in a pre-development stage. A long road is still ahead to develop the sector further and scale up production and markets. The *Alliance* developed a database for cataloguing multi-purpose research infrastructure available to *Alliance* RGD institutes and companies. The analysis showed that the BSR lacks multi-use, open access, pilot-scale facilities relevant to (blue) biotechnology, which makes it difficult to test, validate and de-risk innovation at scale. Some large-scale facilities exist, such as the Kalundborg Forsyning photobioreactors, but they are often not accessible and others are not modular.

Recommendation: The *Alliance* database of relevant blue biotech experts, institutions and their infrastructures is a critical resource for creating product development chains. The mapping of multi-use, open-access, pilot-scale facilities should be expanded, and visibility of and accessibility to facilities be enhanced. Furthermore, the database should be connected with other similar database tools in Europe to increase visibility and access to end users and boost returns of capital investment into infrastructure.

Eight cross-cutting recommendations for the continuation and expansion of the *Alliance* (Vision for the *Alliance*)

A critical mass of blue biotechnology actors and activities is necessary for sustainable development and support of blue biotechnology innovation in the BSR. To tackle innovation challenges, intensive clustering is needed. Even though national blue bioeconomy clusters are slowly evolving also at sub-regional or national level[2], there is also the concrete need for tight and unimpeded transnational collaboration between these actors and activities in order to enable cross-fertilisation of ideas and support of this highly specialised sector. Transnational network hubs play a key role in connecting partners and creating complete value chains, transferring the technologies, creating innovation banks, and fostering cross-cutting innovation.

The *Alliance* network's functionality is a result of good tools but also the hard work and expertise of the blue detectives and mentors to reach out, expand, and invite their networks into the *Alliance*. This was only possible because blue detectives and mentors had a personal interest, availability, capacity, and support for reaching out.

2 Examples are in Germany the "BaMS" association (a 5-year long innovation project on "Bioeconomy at Marine Sites" financed by the Federal Ministry of Education and Research) and in Sweden the 'National Blue Economy cluster at the Marine Station Kristineberg'.

1 Enlarge and broaden the *Alliance* network

As noted above, it is important to continuously broaden the scope of the *Alliance* partnership to intensify collaboration and incorporate:

- The additional set of 15-20 RGD institutions active throughout the Baltic Sea Region in fields relevant to blue biotechnology,
- The relevant business support institutions including incubators and technology parks,
- The general 'spin-off' and 'start-up' assistance offices, often being part of the universities or chambers of commerce, so as to raise their awareness that they can send any relevant 'blue clients' to the *Alliance* accelerator,
- Companies, who are the potential end-users and/ or clients for the start-ups and SMEs in view of blue biotechnology products and services developed,
- Business angels, funding agencies as well as investors to provide the necessary finance to the start-ups and SMEs.

2 Continue to integrate outputs and results from specific research projects

It is vitally important to jointly capitalise on knowledge generated in the *Alliance* and other projects, especially topic-specific knowledge, by integrating tools and findings into the knowledge base of the *Alliance's* 50+ partners. The SUBMARINER Network, acting as an umbrella "blue cluster" coordinating the *Alliance* actors, leverages generated data and knowledge for triggering future action, empowering key actors to make knowledge-based decisions. Supported through the Blue Platform project (2018–2021, Interreg BSR) and coordinated by the SUBMARINER secretariat, members currently analyse and combine findings of several thematic BSR-related "blue bioeconomy" projects, including the *Alliance*, to increase visibility of project achievements as well as providing recommendations for alignment of future funding and legislation.

3 Continue to remove communication barriers among actors across the value chain

As already pointed out by the ERA-MBT project, lack of communication among actors across the value chains can be a major innovation barrier. As part of the ERA-MBT, a tool was also developed called "Preferred mechanism for bringing ideas to market" with the aim of addressing the communication challenges among the actors in the value chain[3] and improving communication, thereby increasing the success rate of cases. The tool is currently integrated into the 'training package for mentors' under the currently ongoing follow-up project Alliance+.

Indeed, mentors have an important function as mediators and translators between the various actors across the product development chain, as match-making can only work out if the various actors involved properly understand each other's needs and expectations.

Experience shows that communication barriers do not only exist among actors from different countries or between researchers and entrepreneurs; but also between different science disciplines. Even though the *Alliance* has already managed to improve this communication and thus accelerate innovation development, more work still needs to go into streamlining expectations, communication and language between the actors.

4 From project to a continuous transnational blue assistance programme

The SUBMARINER Network plays an important role in coordinating efforts towards knowledge integration on a more systematic and long-term basis.

On the political level, the current update of the EU Strategy for the BSR (EUSBSR) and HELCOM Baltic Sea Action Plan, which in turn will influence the future ERA-Net, Interreg, and BANOS funding programmes – are creating an important foundation to enable the long-term continuous support ecosystem. With that in mind, we highly support any move that would allow more extended durations of support projects from currently three-year periods to longer durations (e.g.

3 http://www.marinebiotech.eu/communication-guidelines

within Interreg). Such longer projects would enable a continuous absorption of benefits across all relevant actors in the Baltic Sea Region.

The business plan scenarios developed under the *Alliance* project show that it may be financially possible to continue providing basic network and matchmaking services on a small scale and on a self-sustained basis through contributions from the network members. The sustained operation of the accelerator services will, however, require strategic public or private funding.

Many of the funding possibilities are regional, which may prevent the use of transnational value chains. An inter-regional funding pool could solve this problem. For example, a transnational fund based on common challenges and animating RIS3 priorities could be made available for flagships. SUBMARINER Network as a flagship already has the mandate to help the EUSBSR reach its targets, but is not receiving strategic support and operates through collecting membership fees and participating in public-funded projects (Interreg, Horizon); a common fund could support operations of the flagship.

Furthermore, a trans-national innovation voucher system would benefit blue biotechnology start-ups and SMEs in the BSR and beyond, as it would allow financing the *Alliance* acceleration services. The innovation voucher system could be financed by European Regional Development Funds from the Baltic and Nordic regions and states. A new mechanism has been examined by the EU since 2018 and is fully aligned with Research and Innovation Smart Specialisation Strategies (RIS3). It is called #Component5 and is a promising opportunity that would enable the long-term existence of the *Alliance* and its innovation support ecosystem, currently not covered by any transnational funding scheme.

5 Funding the *Alliance*, its mentors and cases, is an investment into the sustainable development of the BSR

The *Alliance* has shown that the support services developed really do accelerate blue economy business development throughout the region. They have also proven to be of high value to the research itself – in view of providing a continuous feedback on what is required by the market and society. Moreover, as shown above, all cases contribute to the achievement of the UN SDGs within the region.

Financing the *Alliance* is therefore an investment of the Baltic Sea Region countries into their future.

6 Increase and improve coordination and cooperation with other blue accelerators

In parallel to the SUBMARINER Network and the *Alliance*, numerous new niche networks and specialty accelerator programmes exist or have emerged since 2016. Instead of creating yet another network infrastructure, intensification of collaboration between existing accelerators appears to be the most pragmatic way forward. The *Alliance* has already teamed up with other spear-heading networks, such as the EMBRC-ERIC, BioMarine, and the BlueBio *Alliance* of Portugal. The *Alliance* plans to intensify these existing collaborations in the near future and is open to new ventures.

7 Strengthen education and training in blue biotechnology and blue entrepreneurship

Currently, few training possibilities exist for scientific fields within blue biotechnology – mainly there are options for separate courses or specialisation options as part of biotechnology programmes.

- More high-profile educational programmes are needed to teach the relevant methods and techniques and encourage the young generation to engage in blue biotechnology. The inspiring success stories of the BBMBC[4] or ACES[5] programmes should have a beacon function and may lead to similar future initiatives in the BSR.
- Additionally, more bio-entrepreneurship education opportunities are recommended for future managers and business developers. This is especially relevant for important biotechnology city-clusters, for

4 The "Blue Biotechnology Master Course for a Blue Career" (BBMBC) was an EMFF funded project (2017-2018), which developed a Master's degree in La Rochelle University addressing skills gaps in the Blue Biotechnology sector in Europe

5 ACES was an Erasmus Mundus two-year Master's Degree in Aquaculture, Environment and Society.

example in Kiel, Tartu, or Helsinki, thus copying the success of Copenhagen Business School.

- Finally, we identified there is a lack of basic knowledge, especially connected to the harvesting, purification, and extraction of biomass among non-research professionals / workers.

8 Prepare a 'blue economy' funding guide

Actors along the (blue) biotechnology value chain are dependent on different types of financing. Financing depends on the specific needs (e.g. R&D, prototype development, upscaling, etc.) and funding sources can have geographical restrictions. Therefore, a **funding guide** within blue biotechnology would be of great value to assist the actors in finding appropriate funding solutions for their specific needs.

The *Alliance* from Project to Service Offer: SUBMARINER Network

The *Alliance* is a 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**, including start-ups, SMEs, business support organisations and R&D, and as a business accelerator programme for product development. The *Alliance* comprises more than 50+ actors who are experts in blue biotechnology providing services.

For the upcoming 18 months until January 2021, a selected number of core partners from the original *Alliance* will recruit relevant blue bioeconomy actors to join the *Alliance* to offer as well as receive services, and make *Alliance* financially sustainable by receiving funding for its services offered from sources other than Interreg.

Capitalising on the achievements and progress of the past years, we therefore continue to search for new *Alliance* members as well as cases. Through a whole series of pitching and matchmaking events and joint conferences throughout 2019 and 2020, we will provide numerous opportunities for new cases as well as *Alliance* members to present themselves and to familiarise themselves with the existing *Alliance* network.

Applications are welcome by institutions as well as individual experts:

- Business parks as well as other accelerator and innovation programmes
- Specialists in business development and financing support, marketing and communication companies and experts as well as legal advisors, all interested in blue bioeconomy
- R&D institutions as well as potential spin-offs with suitable technical facilities, biological resources, scientific expertise
- Mentors, business coaches with experience and ability 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

Strategic partners are sought to support our *Alliance* platform and "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 and **fully customised mentoring and service provision** to cases. Also, the *Alliance* seeks out strategic **funding** to enable background operations, such as the very successful and influential *Alliance* **mentors' forum** and the *Alliance* **blue detectives** that provide visibility for the *Alliance* services and scout "around the clock" for new *Alliance* cases.

SUBMARINER NETWORK

To learn more visit:
https://www.submariner-network.eu

List of Abbreviations

ABS	Access and Benefit Sharing
BBI-JU	Bio-based Industries Joint Undertaking
BSAP	Baltic Sea Action Plan
BSR	Baltic Sea Region
DK	Denmark
DE	Germany
DG MARE	EU Directorate General for Maritime Affairs and Fisheries
EC	European Commission
EE	Estonia
EEIG	European Economic Interest Grouping
EMA	European Medicines Agency
EMBRC	European Marine Biological Resource Centre
ERA	European Research Area
ERA-MBT	The Marine Biotechnology ERA-NET
ERIC	European Research Infrastructure Consortium
EU	European Union
EUSBSR	EU Strategy for the Baltic Sea Region
FDA	U.S. Food and Drug Administration
FI	Finland
HELCOM	The Baltic Marine Environment Protection Commission (Helsinki Commission)
IMTA	Integrated Multi-Trophic Aquaculture
LCA	Life-Cycle Assessment
LT	Lithuania
LV	Latvia
MIRRI	Microbial Resource Research Infrastructure
MVP	Minimum Viable Product
NL	Netherlands
OECD	Organisation for Economic Co-operation and Development
PA INNO	Policy Area Innovation
PBR	Photobioreactor
PL	Poland
R&D	Research and Development
RAS	Recircular Aquaculture Systems
RIS3	Research and Innovation Smart Specialisation Strategies
SE	Sweden
TRL	Technology Readiness Level
VC	Venture Capitalists
WP	Work Package

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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"[6], is a highly promising sector in regard to the Baltic Sea Region (BSR). Blue Bioeconomy has the capacity for sustainably providing a plethora of bio-based products and services, thus developing blue growth by simultaneously maintaining and protecting the natural aquatic ecosystem. Key blue bioeconomy sectors include the emerging field of blue biotechnology in addition to aquaculture and fisheries.

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 the 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, which recommended a complementary series of actions required to achieve the ambitious SUBMARINER blue bioeconomy vision. According to this vision, **by 2030, bio-based 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 (2015) 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.

6 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

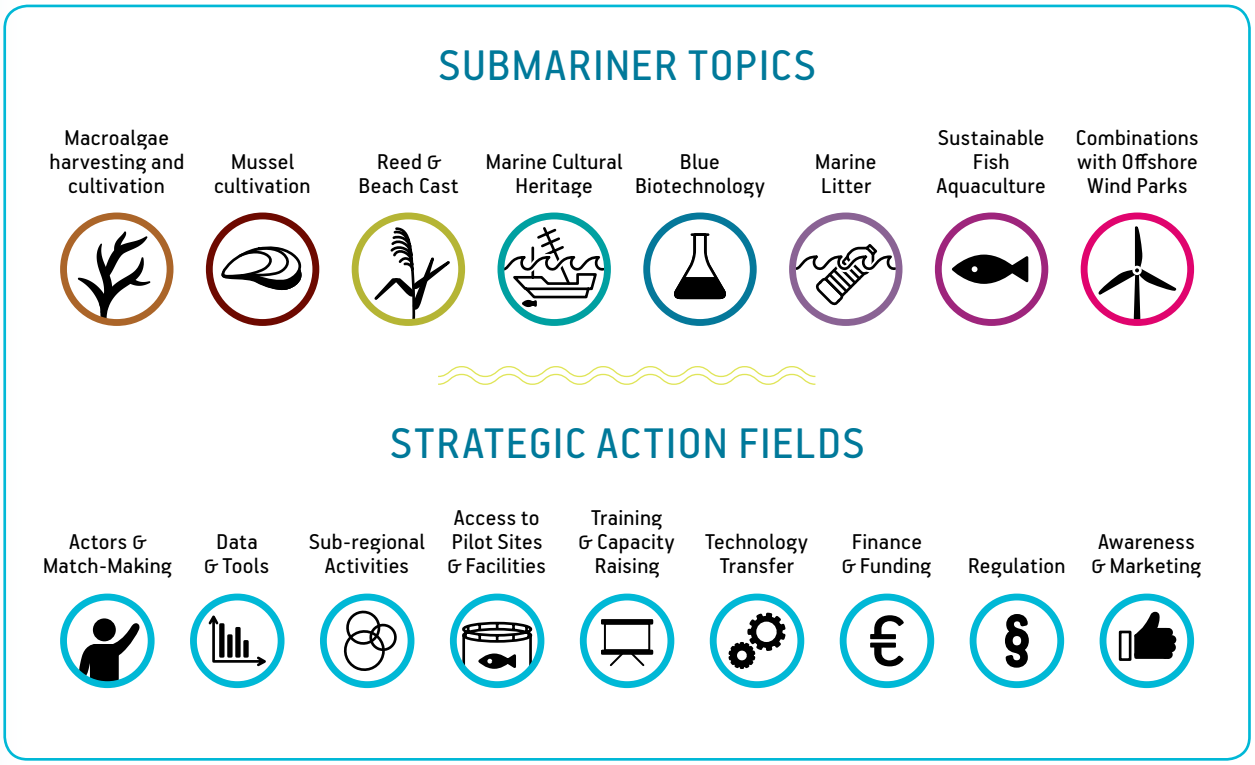


Figure 1 SUBMARINER Topics, as updated in 2019, based on topics 2013 of SUBMARINER Roadmap (2015).

Within blue biotechnology, the Roadmap suggested the following actions:

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

From that moment the idea for the Baltic Blue Biotechnology Alliance project was conceived, but it took two more years 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 the creation of a research network into a fully-fledged science-business cooperation. Emphasis was placed 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 bio-based 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 blue biotechnology value chains across the BSR. Moreover, by working with these cases, network partners would

be informed about the real needs of current and prospective companies right from the start, ensuring that the network would put emphasis on developing urgently needed services.

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 and analysing the RGD needs of the sector in the region, the aim being 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)[7] to be USD 1.5 trillion annually. This encompasses all ocean economy sectors including, for example, shipping, tourism, offshore energy, fisheries, and aquaculture, the latter two being crucial for livelihoods and the world supply of animal protein. Ocean economy is projected to grow up to USD 3 trillion in the 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[8]. Blue biotechnology is a highly promising key enabling technology that unlocks the potential for conquering new frontiers in research and innovation. It 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[9], and major growth for the sector is predicted based on increasing consumer demand for sustainable products including a great potential for the discovery of new drugs, biodegradable materials, and enzymes for industrial processes.

The blue biotechnology product portfolio ranges 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, a profitable and promising category of products derived by marine bioresources. They cover a wide range of substances searched and developed for cosmetics, nutraceuticals, and 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, for instance, macroalgae, are entering the market. Aquaculture farming is the new frontier in food production, yet there are challenges related to high nutrient loads and excess use of antibiotics. These can be solved by the development of Recirculating Aquaculture Systems (RAS), for example, minimalising water exchange and nutrient input into the natural environment and improving feed quality including the 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.[10] Compounds isolated from the Caribbean marine sponge *Cryptotethya crypta* provided the basis for development of the anti-leukaemia drug cytarabine in the 1960s and to the HIV drug Azidothymidine (AZT) in the 1980s, while a toxin purified from a cone snail from the

7 OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris

8 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.

9 Smithers Group: *The Future of Marine Biotechnology for Industrial Applications to 2025* (2015), quoted in EU Blue Growth Strategy (2017)

10 Lindequist U. Marine-Derived Pharmaceuticals – Challenges and Opportunities. Biomol Ther (Seoul). 2016;24(6):561–571. doi:10.4062/biomolther.2016.181

Pacific Ocean[11] led to the development of an FDA (2004)[12] and EMA (2005)[13] approved medication for chronic pain. So far there are several clinically approved marine-sourced drugs against cancer, viruses, and chronic pain, and several more are in late stages of clinical trials[14]. Moreover, cold-adapted enzymes mostly produced by extremophilic microorganisms have been applied in industrial processes to reduce process temperatures (stonewashing, meat tenderising). 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 increasing 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, and Novozymes that are 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, for example cosmetic lines, snacks, etc.

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 2013 Schleswig-Holstein developed a regional development strategy for blue biotechnology[15] to form part of its "Sea our Future" initiative.

Also, Denmark has set a national strategy for blue biotechnology[16], 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 (cf. Europa bio report on Swedish Industrial Biotechnology[6], and in Finland as well there is growing interest and activity towards marine biotechnology research and innovation.

In the background study to the EU Baltic Blue Growth Agenda (2013) almost all Baltic countries, including those with only very limited activities in the field of marine biotechnology (e.g. Poland), rated blue biotechnology 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)[17] 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)[18], the importance for further development of blue biotechnology was ranked highest among the four development fields

11 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.

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

13 https://www.ema.europa.eu/en/medicines/human/EPAR/prialt

14 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*

15 Norgenta North German Life Science Agency, DSN – Analysen & Strategien. Masterplan 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)

16 Havet – en uudnyttet ressource Fødevareministeriet 2010 (in Danish) https://mst.dk/media/91729/havet_en_uudnyttet_ressource.pdf

17 A Sustainable Blue Growth Agenda for the Baltic Sea Region (Commission staff working document adopted on 16 May 2014).

18 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

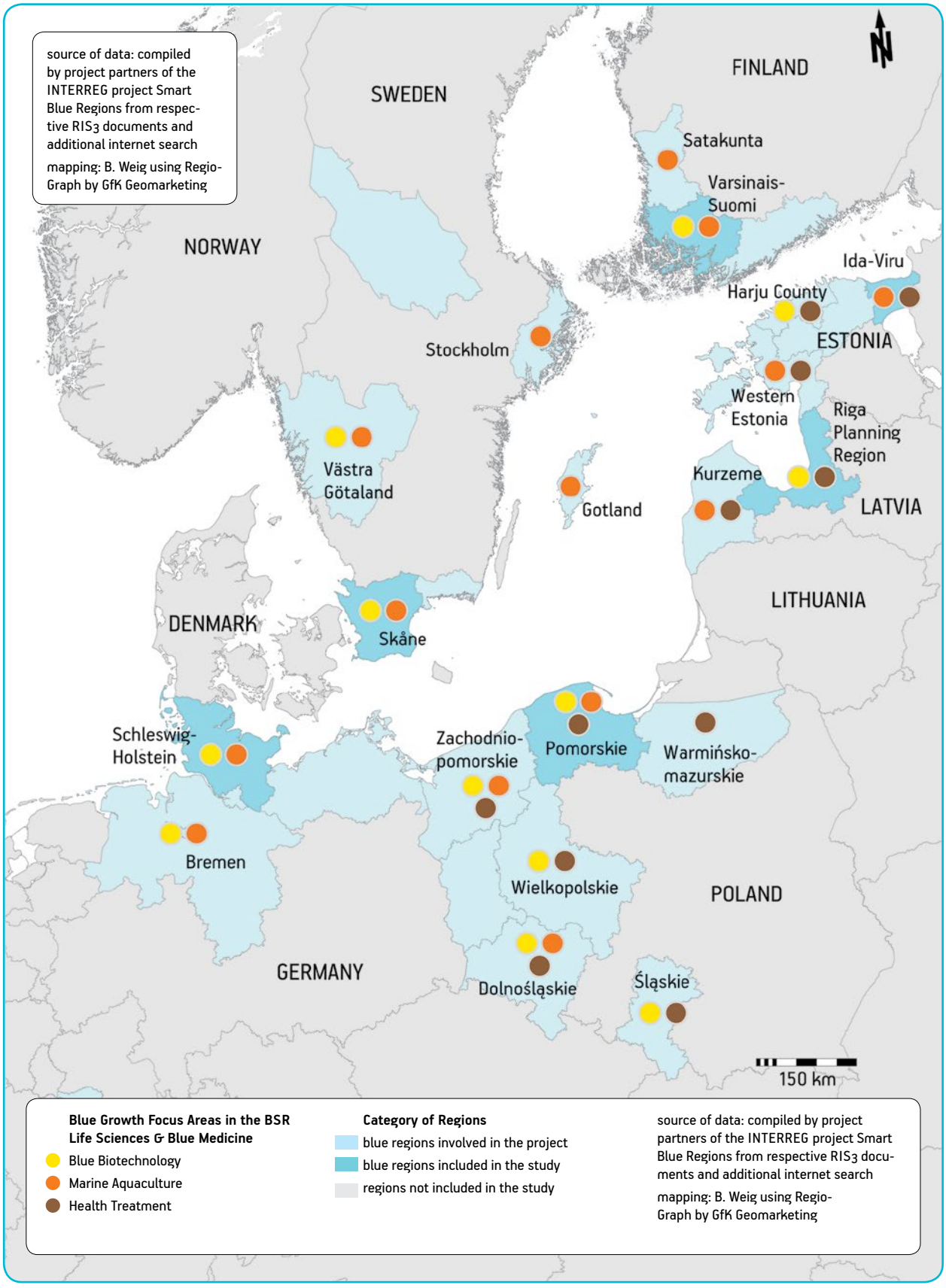


Figure 2 Blue Growth Focus Areas in the field of Life Sciences & Blue Medicine, based on an analysis of regional/national RIS3. Source: Smart Blue Regions project (Interreg BSR, 2019).

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 with, 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)[19]. The Baltic Sea is considered as a marine area largely suffering from eutrophication[20] and moreover, hazardous substances including heavy metals have been identified as a major problem in many Baltic Sea areas[21]. 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 the highest interest.

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 biotechnologies, and they are operating equipment and infrastructure for blue biotechnology (Chapter 3).

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 Figure 3, we observe RIS3 and selected fields of Blue Biotechnology among the Life Sciences & Blue Medicine sub-categories (yellow dots on the map).

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

19 http://stateofthebalticsea.helcom.fi/biodiversity-and-its-status/

20 http://stateofthebalticsea.helcom.fi/pressures-and-their-status/eutrophication/

21 http://stateofthebalticsea.helcom.fi/pressures-and-their-status/hazardous-substances/

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 the 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 a 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, 6) to conserve and 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"[22].

1.4.2 EU and Baltic Blue Growth Strategy

Blue growth (2017)[23] is a long-term strategy launched by the European Union to support and stimulate sustainable growth in marine and maritime sectors. It aims to achieve 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**.

The strategy has three main focus areas: 1) Development of sectors with 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[23].

Building on the EU-wide Blue Growth Agenda, the European Commission adopted the **"Sustainable Blue Growth Agenda for the Baltic Sea Region"**[24] in 2014, which puts focus on the Baltic Sea region's specific characteristics and strengths through which the full potential for growth and innovation of the region's maritime economies could be harnessed. It proposes a more strategic approach to the "blue growth" delivery through a dedicated agenda based on the following elements:

- Boosting innovation and sustainability.
- Developing skills and qualifications, cluster development.
- Using existing cooperation structures and multi-sectoral dialogue.
- Targeting maritime projects for access to finance.

Based on qualitative and quantitative analysis, the underlying study had identified short sea shipping, coastal and cruise tourism, offshore wind, shipbuilding, aquaculture, and blue biotechnology as the most promising sectors of the Baltic Sea region's maritime economy. They share a common characteristic in that their most successful actors are highly innovative, compete on European or world markets, have sustainability high on their agenda, and already generate or will in the future generate a significant number of jobs.

The results of the following systematic stakeholder dialogue, initiated by the European Commission in September 2016, focused on shipping, coastal and maritime tourism, environmental and monitoring technology, as well as the blue bioeconomy. Strategic Action Fields identified to drive the blue bioeconomy highlighted the need to work on regulation, communication, networking, and marketing; technology as well as finance and funding.

22 https://sustainabledevelopment.un.org/sdg14

23 https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en

24 A Sustainable Blue Growth Agenda for the Baltic Sea Region (Commission staff working document adopted on 16 May 2014).

1.4.3 Marine Biotechnology Strategic Research and Innovation Roadmap

The ERA-MBT research and innovation roadmap (2016)[25], according to its 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 for 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[25].

> ***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.***

25 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.

1.4.4 Blue Bioeconomy Roadmap

The Blue Bioeconomy Forum was an 18-month-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.

The 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[26]. 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"[27]. It should identify critical enablers and barriers to cross with regard to further 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)[28]. The study compiled a review of the status of blue biotechnology within the EU, construction of a stakeholder database and 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.

26 https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1349

27 https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1355

28 Study in support of Impact Assessment work on Blue Biotechnology (2014) EC EMFF

1.4.5 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 the development of sustainable legislation and actions for economic development. After implementing the bioeconomy strategy for five years, the EU funding for activities supporting bioeconomy has doubled.

An update in the bioeconomy strategy[29] was released in 2018 in which oceans and the role of blue bioeconomy are recognised to have strategic importance. Oceans are regarded to play a central role as a biomass supplier, for example for food and other resources, to cover the needs of an increasing global population. However, knowledge on marine ecosystems and their dynamics is limited compared to their terrestrial counterparts. 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 us to better assess and weigh opportunities and potential risks inherent to marine bioeconomic activities."

1.4.6 EU Strategy for the Baltic Sea Region

In 2012, the European Commission adopted the EU Strategy For the Baltic Sea Region" (EUSBSR), which has three main objectives – 1) save the sea, 2) connect the region, 3) increase prosperity[30] – that focus on the specific environmental challenges of the Baltic Sea. These challenges have been addressed and the potential solutions have been sought by both the EU-funded BONUS programme and by HELCOM, and they have been funded by Interreg BSR, which also directly supports coordinating activities of macro-regional cooperation. The process and progress of the EUSBSR is demonstrated by the flagships, which serve as pilot examples for the 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, PA nutri, and HA maritime spatial planning. The EUSBSR is currently under revision and an update is expected to be launched in 2020.

1.4.7 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 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"[31]. The BSAP can be relevant specifically to blue biotechnology with regard to its goals on eutrophication, i.e. for bioremediation applications. The BSAP is currently under revision, and an update is expected in 2021.

1.4.8 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, as well as 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, and inclusive economic development. To reach this vision the programme defines 15 action points under three thematic areas: Innovate – Accelerate – Network. The focus is on the development of new policies on a regional, national and Nordic level, for increased funding, better education, labelling and certificates, bioeconomy clusters, and several other areas"[32]. The strategy reflects the R&D and innovation needs of many technological fields including aquaculture, blue biotechnology, biorefining and recycling.

29 https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy

30 https://www.balticsea-region-strategy.eu/about/implementation

31 http://www.helcom.fi/baltic-sea-action-plan

32 https://www.norden.org/en/publication/nordic-bioeconomy-programme-0

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

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

1.5 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 a European as well as a 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 programme ever realised with nearly €80 billion of funding available to be spent in a seven year period (2014 to 2020)[33]. H2020 is a financial instrument, which aims to drive economic growth and create jobs. The goal is to ensure, that Europe produces world-class science, removes innovation barriers , and facilitates public-private cooperation to create innovation . **Blue Growth call** (H2020-BG-2018-2020) is part of the Horizon 2020 work programme (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."[34] Some funded blue biotechnology Horizon 2020 projects are: **MacroFuels** (2016–2019)[35] aiming to produce advanced biofuels from seaweed or macroalgae. 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[36]" aiming to use jellyfish as a source to combat marine litter.

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 in order 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[37]. Some funded blue biotechnology projects are **MACRO CASCADE** (2016–2020)[38], which 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)[39] 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)[40] 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)**[41] 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[42] 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

33 https://ec.europa.eu/programmes/horizon2020/what-horizon-2020

34 https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-food_en.pdf

35 https://cordis.europa.eu/project/rcn/199672/factsheet/en

36 https://cordis.europa.eu/project/rcn/214293/factsheet/en

37 https://www.bbi-europe.eu/about/about-bbi

38 https://www.macrocascade.eu/

39 http://www.aquabioprofit.eu

40 http://www.biosea-project.eu

41 https://cordis.europa.eu/project/rcn/222679/factsheet/en

42 https://ec.europa.eu/easme/en/life

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. **SUNALGAE**[43] is a project of a Swedish SME called Swedish Algae Factory. The project's main objective is to demonstrate a new, innovative algae material for enhancing the efficiency of silicon based and thin film solar panels. In addition to the traditional projects, there is a new project type, so-called integrated projects (IP). An integrated project is large-scale and is based on a regional or national plan or strategy[44]. The project started in January 2017 and is ongoing until the year 2024. The goal is to improve the aquatic environment, mainly in the middle Swedish waters that run into and affect Lake Mälaren and the northern Baltic Sea[45]. Ecopelag a project demonstrating large scale mussel farming for improving the state of the environment in the Baltic Sea[46].

The EMFF BlueEconomy 2018 call[47] 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 three topics that are part of this call for proposals: 1) Blue Labs: innovative solutions for maritime challenges. 2) Blue Careers in Europe. 3) Grants for the Blue Economy: investing in innovation. There were 108 calls submitted in total.

Blue Economy Investment Platform (DG-MARE)[48] is a three-year project contracted by EC DG-MARE and implemented by a consortium headed by PriceWaterCoopers and CARSA companies. 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 investment readiness". The project started in July 2019 and in the next three 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 section 1.3.3). The final conference, held in Oslo on 20–21 November 2017, was used as an 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**. As part of the ERA-MBT, a tool was also developed called **"Preferred mechanism for bringing ideas to market"** with the aim of addressing the communication challenges among the actors in the value chain and enabling the user to prioritise the tasks ahead, improve communication, and ulitmately increase the possibility that their product will be brought successfully to the market. The ERA-MBT initiative ended in 2017.

The subsequently launched **ERA-NET COFUND on the Blue Bioeconomy** – Unlocking the Potential of Aquatic Bioresources (BlueBio)[49], 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

43 https://swedishalgaefactory.com/project/eu-life-sunalgae/

44 http://extra.lansstyrelsen.se/lifeiprichwaters/sv/om-rich-water/Sidor/EUs-miljoprogram-life.aspx

45 http://extra.lansstyrelsen.se/lifeiprichwaters/sv/om-rich-water/Sidor/default.aspx

46 http://www.ecopelag.se/

47 https://ec.europa.eu/easme/en/news/blue-economy-call-187-million-available-funding

48 https://webgate.ec.europa.eu/maritimeforum/en/node/4388

49 https://bluebioeconomy.eu/

contribution in the range of €6.5 million. The co-fund, which was launched in September 2018 (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[50]. 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 their 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 the 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[51], there are **Baltic Blue Growth**[52] on mussel farming demonstration, **Smart Blue Regions**[53] on Blue Growth RIS3 Smart Specialisation Strategies of regions, and **GRASS** (2018–2021)[54] on capacity building in macroalgae production and use. Regular project calls are now closed. The **Blue Platform project** (2018–2021)[55] will integrate the innovation capacity of many sectors including blue biotechnology and aquaculture. This project 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 its website, "BONUS issues calls 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"[56]. 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 BAltic and NOrth Seas and therefore be renamed to BANOS (current Horizon 2020 CSA project to prepare BANOS framework[57]).

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. The Nordic Bioeconomy Programme was mentioned in section 1.3.8. 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

50 https://www.interreg-baltic.eu/about-the-programme.html

51 www.balticbluebioalliance.eu

52 www.balticbluegrowth.eu

53 www.smartblueregions.eu

54 www.balticgrass.eu

55 https://www.submariner-network.eu/blue-platform

56 https://www.bonusportal.org/about_us

57 https://www.banoscsa.org/banos_csa

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 afore-mentioned programmes and 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 Invest Platform is a promising new support mechanism for blue economy 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 initiative.

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 programme as well as Interreg and ERA-Net programmes).

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 with extended project durations. Such scenarios would have a positive impact on the absorption of benefits associated with building new support structures and mechanisms, such as the *Alliance* innovation platform and the SME accelerator programme, and establish a good potential for long-term process financial support.

1.6 Parallel blue biotechnology networks and clusters

The *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 the SUBMARINER Network, other networks have also evolved with slightly different scopes. 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 establishing and sustaining collaborations and partnerships with other important networking actors. The *Alliance* and the SUBMARINER Network wish to collaborate even more 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. The *Alliance* has established links to many of these organisations:

BioMarine[58] 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 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 financially supporting SMEs to attend these events, and by actively promoting its 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 **BlueBio Alliance** (BBA) is a non-profit Portuguese association founded in Cascais in July 2015. It includes all subsectors of the marine biotechnology value chain

58 https://biomarine.org/page/what-is-biomarine

in Portugal[59], "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 has so far launched two calls for their Blue Bio Value accelerator programme, and has collaborated with the *Alliance* by offering promotion, creating joint events, and in mentoring start-ups and SMEs. The BBA is involved in many ways in the *Alliance*: the Interdisciplinary Centre of Marine and Environmental Research (CIIMAR) in Porto represents a link between the *Alliance* and the BBA, since it is enrolled in the Portuguese BBA and is also involved as a mentor in the *Alliance's* mentoring programme. Moreover, the *Alliance* has also 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 the occasion of the European Maritime Day 2019 in Lisbon, both the *Alliance* and the BBA developed a joint workshop inviting four blue biotechnology cases, including the two *Alliance* cases Vetik (EE) and Hoekmine (NL), in which the case owners elaborated on the innovation barriers many SMEs face within blue biotechnology and what support they received from the *Alliance* and the BBA.

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

The **EMBRC-ERIC**[60] 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 relationship and by 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 four 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[61]. The EMBRIC consortium comprises 27 partners of four different types (academia, research institutes, non-for-profit organisations, and industry) from nine countries, among which five partners come from Germany.
- **Assemble Plus** is an EMBRC project[62] 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[63] that will establish a collaborative framework of shared services between the ESFRI Biological and Medical Research Infrastructures that will transform the European research community – from the 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.

59 https://www.bluebioalliance.pt/en_GB/

60 http://www.embrc.eu/

61 http://www.embric.eu/

62 http://www.assembleplus.eu/

63 https://www.corbel-project.eu/about-corbel/participants/embrc.html

- **EMBRC BioBank** (EBB) is a three-year project (2017–2020)[64] 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 governmental departments in Spain, Portugal, and the United Kingdom responsible for access to genetic resources – the Access and Benefit Sharing (ABS) and Competent National Authorities (CNAs). One of the *Alliance* mentors, 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)[65] is part of the Biomedical Science Research Infrastructure (BMS RI) ESFRI landscape. Currently, more than 40 public biorepositories and research institutes from 19 European countries collaborate to establish MIRRI as a European Research Infrastructure Consortium (ERIC) under EU law.

ScanBalt Health Region[66] is a flagship in the EU Baltic Sea Region Strategy like SUBMARINER Network. ScanBalt is a think tank, accelerator, matchmaking 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 a sub-group of ScanBalt would fail to address the whole range of blue bioeconomy actions.

PILOTS4U is a BBI project (2016–2019)[67] that 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, we strive to align activities with other BSR, European, and global clusters and networks, with the goal to integrate knowledge, exchange services (mentoring, service provision, promotion, knowledge gained), develop joint events, send the *Alliance* partners and cases to third-party pitching events and vice versa, 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)[68] 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.

64 https://www.bluebiobank.eu/

65 https://www.mirri.org/home.html

66 https://scanbalt.org/projects/scanbalt-health-region/

67 https://biopilots4u.eu/

68 https://www.submariner-network.eu/projects/blue-generation

In this chapter we introduced the blue bioeconomy and blue biotechnology networks and clusters in the Baltic Sea Region, analysed overarching strategies and funding programmes scoping the sector, and presented examples of blue biotechnology RGD 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 the 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 now exist or have emerged. The *Alliance* aims to team up and intensify existing collaborations, and this should be pursued by the other networks, too. Networks should open up to form collaborative transnational clusters instead of duplicating existing network infrastructures.

The aim of the *Alliance* is to reach the critical mass of 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 also vitally important to jointly capitalise on knowledge generated 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, for example through strategic funding. The potential of extended financial schemes would be beneficial to allow the absorbing of benefits by end-users.

2. KNOWLEDGE GAINED FROM THE BALTIC BLUE BIOTECHNOLOGY ALLIANCE (2016–2019)

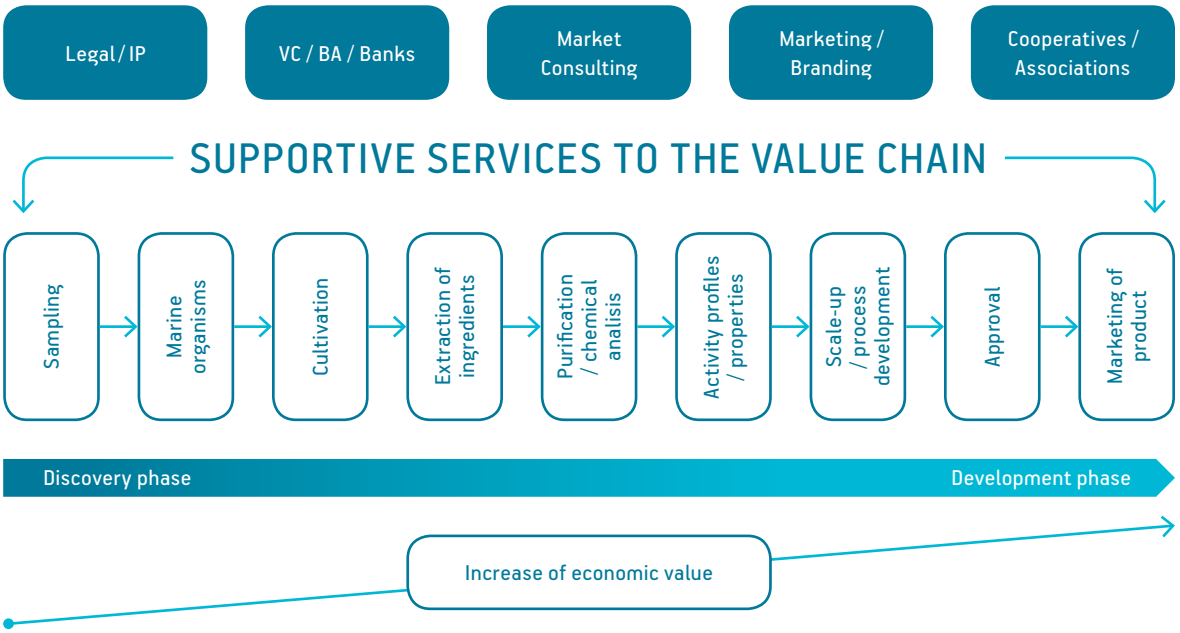


Figure 3 Blue biotechnology value chain. Image credit: SUBMARINER Network.

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 cases. The knowledge gained from this three-year project represents an important asset in the light of continued and self-sustained operations of *Alliance* beyond the end of the project's lifetime.

The aim of this chapter is to summarise the collected experiences and findings of the project activities, including the mentoring programme and the service offer. Furthermore, effort has been made 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 three-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 commercialisation (TRL 9) can be a copious, often expensive, and in many cases serendipitous process, and for this reason 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.

The *Alliance* consortium originally comprised 26 project partners of whom 15 partners were offering services and 11 partners were service end-users. The end-users were typically start-ups and 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 they offered. Each partner has a distinctive portfolio of services to offer in line with their expertise, competencies, and resources. The portfolio and expertise of the *Alliance* partners were

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 development	Communication	Legal advice
GEOMAR Helmholtz Centre for Ocean Research Kiel	✓	✓	✓	✓			
SUBMARINER Network for Blue Growth EEIG	✓				✓	✓	
BioCon Valley GmbH	✓				✓	✓	✓
Royal Institute of Technology Sweden (KTH)	✓	✓	✓	✓	✓	✓	
University of Gothenburg	✓	✓	✓	✓			
Finnish Environment Institute (SYKE)	✓	✓	✓	✓			
University of Gdańsk	✓	✓	✓	✓	✓		
Pomeranian Special Economic Zone Ltd.	✓				✓	✓	
Public institution Coastal Research and Planning Institute (CORPI)	✓	✓	✓	✓	✓		
Danish Technological Institute (DTI)	✓	✓	✓	✓			
Klaipeda Science and Technology Park (KSTP)	✓				✓		
CleanTech Latvia	✓	✓	✓		✓	✓	
Tartu Biotechnology Park	✓				✓	✓	✓
Svanvid Sp. z o.o.	✓				✓		
Scottish Association for Marine Science (SAMS)	✓	✓	✓	✓	✓		✓

presented in detail within the "Baltic Blue Biotechnology Alliance – Service Offer Brochure"[69].

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.

During the course of the three years of the *Alliance* project, in total 26 cases were enrolled in the mentoring programme as end-users. While five cases were selected as project partners during proposal preparation stage, 21 additional cases were recruited during four recruitment rounds operated as calls for ideas.

By the end of the project, some "early" cases (in the project since its start or recruited during 1st call for ideas) decided to offer their experience and also services to

69 https://www.submariner-network.eu/images/projects/alliance/downloads/sub-alliance-brochure-WEB.pdf

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	Communication	Legal advice
CRM – Coastal Research & Management	✓	✓		✓	✓		
Furcella Oü	✓				✓		
KosterAlg				✓			
SFTec Oy	✓		✓				

"newly recruited" (during 3rd and 4th call for ideas) cases resulting in a case-to-case collaboration. These cross-case collaborations, that mostly involved start-ups and SMEs, were very potent in terms of accelerating business developments and further raising the collaborative spirit of the entire *Alliance* family. Some examples of cases are shown in Table 2 – see CRM, SFTec, and *Furcella* – that offered besides mentoring also their scientific or technical expertise to other cases.

In the beginning of 2019, a core-team of the *Alliance* project consisting of seven *Alliance* consortium partners applied for a project extension of 18 months 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 thus, the Alliance+, the project extension of the Baltic Blue Biotechnology Alliance, will be funded until January 2021. 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. Case analyses are presented separately in section 2.5.

When joining the *Alliance* mentoring programme, 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 service providers or contacts helping in the actual implementation of the respective case.

In the course of the mentoring process, the business plan was always evaluated and updated in close collaboration with 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**. On many occasions, case owners were advised to change the focus of the business plan, for example to investigate other market applications or technologies. The mentors' 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 2.4.

All 26 selected cases received this mentoring support offered by the *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 RGD institutions and three 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 four different support categories with Biofisk (DK) being supported in all seven categories, while on the other hand the cases Maresome and Enzymicals (both DE) requested only networking support beyond the mentoring. Notably and by intention, 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, mentors, and service providers (project partners), the *Alliance* also fuelled cases-to-case collaborations that were an add-on to the *Alliance* partnership. In total, we recorded 12 case-to-case collaborations (CRM-Organic Seaweed, CRM-LoondSpa, CRM-Vetik, CRM-KosterAlg, KosterAlg-SFTec, KosterAlg-Organic Seaweed, KosterAlg-DoS, Furcella-Vetik, SFTec-Vetik, Kalundborg-PowerAlgae, PowerAlgae-PhytoBox, and EHP-Kalundborg) that either exchanged services and/or resources, or conducted joint experiments to advance their product development.

2.3 Recruitment of cases

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", namely in research labs, on conferences, pitching events, and accelerator programmes. The blue detectives are very good at discovering novel cases. This strategy of using blue detectives plays a huge role for the 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 a total of four of these calls for ideas within the project's lifetime.

At this step, the proper **national contact points** play a crucial role. They can answer the various requests of different potential case candidates and respectively guide the prospective applicants through the application process after establishing the initial contact. National contact points have been allocated on a voluntary (but continual throughout the project lifetime) basis, and they have been key structural elements in the recruitment process since they serve as facilitators and entrance gates to the *Alliance* for newcomers, both for cases and partners.

Submitted applications to the calls for ideas were evaluated by a panel of chosen experts. The pre-decided and publicly known evaluation criteria for the acceptance

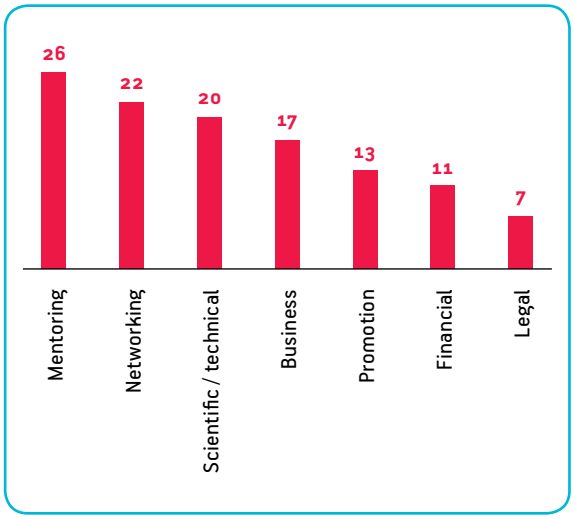


Figure 4 Different service categories delivered to cases by the *Alliance* in the framework of the mentoring programme. All 26 cases received mentoring.

of cases were: 1) relevance for the Baltic Sea Region, 2) sustainability, 3) feasibility, 4) market potential, and 5) suitability of competences of *Alliance* mentors and service providers to applicants' needs .

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 with 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, six as project partners and five for mentoring).
- Gothenburg, SE/April 2017 with evaluation of applications received in response to the 2nd call for ideas (four cases accepted for mentoring).
- Berlin, DE/November 2017 including evaluation of applications from the 3rd call for ideas (two cases accepted for mentoring).
- Copenhagen, DK/April 2018 in which a pitching session was realised in response to the 4th call for ideas; both cases applying to this call for ideas were accepted for mentoring.

The call material was developed jointly within 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 through online media by advertising the calls on own websites, newsletters, and among our own networks.
- 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 a strong presence in *Alliance*, with multiple partners proactively scouting for cases, and promoting the *Alliance* via the above-mentioned recruitment strategies were more successful. When the *Alliance* recruitment was less proactive– for example single publishing on a thematic website – it did not return any case applications. Based on this experience, we regard personal promotion and direct case scouting via blue detectives as key strategies for accessing future *Alliance* cases.

The recruitment strategy pursued from 2016–2019 resulted in 34 cases that applied to the four calls. Since only 26 cases were finally accepted, this also means 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 were then accepted to join the mentoring programme.

The main reasons for the 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) with a poorly-convincing idea.

In summary, out of 11 rejected candidates in total, eight were rejected after the first call for ideas. Five of the 11 rejected cases were from Germany (historically the highest share of applications have been received from Germany). Also, three rejected applications came from countries outside of the programme area and had no contextual connections to the Baltic Sea.

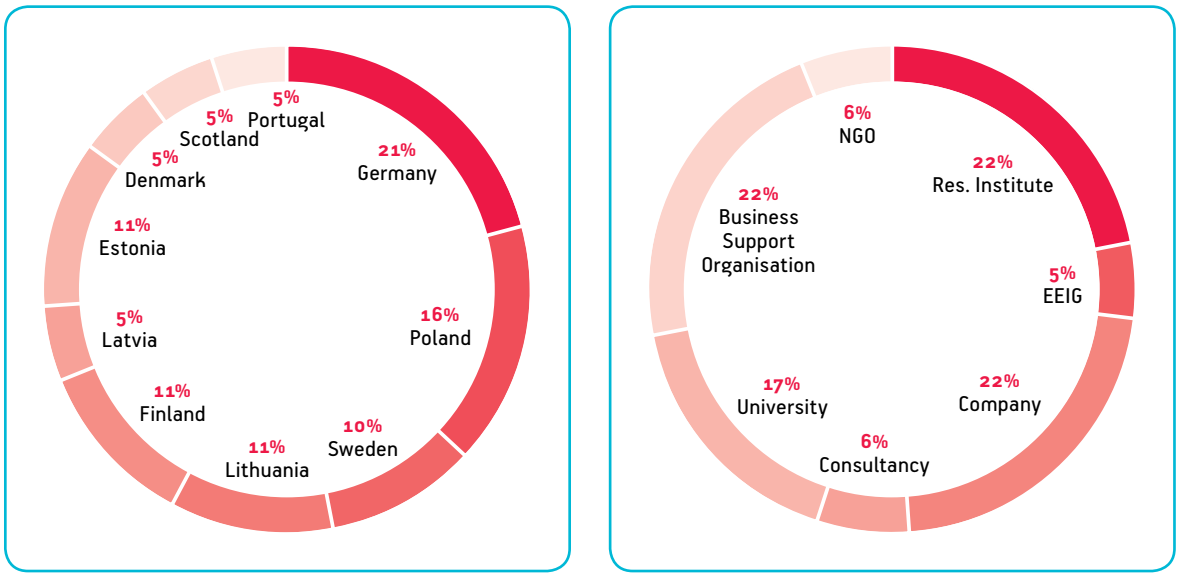


Figure 5 Country of origin among 19 *Alliance* mentors (left) and type of organisation among the *Alliance* mentors (right); figures include veteran cases offering mentorship.

2.4 *Alliance* mentors and service providers

Mentors play a critical role in the success of their cases. During the *Alliance*, the mentors not only guided "their" cases, including identification of their case's needs (jointly with the case owner), but they were also crucial in the determination of optimal pathways for implementation and case implementation itself. On several occasions this also included a suggestion of strategic changes, like in the business setup or target market. The mentors typically connected the case owner with the *Alliance* through the mentors' forum, but they also represented the cases' interests, for example in finding the right partners within the *Alliance* (mentors' forum) and also outside the project environment, such as conferences or matchmaking events. As a result the selection of mentors in the recruitment process was of vital importance for individual case progress.

In the course of the *Alliance* project, 18 organisations from ten countries, including eight 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 recruited cases by the mentors' forum, after careful selection, by matching the cases' initial service requests 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 to 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, for example KosterAlg – Gothenburg University, Baltic Probiotics – KSTP and CORPI, and Vetik – TBP.

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 seven different services offered by the 19 project partners (and associated partners) of the *Alliance* differ-

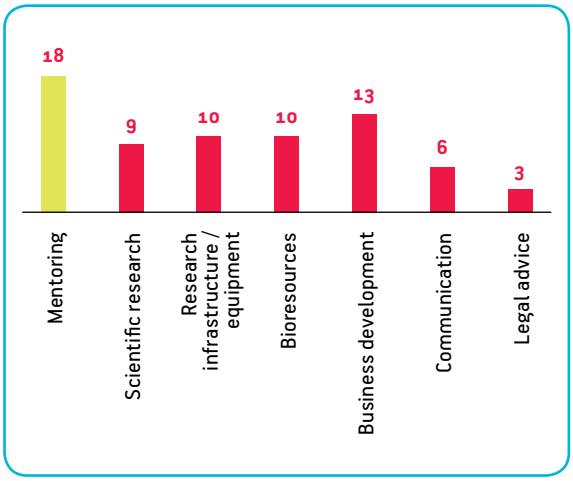


Figure 6 Services offered by the 19 project partners (and associate Partners), including mentoring (green line). Numbers on bars indicate the number of services offered by type to an equal number of cases.

entiated by service type. In Chapter 2.5 every service will be addressed separately.

In conclusion, the *Alliance* mentors in ten different countries are characterised by 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 from the cases.

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

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

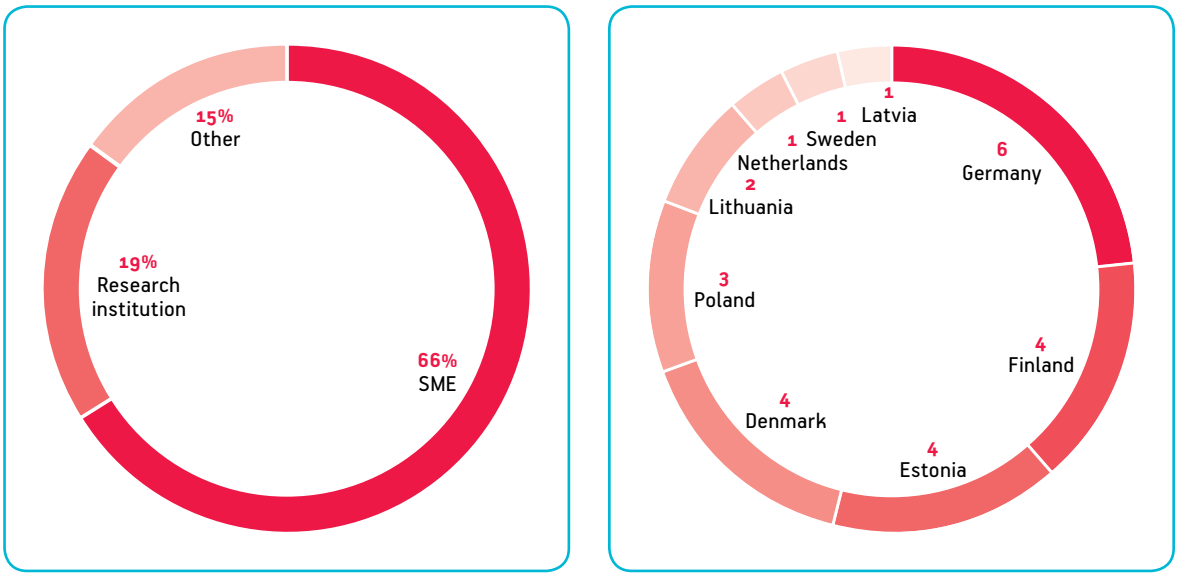


Figure 7 *Alliance* cases with regard to the type of organisation (left) and country of origin (right).

Table 3 Overview of *Alliance* cases, their country of origin, and main market/service outline. *: partner left 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	Cosmetics with algal extracts
8	Biofisk	Denmark	Insect feed from beach cast
9	KosterAlg	Sweden	Baltic macroalgae as food
10	SFTec	Finland	Dryer for biomass
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 biomass
18	Organic Seaweed	Denmark	Macroalgae-derived sunscreen
19	Uni Gdansk – Biogas	Poland	Biofuel generation based on microalgae cultivation
20	EHP	Finland	Sea monitoring equipment and data
21	Vetik	Estonia	Red algae extract for cosmetics
22	Uni Gdansk – Smart Bloom	Poland	Bioplastic from cyanobacterial blooms
23	LoondSPA	Estonia	Lake mud and mineral water based cosmetics
24	Phytolinc	Germany	Photobioreactor development for microalgae cultivation
25	Department of Seaweed	Germany	Seaweed platform
26	DTU – Biotrino	Denmark	Food ingredient from microalgae

and a transdisciplinary character for the development of products.

The concept of the *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 the 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

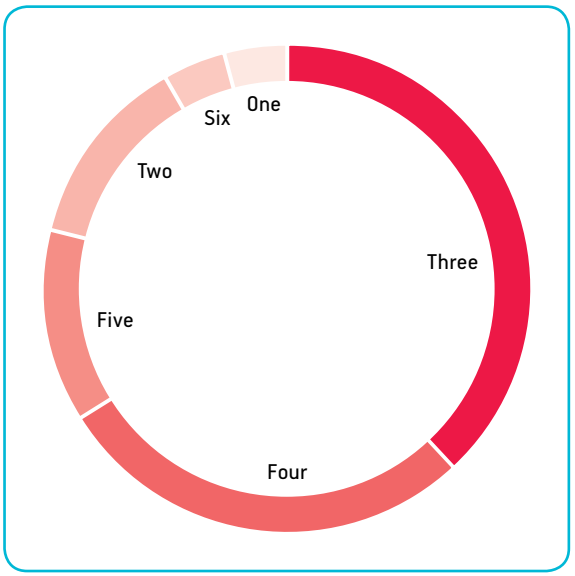


Figure 8 Number of transnational connections for all *Alliance* cases. Country of origin of the case owner is included in the calculation.

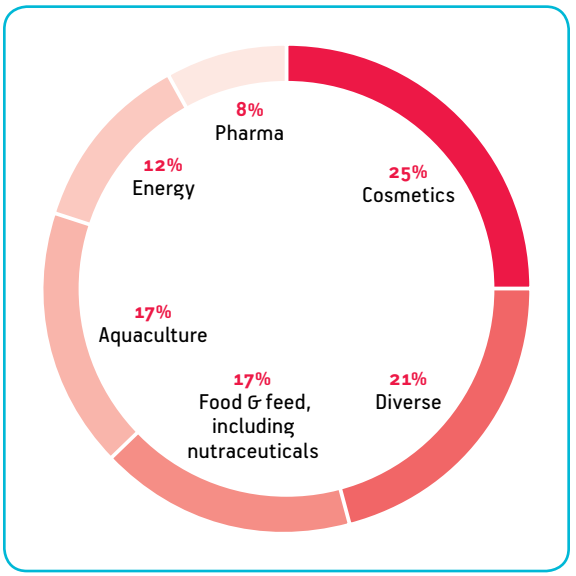


Figure 9 Target markets of the offered products.

throughout the mentoring programme. 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 programme in particular and the project in general.

As foreseen, various types of **products** were in the scope of product development in the framework 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 consumer products, four cases developed processing devices and three aimed at providing alternative bio-based energy supply solutions. The devices were aimed at enabling production and its control or valorisation of blue biotechnology relevant biomass.

The cosmetic sector was the **target market** for most products in development by the *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 and diverse applications were targeted by four cases (e.g. the case Vetik developing red-algae based products for application in the cosmetic but also the food colorant market). Only two cases targeted the development of products for the pharma sector, a sector which promises high revenues but to which the path is spiked with high regulatory hurdles as well as expenses and requires long development times. As the cosmetic sector promises comparably quick revenues with much lower 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.

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 (e.g. utilities) with 20%.

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 species (28%) as biological resources, both knowingly featuring valuable ingredients (e.g. phlorotannins, phycoerythrin, fucoidan, omega-3-fatty acids) with high biotechnological application potential and, consequently, 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

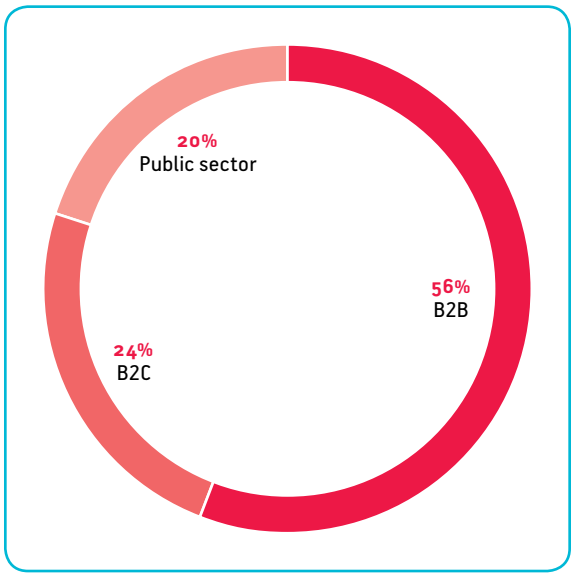
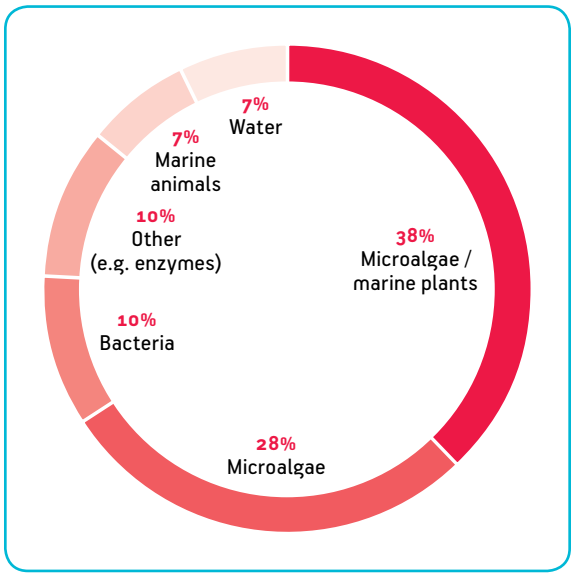


Figure 10 Client sectors the cases target.

themselves to blue biotechnology since they are cultivable in large quantities, are only used as a 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.

With respect to blue bioeconomy, notably, five cases focus on the development of products using biomass generally considered to be waste. This is true for Biome (mussel shells), Biofisk and Movable Biogas Factory (both use beach wrack/beach cast 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); ten cases used wildly collected biological resources. Three cases (Geoterma – hydrothermal water, EHP – water, and 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 programme. But sustainability is a criterion that 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 the wild). Sustainably obtained biological resources are key to a sustainable blue biotechnology. Hence, in the framework of the *Alliance,* new partnerships were formed to safeguard a sustainable supply of biological resources. Moreover, in other cases the mentors performed sustainability and feasibility assessments within the framework of case implementation, for exam-



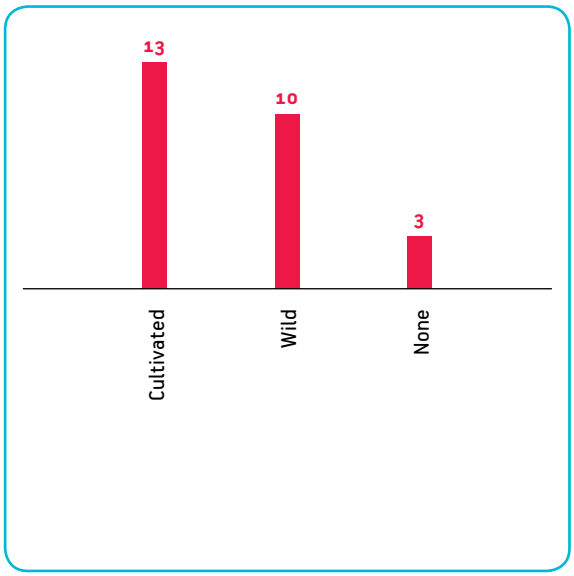


Figure 11 Used biological resources for product development (left) and sourcing of biomass (right).

Figure 12 The size of boxes corresponds to the number of cases contributing to the different UN Sustainable Development Goals (SDGs).

ple with respect to energy input in the 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 a matrix in Figure 13.

All 26 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 four 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 the bioprospecting stage (Figure 15). At the end of the project, this assessment was repeated to evaluate the progress in product development due to the *Alliance*'s contribution.

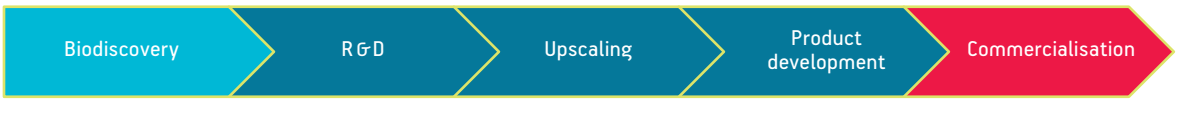


Figure 13 Simplified value chain used for assessing the TRL stages of cases applying to the *Alliance*.

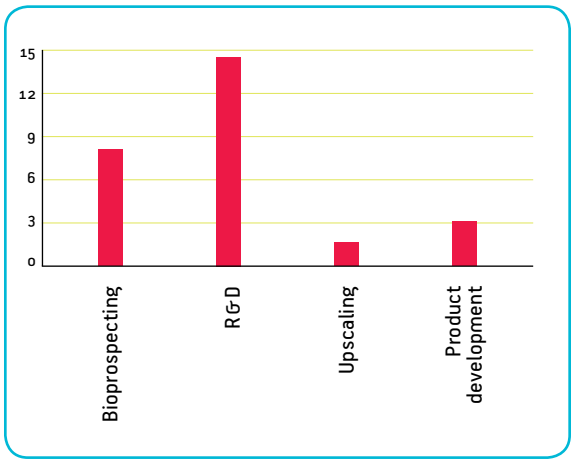


Figure 14 Value chain stage of the cases when entering the *Alliance* following the simplified value chain stages in Figure 14.

On average, due to the *Alliance* support, the cases advanced one step in their product development (Figure 16). This is an average calculated over all cases. Since case recruitment took place in five different cohorts, the progress naturally differed between the cohorts due to several factors, like establishment of the mentoring programme 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, e.g. a bilateral agreements for provision of a sustainably harvested biological resource.

At the same time, several cases changed their direction or broadened their product development activities as a result of the feasibility analyses performed with the help of their mentors. This was a major contribution by the *Alliance* to case development (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 for instance 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.

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 and proceeded from R&D to commercialisation of their products. Both newly developed products carry the *Alliance*/Interreg label. The

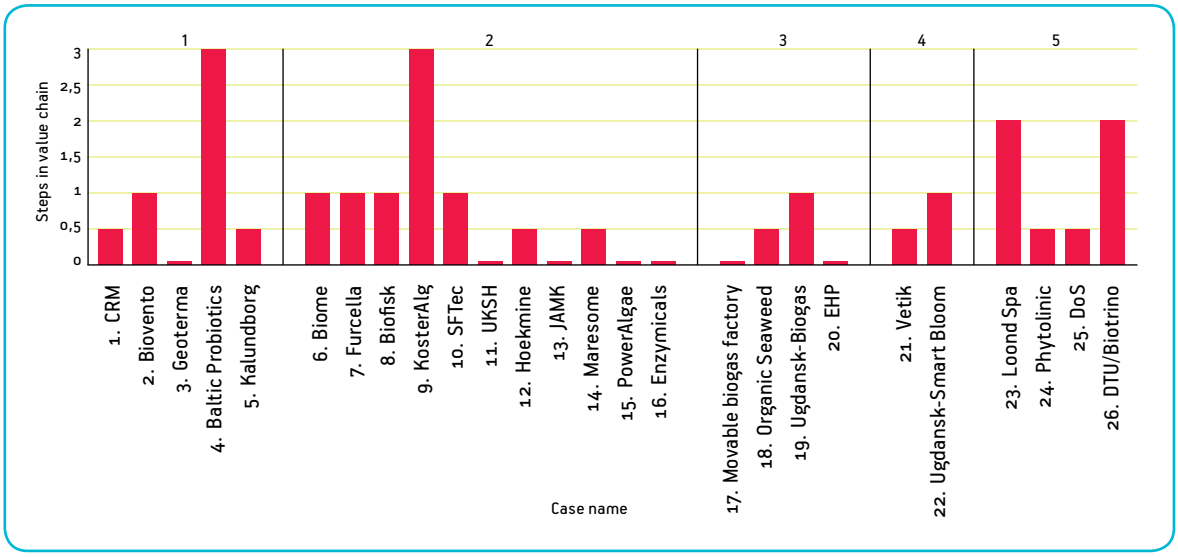


Figure 15 Individual progress of cases in the value chain. The numbers above the diagram reflect different case cohorts: 1. Reserved partners (March 2016); 2. Cases recruited at pitching event in Helsinki (October 2016); 3. Cases recruited at pitching event in Gothenburg (April 2017); 4. Cases recruited during partner meeting in Berlin (November 2017); 5. Cases recruited during pitching event in Copenhagen (April 2018).

Figure 16 Pictures show KosterAlg harvest on the offshore farm (left) and Baltic Probiotics "Smart Fishery" probiotic solution to improve fish health for aquaculture fish (right). Photo credit: Koster Alg (left) & SUBMARINER Network (right).

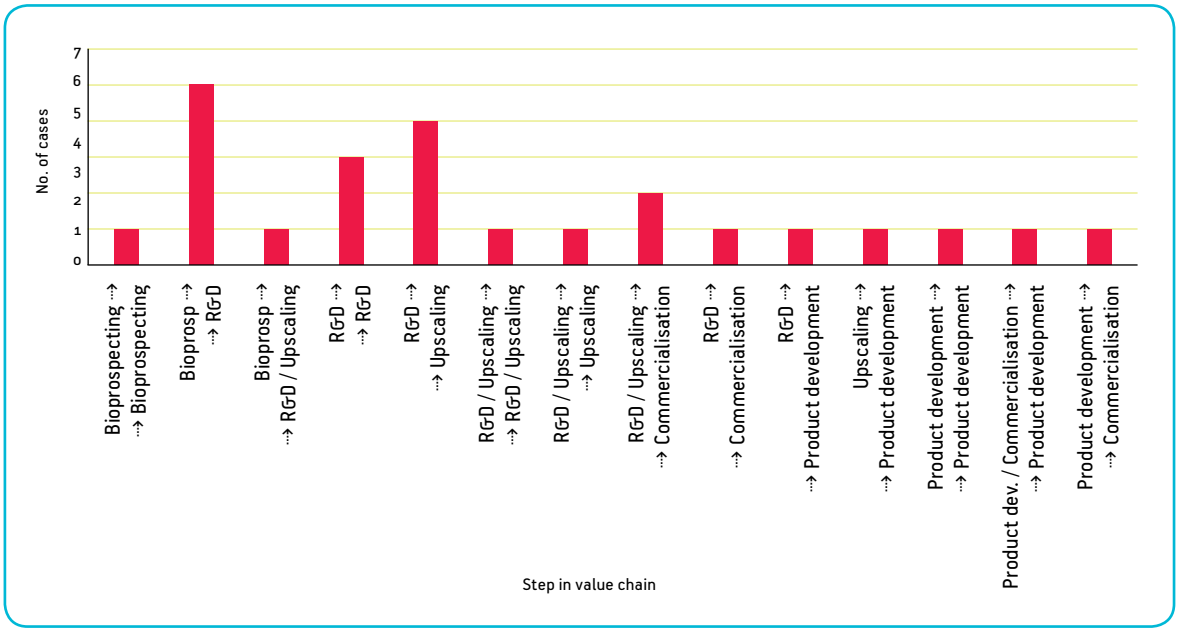


Figure 17 Progress of *Alliance* cases in the value chain with respect to different steps.

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 18 shows the different progress steps made by the *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 the bioprospecting stage before joining the *Alliance*, have moved forward to R&D within the *Alliance* project, and five advanced from R&D to upscaling, which nicely underlines the success of *Alliance* in taking blue biotechnology development in the BSR one step further. **With the help of the *Alliance*, commercialisation of newly developed products started in three cases (Baltic Probiotics, Furcella, and KosterAlg) and prototypes are ready from two more cases (CRM and Biome).**

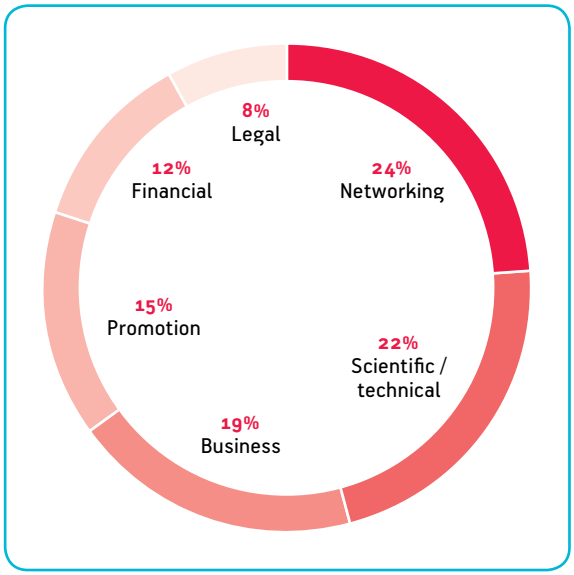


Figure 18 Distribution of available services from *Alliance* service providers (adapted from Table 1).

2.6 Service provision

In the scope of the mentoring programme, the *Alliance* service offer describes the technical support offered to the cases. In Table 1 the *Alliance* partners were presented alongside the services they were able to offer throughout 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 a few partners, although this was not the main focus in the original *Alliance* partners' portfolio. Additionally, legal advice was offered by specialists subcontracted by the project.

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 at 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 services offered 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 of know-how, access to equipment or infrastructure, propagation/cultivation of biomass, chemical analysis, etc.), although many services provided to cases were also related to business development (i.e. development of a 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 services are difficult to measure (detailed analysis in chapter 2.1 Service provision). Most cases were profiled on the *Alliance* website and they were also represented in national and international matchmaking events in which other *Alliance* partners, for example SUBMARINER Network, participated. Cases also accessed external events (e.g. participation in the BioMarine Convention, Blue Bio Value accelerator, etc.). Therefore, promotional service may be underestimated.

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 one prerequisite for success. One of the main criteria during the *Alliance* recruitment process was a suitability assessment with regard to available expertise within the *Alliance* consortium. In practice, this included a careful a

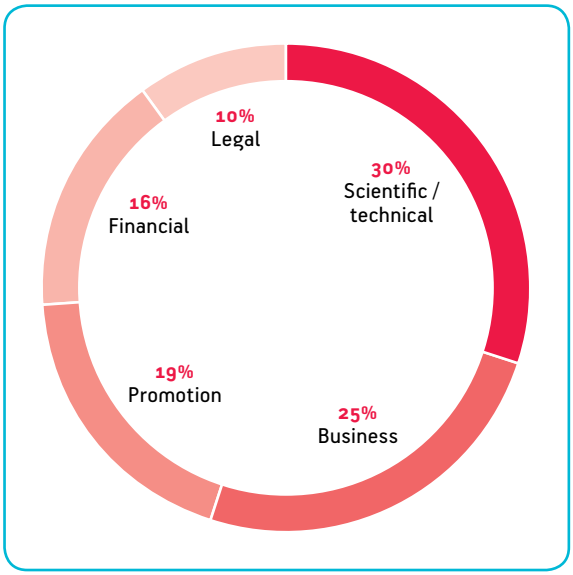


Figure 19 Distribution (percentage) of services delivered to cases, apart from mentoring (adapted from Figure 5).

priori analysis of expertise available in the *Alliance* and matchmaking based on needs specified in the applications. A negative result of this evaluation could also be a reason for rejection.

What makes the *Alliance* stand out 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 a case development strategy together with the mentor. At a second level, actors, data, and actions are aligned with the strategy and support the development of the case. But in essence, there is a large degree 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 meet the case needs through the mentors. This is an important approach given that each case is unique; they are in the very early development stage and their development pathways, thereby needs, can be very different.

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

The most frequent (24%) service request was related to networking, that is 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, such as 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 the *Alliance* for support in product development.

Analysis of service requests and correlation with the service offer is very important since it allows useful conclusions

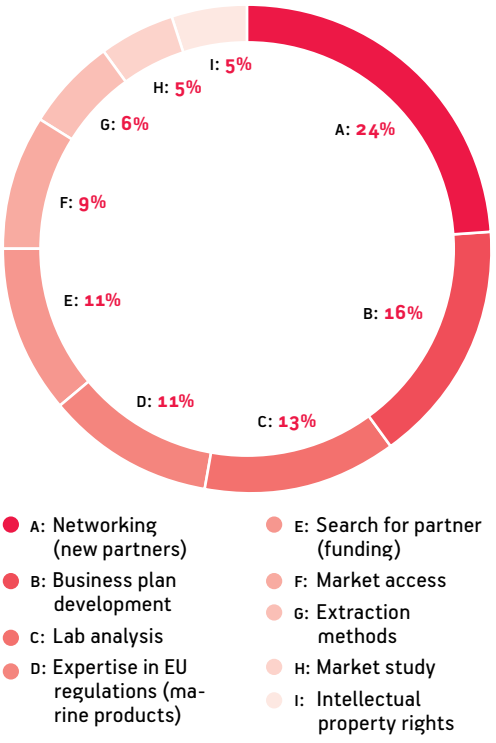


Figure 20 Case requests for support as defined in the case fiche after collaboration of mentor with case owner.

to be drawn 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), it is apparent that networking (promotion, matchmaking, outreach) is a very important service for cases. This also means that coordinated efforts will likely increase the impact and integrated approaches can be used to transfer knowledge to client cases, for example 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 also selected with regard to the available expertise or 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 provided by an external specialist in nutraceuticals, some cases requested marketing data, which the *Alliance* could not provide. Instead the *Alliance* provided information on where to access the data.

When service requests could not be fulfilled by the *Alliance*, for example when a service was highly specific or beyond the expertise of the *Alliance* service providers, a case mentor addressed the need in the mentors' 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, one case needed a heavy metal analysis, which could not be provided within the *Alliance*. The case's need was finally addressed by subcontracting an external company. As the *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. On those occasions external experts were subcontracted, providing their services to the *Alliance*. These specialists are now associates of the *Alliance* and may be contacted on demand.

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

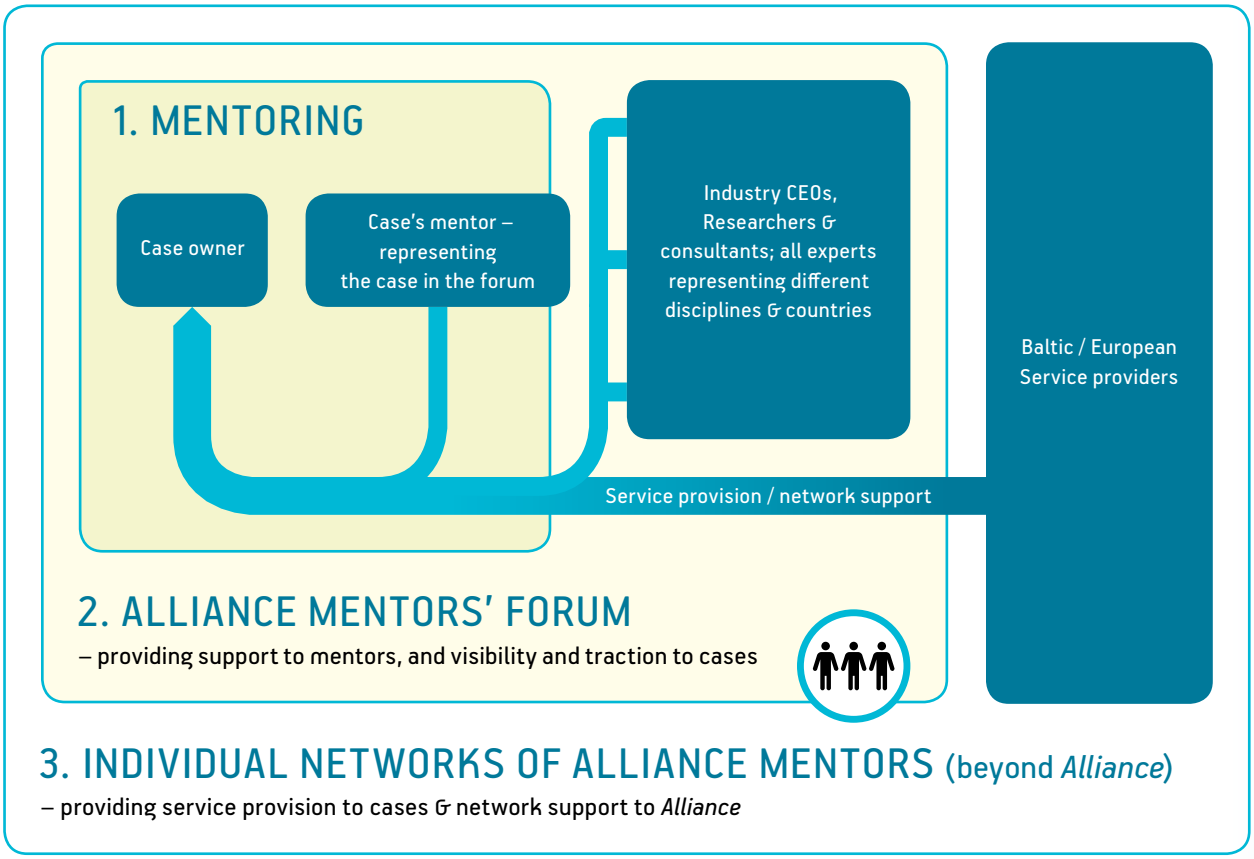


Figure 21 Scheme presenting the mentors' forum of the *Alliance*, and relationship with a case.

The *Alliance* **mentors' forum** was an important structure developed within the *Alliance* that is 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 and physically. Mentors participated in a bottom-up approach coordinated by the project's lead partner (GEOMAR). The purpose of the forum was multifold: 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 mentors were often also service providers and hence absolutely crucial for case implementation and success), then these mentors reached out to the forum to address a service request and search for other service providers to satisfy the request. Usually, the case needs were satisfied by reaching out to the forum, which reflects 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*.

respective external networks for support. As an example, when the case Biome needed a new supplier of blue mussel shells, the SUBMARINER Network reached out to partners (mussel farmers) from the Interreg (BSR)-funded Baltic Blue Growth project, which could provide blue mussel shells. This is a good example of the **need for a supercluster**, such as the SUBMARINER Network, which is operating beyond borders (transnational) and, moreover, across different blue bioeconomy sectors, such as in the aquaculture of algae, fish, shrimp, or mussels. Moreover, these examples also show the success of the *Alliance* to unite actors from different stages of the value chain and thus to create the critical mass for supporting blue biotechnology product development on a transnational scale in the BSR.

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

2.6.1 Networking, matchmaking, communication, and lobbying

Networking and matchmaking is a standard package offered in combination by the *Alliance* and SUBMARINER Network hub to ALL partners, associates, and cases

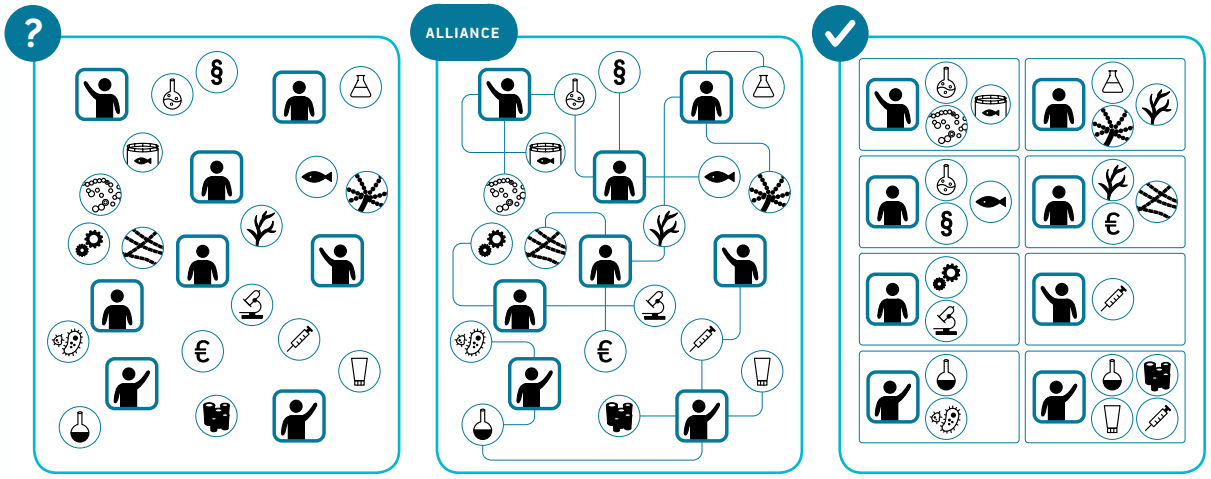


Figure 22 *Alliance*/SUBMARINER matchmaking process.

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 matchmaking process.

All *Alliance* partners and cases have been given several opportunities for networking, matchmaking, and promotion via an accessible address book of actors, workshops, matchmaking events, and ongoing search for and training of new cases and mentors as well as reaching out and advertising their cooperation requests via SUBMARINER e-newsletters and website.

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

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

Networking was the most frequently offered service to cases. In addition to the promotion, matchmaking, and networking services offered to all cases by the *Alliance*, communication training and lobbying was provided to a few cases by 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 programmes such as the participation of Hoekmine and Vetik in the Portuguese Blue Bio Value accelerator programme in 2018
- STARTUP day, a regional event in Tartu, Estonia, co-organised by *Alliance* partner Tartu Biotechnology Park, contributed to the promotion of Estonian cases at regional level
- DoS case prepared an art exhibition in Tjärnö, Sweden, co-organised by their mentors 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 has actively promoted cases' interests with 1-on-1 matchmaking meetings and distribution of marketing material; Hoekmine attended the event
- BioMarine Convention 2018 has actively promoted cases' interests with 1-on-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, at which R&D partners and selected cases gave a pitch talk or presented their case on a poster (seven cases: CRM, Furcella, UKSH, Biofisk, Uni Gdansk Smart Bloom, Phytolinc, Hoekmine)

2.6.2 Placement and training opportunities

As an innovation platform, the *Alliance* 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, on-the-job-training, courses and other important opportunities were announced. All relevant opportunities offered by the *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 well as innovation policies. Finally, we aim to help RGD 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 and to secure funding for their next steps in product development.

2.6.4 Scientific/Technical support

Scientific and technical support is an umbrella service term that pools individual and institutional capacities and access to infrastructure offered to cases by *Alliance* partners. 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 nine project partners and three cases (cross-case service offer). Twenty cases have received this type of support. Scientific and technical support had the most pronounced impact on collaboration among partners and cases and they 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 on 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 RGD effort, for example for realising a proof-of-principle study.

The 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, over the course of the project **a database for cataloguing multi-purpose infrastructure and equipment** owned by *Alliance* partners was developed. This publicly accessible *Alliance*[70] database is a very useful asset for researchers and companies alike. The database contains laboratory equipment, analytical techniques, pilot scale facilities and even research vessels that are offered by the *Alliance* partner institutions and can be made accessible to *Alliance* partners and cases. For lab equipment alone, the database contains 86 entries. All these examples of 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 in the PILOTS4U BBI project (2016–2019). The database categories that PILOTS4U uses, are both upstream and downstream technologies, which could be integrated within the *Alliance* database. So far, there has been no collaboration between both projects but KTH, a project partner in both projects, would be the obvious route to link the two sets of databases.

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 beyond the influence of the *Alliance*. However, several *Alliance* partners hosted biological resources and offered access.

The *Alliance* has developed an online catalogue on biological resources in the form of a "one-stop-info-shop" that lists the biological resources of the *Alliance* partner research institutions. The **Blue Bioresources Catalogue** also lists the respective contacts at the partner institutions. It has been developed with the support of all *Alliance* partners and coordinated by the project's lead partner

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

Culture collections worldwide

Outside the *Alliance*, on a worldwide basis, most culture collections host microorganisms. According to the culture collections information worldwide[71], in 2014, 647 culture collections from a total of 70 countries were 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, with 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[72]. 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 in the total number per country, for instance France (38) is apparently following a more decentralised system compared to Germany with 13 or Sweden with three 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, the European Culture Collections' Organisation (ECCO)[73] has been in existence, whose aim is the promotion of collaborations and the (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). 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 as common in microorganism cultures. Often cyanobacteria (counted here as bacteria due to their prokaryotic nature) are included as algae in culture collections. Worldwide, *Phycology.Net*[74] lists 21 culture collections of marine microalgae, most of which are hosted in the US (four) followed by France and Germany (three each).

Outside the *Alliance*, only dispersed information of curated collections of specifically marine resources can be found. The Roscoff culture collection[75] in France harbours marine microalgae, macroalgae, protists, bacteria, and viruses, and the Marine Biological Association[76] in the UK specialises in marine phytoplankton. The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) also hosts a collection of >1,000 microalgae cultures[77].

71 http://www.wfcc.info/ccinfo/index.php/home/statistics/#m1

72 http://www.wfcc.info/ccinfo/index.php/home/statistics/#m4

73 https://www.eccosite.org/

74 http://www.phycology.net/Content/PNetContent.cfm?MID=135

75 http://roscoff-culture-collection.org/

76 https://www.mba.ac.uk/facilities/culture-collection

77 https://www.csiro.au/en/Research/Collections/ANACC

GEOMAR. The catalogue is published on the *Alliance* website[78].

The overview shows that, in total, a diverse range of biological resources are available at *Alliance* partner organisations, i.e. collections of viruses, bacteria including cyanobacteria, fungi, microalgae, macroalgae, crustacea, molluscs, and fish. The organisations hosting the biological resources available in the *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.

However, interestingly enough, access to biological resources was not among the most highly demanded services in the *Alliance*. Only five cases requested and received biological resources or access to them from *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 their own collections, cultivation and/or sustainable harvest. Additionally, networking and case-to-case cross-collaboration within the *Alliance* also led to a biological resource exchange when the raw material was not on offer by the regular partners, 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, such as 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.

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 of 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 two 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 fourth 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 fundraising.

Concerning support in business development, the *Alliance* recruited the company Gaia Consulting Oy (Finland) to develop a **quick scan business assessment tool** that assesses the business plan status of a case and recommends immediate strategic steps to increase business viability. The tool was accessible and used in the *Alliance* mentoring programme. The quick scan tool is used jointly by mentors and case owners at the beginning of the

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

78 https://www.submariner-network.eu/projects/balticbluebioalliance/one-stop-info-shop-for-bioresources

mentoring programme, and it has been very useful not only for both informing case owners on current status and immediate needs but also for mentors in helping them integrate knowledge and accelerate the 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 validated by the assessment of several pilot cases at different value chain stages, sectors, and countries of origin. Since its establishment, this business assessment tool has been an integral part of the initial phase 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 lacking, 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 include: creating an added value by project development, joint fundraising initiatives, access to new scientific ideas, forming spin-off companies, joint publications or patents.

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

In total, 11 cases received financial support through the *Alliance* project after being granted partner status. Financial support covered their salary costs (for the project), equipment purchases, and travelling costs. This financial support was substantial for the *Alliance* cases, which was also reflected in the amount of applications received for the different calls for ideas. The first call for ideas, which included financial support for accepted cases (by granting project partner status) attracted 20 candidates in total. In the second call six candidates applied, in the third call three candidates and in the fourth call five candidates. We speculate that the number of candidates declined across the cohorts also because the financial support was not on offer. In the future, the *Alliance* will also consider financing support schemes for cases that cover not only service provision but also direct financing of the case, such as by including salaries and capital costs.

Financial support was not a distinctive part of the *Alliance* service offer, but rather part of business development, for instance as support in fundraising. Fundraising support was offered to four 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, for instance Hoekmine, Vetik, SFTec, and KosterAlg, have been very successful in attracting financing outside the *Alliance*. 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.

2.6.7 Legal advice

Legal issues were one of the most relevant barriers cases faced and, as we saw in Figure 5), seven cases received legal support. The needs reflected a broad spectrum of legal issues, from implementation 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-on-one case consultations, in which the

respective mentors were also involved. On many occasions, mentors supported the cases in the implementation phase, for example by running the online patent searches. 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 agreements for patent and trademarks, non-disclosure agreements, material transfer agreements, as well as a R&D collaboration service agreement. All the templates and guidelines are available to and accessible by *Alliance* cases and partners.

Furthermore, three partners (Tartu Biotechnology Park, BioCon Valley, and SAMS) have offered diverse expertise on legal issues. The mentors assisted the cases in raising concrete questions, such as how to set up a start-up in Sweden or an organisation in Germany, how Poland interprets certain EU regulations, EU safety aspects with regards to using recycled biomass for food and feed sectors, and the 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.

2.7 Knowledge gained from the mentoring programme

During the setup of the mentoring programme, the 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 the wide spectrum of blue bioeconomy sectors, we have developed a **fully-fledged innovation platform, a mentoring programme and a service offer (accelerator)** that can accommodate many needs at different stages in the product development chain. However, given the current consortium composition, capacities and resources, we mainly attracted SMEs and start-ups with a business idea at bioprospecting and R&D stages, although we have also provided services to cases in more advanced stages (upscaling and commercialisation). The *Alliance* has been very successful in raising the confidence of cases owners, promoting and giving access to a niche-networking platform for matchmaking, providing concrete answers to concrete questions, and supporting 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, and business developers (CEOs of companies).

One attribute of the *Alliance* is 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 because they have experience and enlarge the mentoring offer and services. The veteran cases act as role models for new clients and they can provide unique insights, capacities, and resources as 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 develop further in the *Alliance*.

Transnational and cross-institutional cooperation between R&D experts and SMEs was necessary already at very early stages, and it has also proven to be 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. Likewise, it was more difficult for mentors to contribute to case progress when the progress was not driven by the cases, as communication/mutual trust was absolutely indispensable for progress even if legal documents (NDA, etc.) were existing.

One critical factor for case progress was often **geographical proximity** between case owner and mentors. The setup, which uses 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 of all mentored cases (real-

ised by monthly mentors' forum telephone conferences). Also the 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 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 backgrounds, possess diverse technical expertise, and diverse knowledge of business development, technology transfer, and innovation management. New mentors will need training to fulfil their 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**.

The **mentors' forum** was of strategic importance for supporting cases and mentors alike. This 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 outreach to their own networks to find a new contact for a case when needed. The mentors' forum was a platform for a collective memory and a pool of expertise. In 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 to efficiently support and orient case progress, following case requests. Towards this end the ideal **soft skills** for becoming an *Alliance* mentor include being outgoing, proactive, and service-oriented. They should ideally have expertise across science and business development.

The recruitment of cases was organised at a national level, recruitment strategies varied by country and returned varied degrees of success in terms of the number of new applicants. The most successful tactics in recruitment were the use of proactive approaches and more than one channel for promoting the mentoring programme and especially the use of personal contacts for scouting 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 even if they had advanced to other stages of the value chain. Knowledge-based product development is a selling point that is gaining importance also in sectors like cosmetics, nutritional supplements, and 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 waiting phases until the start of implementation, which can significantly affect 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 that are commonly regarded as waste for the industries related to human consumption, such as food or feed.

During the project the *Alliance* consortium has also experiencedthat **auxiliary innovative technologies** such as the 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.

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 research institutes and universities with expertise in blue biotechnology in the BSR. Although not comprehensive, this analysis aims to support identification of potential strengths and gaps in blue biotech-related R&D. Among the 62 surveys sent, we received responses from 15 external R&D institutions, in addition to the responses of nine R&D *Alliance* partner institutions of the. Data from 24 Baltic institutions (and departments) are represented in the blue biotechnology map of capacities and provide useful evidence on 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 missing responses. A list of BSR actors relevant to blue biotechnology R&D, including those that participated in the survey are analysed below, are presented in the Annex.

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

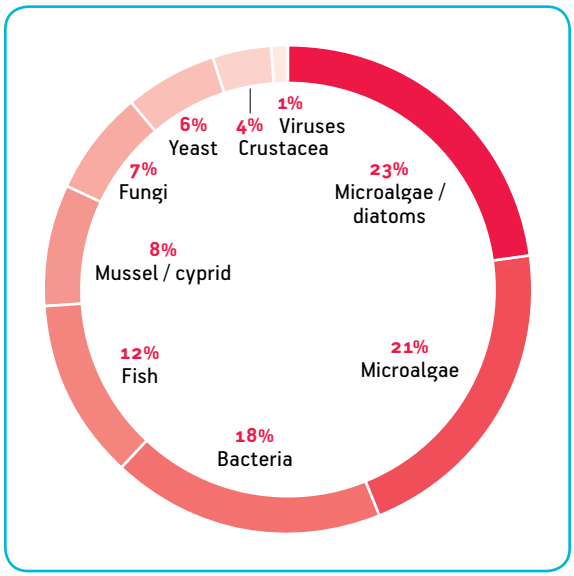


Figure 23 Type of marine biomaterials used for R&D (right).

In the question of **what type of biological resource represented 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 finally crustaceans.

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, such as in metabolomics, biomass characterization, water chemistry, and contaminants analysis
- 18 had competencies and facilities to scale up and down technologies, such as 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 biomass or for use as microbial factories for production of chemical compounds with added value, for example commodity chemicals 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 to calculate implications of human

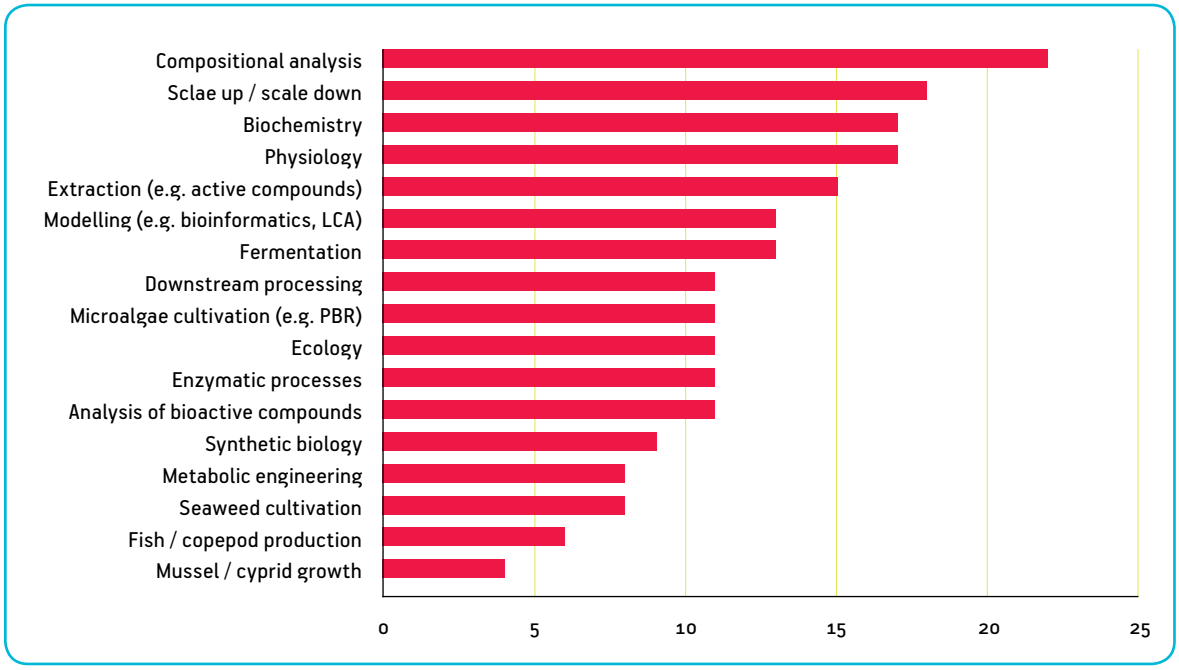


Figure 24 Expertise of R&D institutions in blue biotechnology.

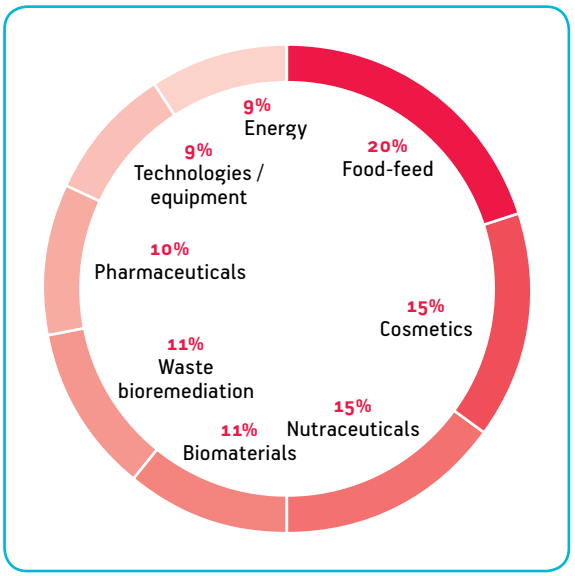


Figure 25 Blue bioeconomy market products in which R&D institutions have expertise and interest.

activities such as life-cycle assessment of technological applications

- 11 could cultivate microalgae in photobioreactors and four could cultivate macroalgae on longlines and/or in tanks
- 11 departments had expertise in marine ecology, industrial ecology, ecosystems and natural habitats
- Eight out of 24 had expertise in metabolic engineering and/or synthetic biology that unlocks the potential of microorganisms by altering the genome, for instance to increase resistance against pathogens and stress factors and improve production of target compounds including secondary metabolites with bioactive properties
- Six institutions had expertise in breeding and growing fish, for instance in tanks, and also testing for animal diseases, etc., and four had expertise in mussel farming

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, including bioreactors and driers, while a few are working directly with energy production or waste valorisation.

From the analysis above, an even distribution of skills and resources in chemistry, biology, ecology, mathematics, 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 surveying research institutes with primary expertise within blue biotechnology and not aquaculture, and thereby the survey is biased. 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 the production of a variety of products, such as food nutraceuticals, 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 the current analysis we see an even distribution of expertise within the various marine biomaterial sources.

3.2 Innovation ecosystem

The recipe for 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, all the way from developing a prototype until the product has 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 in the road, so important struc-

Foresighted blue biotechnology research needs and bioresources in the BSR

An online 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[79]. More than 100 conference delegates responded to this survey. Three strategic questions were posed 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. The numbers in parenthesis are the answers in percentages, more than one answers per question were allowed:

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%)
4) Sustainable and affordable energy sources (22%)

Can you identify the potentially highly profitable products?

1) Cosmetics and healthcare (64%)
2) Food and nutritional supplements (61%)
3) Antibiotics and pharmaceuticals (46%)
4) Special/valuable biobased compounds (e.g. enzymes, bioplastics, fine chemicals) (39%)

What are gaps and bottlenecks for solving the 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%)
4) Business development support (25%)

The results obtained 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 previously under-utilised material (e.g. algae) for developing novel foods including marine superfoods. In terms of marine biotechnology-derived products generating the highest potential revenues, cosmetics/healthcare and nutrition, including 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 reflect 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. •

79 https://www.sli.do/

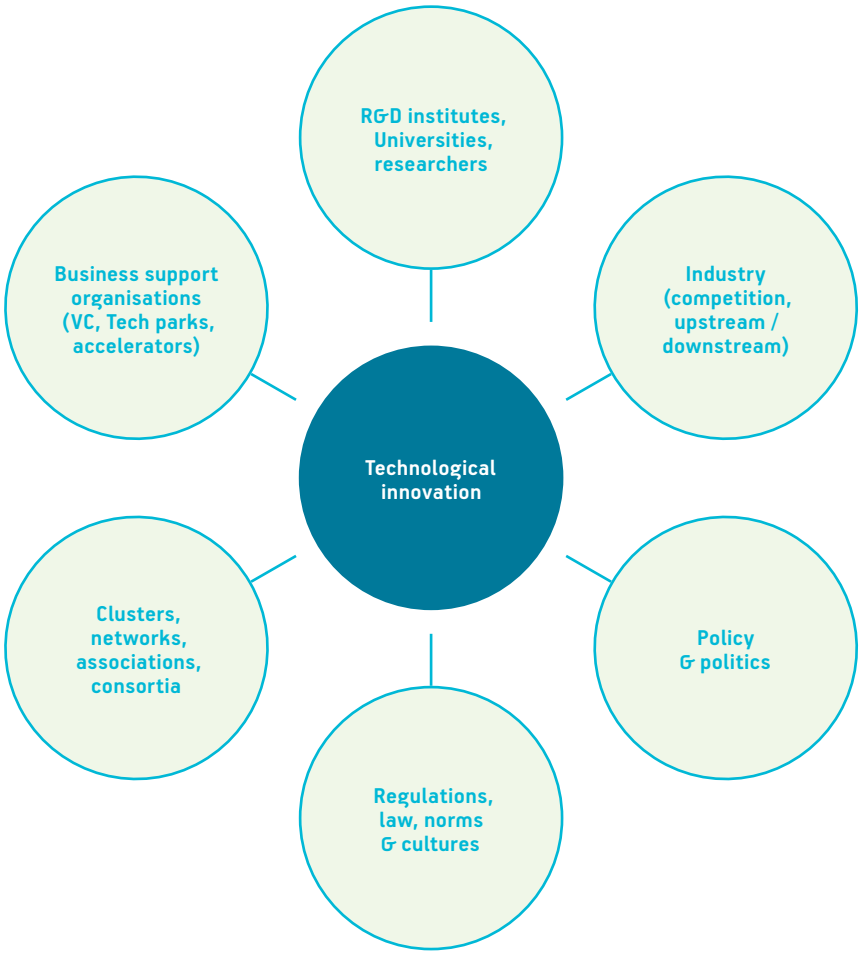


Figure 26 Structures influencing the advancement of a technological innovation throughout its lifespan, from building a prototype to attaining market saturation.[78]

tures can be missing or present but not functional. In this case, professional clusters, associations and networks solve part of the problem and boost business creation by co-locating resources a short distance away, including knowledge, human capital, finance, and infrastructure, which can effectively advance technological innovation.

The status of blue biotechnology innovation capacity in BSR is a critical factor for the 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 we can also see that institutions are 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, for instance all of Denmark and Lithuania's data are missing from the analysis, and also the Småland region in Sweden.

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

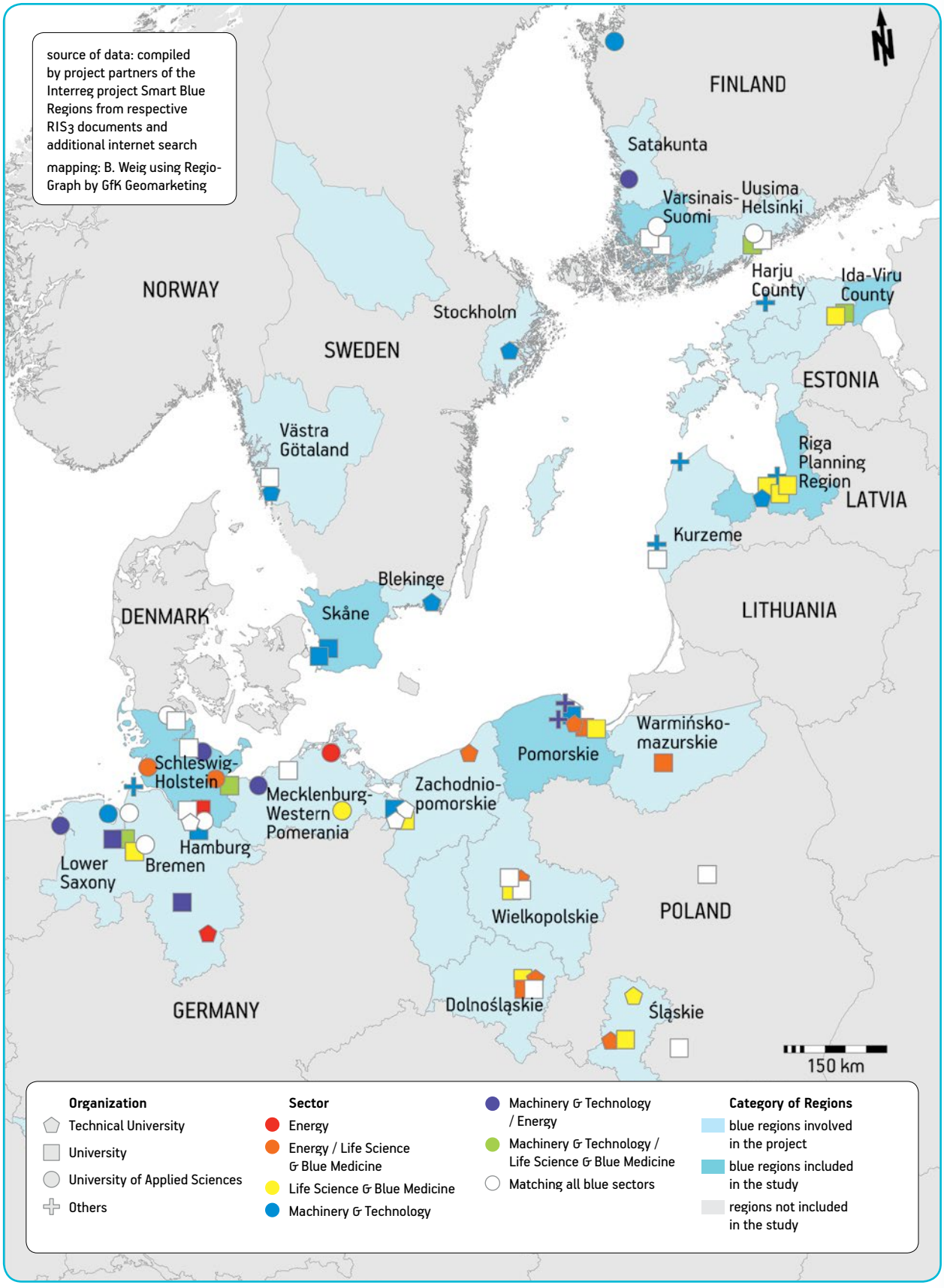


Figure 27A Map depicting findings from six BSR regions (NUT2) on business support organisations (actors' map). Source: Smart Blue Regions project (Interreg BSR).

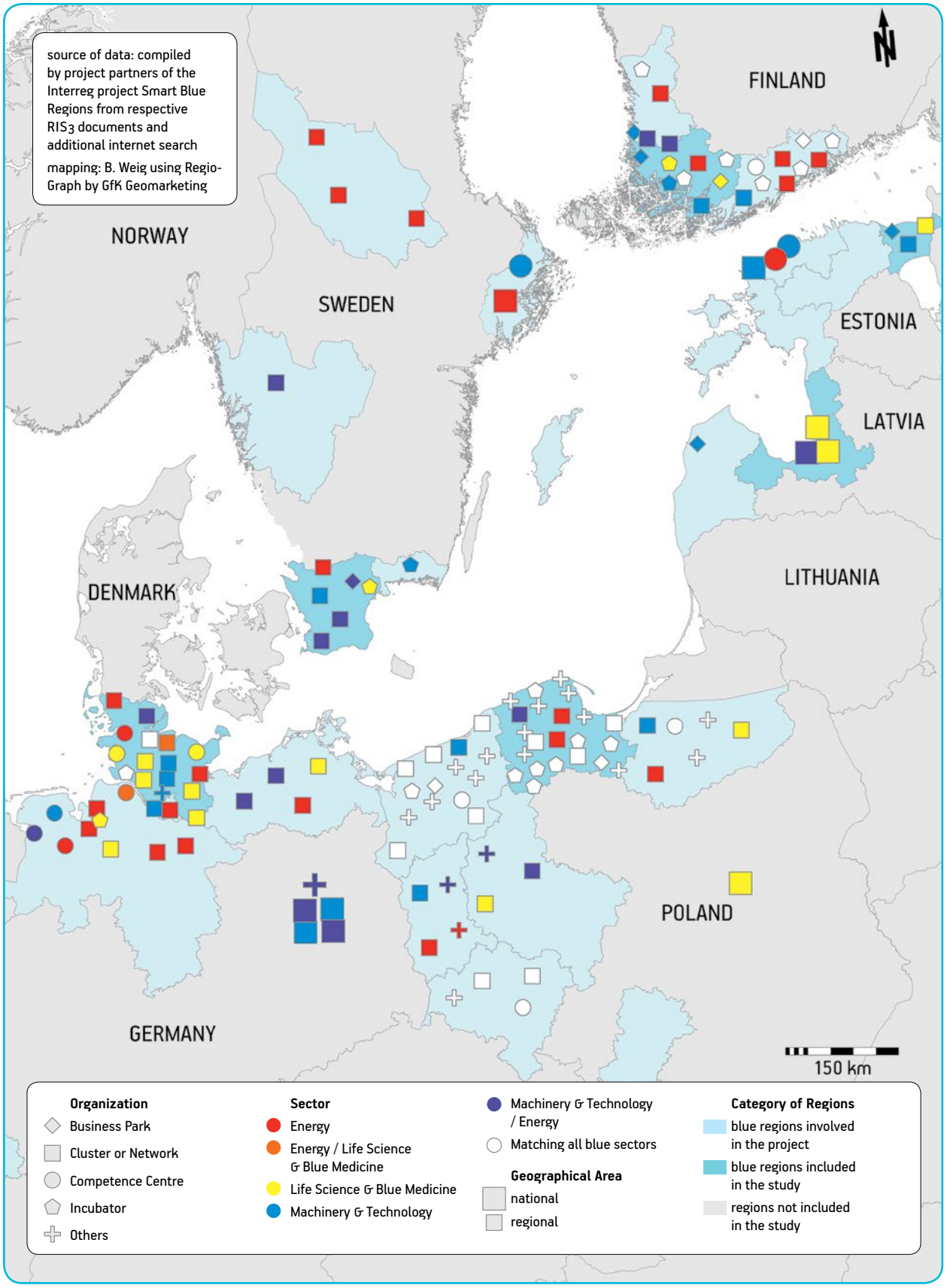


Figure 27B Map depicting findings from six BSR regions (NUT2) on higher education institutions (actors' map). Source: Smart Blue Regions project (Interreg BSR).

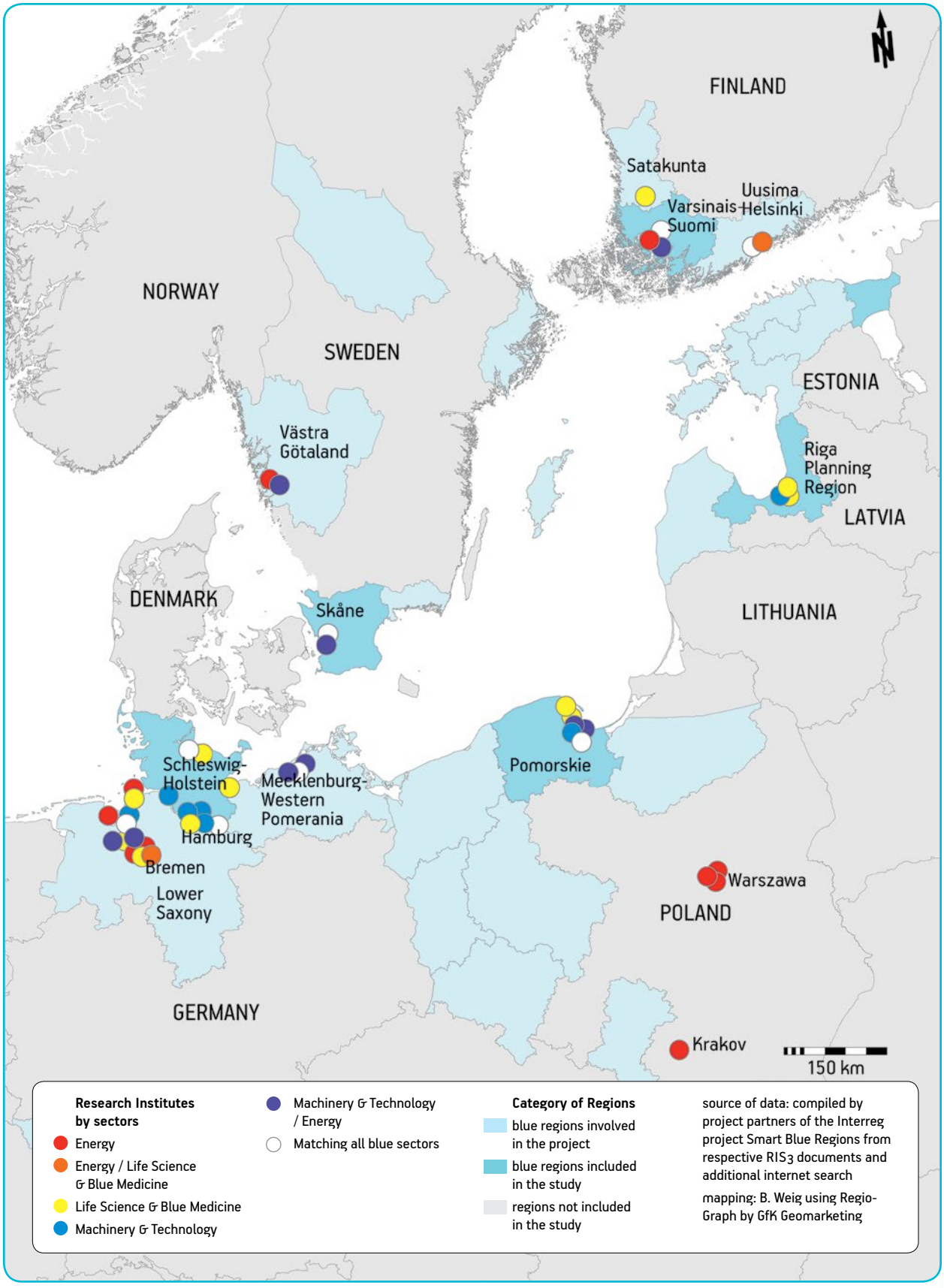


Figure 27C Map depicting findings from six BSR regions (NUT2) on non-university research institutes (actors' map). Source: Smart Blue Regions project (Interreg BSR).

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 4 below, we analysed the available study programmes in higher education within blue biotechnology in Northern Europe. This analysis provides an indication of the available programmes and courses and is not a comprehensive analysis.

Table 4 Offered higher education programmes within blue biotechnology and bioentrepreneurship in Northern Europe.

Country	Study Programmes	Stand-Alone Courses
Poland	University of Gdansk (Oceanography and Geography Department) offers a two-year MSc programme in **Biological Oceanography with a specialisation in marine biotechnology**. There are about ten universities offering biotechnology programmes at BSc MSc and PhD level, but mainly focusing on 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; gene and genome engineering of marine organism; bioinformatics; blue biotechnology; biotechnology company training.
Germany	There are about 70 MSc programmes 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 at University of Bremen, University of Greifswald, University of Kiel, and University 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 present in the 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[81, 82].

81 https://eliademy.com/catalog/catalog/product/view/sku/e56938e154

82 https://eliademy.com/catalog/catalog/product/view/sku/8030f496de

Country	Study Programmes	Stand-Alone Courses
Denmark	Denmark system offers many programmes in biotechnology, but not "blue". Danish Technical University (DTU) offers a two-year MSc programme in **Aquatic science and technology**[83]. The MSc, with three study specialisations, allows you to specialise in one of three emphases: Aquaculture, Fisheries, and Oceanography. DTU in collaboration with other Nordic Universities offers a two-year joint **MSc in Aquatic food production – safety & quality**[84]. 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 two-year programme in advanced biology and biotechnology with business tools and methods[85].	
Norway	The Arctic University of Norway offers a two-year MSc programme on **Marine Biotechnology**[86] that trains graduates with advanced skills in genetic, biotechnological, and molecular biological techniques.	
United Kingdom	Scottish Association for Marine Science (SAMS) in Scotland offers a one-year Master of Research (MRes) programme in **Algal Biotechnology, Biology and Ecology**[87]. Heriot-Watt University is offering the one-year MSc. programme **Marine Biodiversity and Biotechnology**[88].	
Transnational joint MSc programmes relevant to Northern Europe	University of Gothenburg offers the joint Nordic two-year MSc programme named **Sustainable Production and Utilization of Marine Bioresources** (MAR-BIO)[89]. SAMS jointly with other EU universities offers the Erasmus Mundus two-year Master's Degree in **Aquaculture, Environment and Society** (ACES)[90]. BBMBC was a 2-years project funded by EASME (EMFF) that designed and piloted a transnational **Blue Biotechnology** MSc programme (2017–2018)[91]. The programme focuses on blue biotechnology and is dedicated to its application particularly in the health, nutrition, and aquaculture domains. University of Stirling (UK) was the only partner from in Northern Europe.	

83 https://www.dtu.dk/english/education/msc/programmes/aquatic_science_and_technology

84 http://www.aqfood.org/

85 https://www.cbs.dk/en/study/graduate/msc-in-business-administration-and-bioentrepreneurship

86 https://uit.no/utdanning/program/541796/marine_biotechnology_-_master

87 https://www.sams.ac.uk/study/postgraduate/sams-algal-biotechnology-biology-and-ecology-mres/

88 https://www.hw.ac.uk/study/uk/postgraduate/marine-biodiversity-biotechnology.htm

89 http://holar.is/en/marbio_a_nordic_masters_programme

90 http://www.emm-aces.org/

91 https://www.bbmbc.eu/

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

The analysed RGD 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 the 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 the 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 the Copenhagen Business School. The Blue Generation project (EEA grant) raises awareness and mobilises groups of young people to get involved in the opportunities of blue economy, including blue biotechnology as an upcoming sector.

4. RESEARCH & INNOVATION: STRENGTHS AND OPPORTUNITIES OF BALTIC BLUE BIOTECHNOLOGY R&D

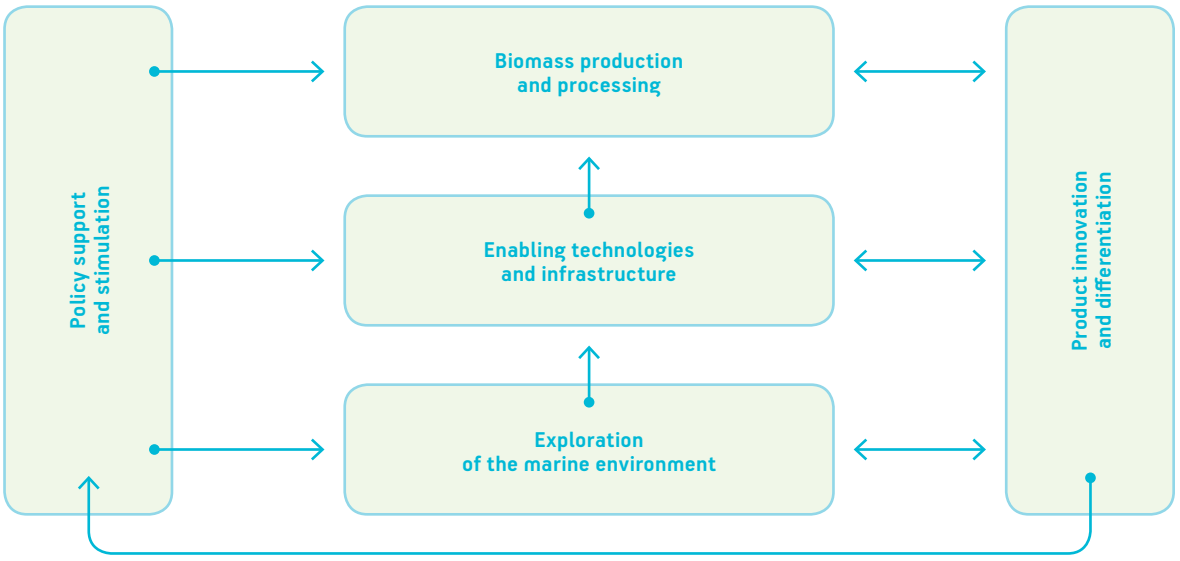


Figure 28 ERA-MBT framework of analysis of five thematic areas.[25]

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 the 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 up to 2030[25]. The framework of the roadmap was incorporated here in order to provide validation and feedback from the Baltic Sea Region as well as a sense of progress after two 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.

4.1 Exploration of the marine environment

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

Strengths of the BSR:

- Baltic marine and freshwater ecosystems host a specific biological diversity of organisms, such as fungi, micro – and macroalgae, bacteria, sponges, and mussels, as a result of the special condition of the Baltic Sea (see also text box 1.2). These bioresources can be used directly as a biomass source (e.g. protein), they can be producers (as microbial factories) of valuable natural products, or finally they can provide new knowledge or new data. 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 use the opportunity to take action and unlock the potential of their marine and freshwater biological resources. One opportunity would be to use the blue biotechnology field to support blue growth (generate and promote employment as well as economic and regional development, while at the same time contributing to growth and cohesion).

Figure 29 Photo credit: SUBMARINER Network.

- A rich diversity of biological resources is available at *Alliance* partner institutions in collections of viruses, bacteria including 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, breeding or growing fish or copepods) and are highly likely to contribute to the *Alliance* Blue Bioresources Catalogue. 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[71] 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 and to benefit from accessing information on availability and accessibility of aquatic biological resources in accordance with the guidelines of the regulatory framework on access and benefit sharing (ABS) 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, and alleviate innovation barriers of implementation of the ABS protocol, such as with 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 establish yet 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 in the calculation to enable common solutions. Project funding programmes are going in this direction, with some exceptions, with many 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 modified or already have the natural capacity to produce biotechnologically important compounds (e.g. enzymes).

4.2 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 24 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 many BSR universities and research institutes are enlisted in world ranks.
- 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 macroalgae 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 four cases were developing technologies and solutions for the aquaculture sector, like *Baltic Probiotics*, which develops products to improve fish health in tanks, *Biofisk*, which develops 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 in the *Alliance* mentoring programme, 20 cases requested and received scientific/technical support, including 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 they have also funded research on valorisation of residual biomass resources, such as beach wrack and bycatch, and processing side-streams and by-products, as we saw in Chapter 1.4. The majority of the projects from the BSR (having a 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. jellyfish 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 to SMEs in a niche sector. On the negative side, according to 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 EU initiatives tailored to SMEs. Other SME innovation funding schemes such as 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) and 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 ten 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 the blue bioeconomy across the BSR. This includes project findings of the Baltic Blue Biotechnology Alliance and Alliance+ (both Interreg BSR), but also fosters synergies with other regional or national clusters or pan-European R&D clusters, for instance EMBRC-ERIC are not covering BSR.

Opportunities in the BSR:

- As mentioned, the Baltic Sea is far from reaching "Good Environmental Status" due to (among other reasons) excess nutrient pollution (e.g. nitrogen and phosphorus) 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 microalgae or seaweed cultivation and harvesting, sustainable fisheries management, and mussel farming, have been considered biological methods with a high potential to improve environmental status by removal of excess nutrients. 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 needs to be collected from large-scale projects to address open questions.
- Furthermore, algal blooms or beach wrack are also promising alternative aquatic biomass resources, albeit often of lower quality and often labelled as "waste" from a regulatory perspective. The SUBMARINER Network is addressing environmental issues of the Baltic Sea and taking action towards improving the environmental status of the sea since 2013 by lobbying and communication, project development (*Alliance*, Baltic Blue Growth, GRASS projects), and developing studies and roadmaps. Also, several other projects such as Interreg BSR GRASS and CONTRA, which includes SUBMARINER Network members as project partners, consider how to best harvest seaweed or collect beach wrack for product development, while various other projects (e.g. Interreg BSR Baltic Blue Growth, BONUS OPTIMUS or the Swedish LIFE IP Rich Waters ECOPELAG) test how to best cultivate mussels to improve the environment in the Baltic Sea. Interestingly among *Alliance* cases, there was one spin-off from University of Gdansk investigating product development from algal blooms.

4.3 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, for example of food and feed (35%), cosmetics (15%), biomaterial and waste bioremediation (each 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, the blue biotechnology field is famous for drug discovery and historically many drugs have been derived from marine organisms such as sponges, but the analysis revealed that only a small fraction of participating institutions was engaged in drug discovery (10%) while the majority are engaged in research for other market applications.
- The analysis of the BSR entrepreneurial experimentation trends shows a different picture from the research R&D institutions. Analysis of 26 *Alliance* cases showed that the most popular markets for business have been cosmetics (25%), followed by food and feed (17%), energy (12%), and finally pharmaceuticals, with only 8% of cases. This is no big surprise, since the cosmetic sector promises quick revenues opposed to much lower 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 in trend in many Scandinavian countries as well as Eastern Baltic countries that are popular tourist and spa treatment destinations. There is also a very interesting trend in developing hardware

Figure 30 Photo credit: Julian Lohmann, Aalto University / DoS.

technologies and solutions for aquaculture, such as sensors and filters and fish health boosters for tanks.

- The *Alliance* mentoring programme has been pivotal for the advancement of cases and also influential for the mentors. Access and development of new ideas and joint projects, etc. has not been 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 over the course of the mentoring and the service offer. This was a combined result of discussions with experts and access to new materials and data, such as from scientific/technical services.

Opportunities in the BSR:

- Many large manufacturing companies have a track record in investing in R&D and participating in blue biotechnology R&D projects. For example, companies like CP Kelco, BASF, DSM, FMC Biopolymer, and Novozymes all have strong innovation portfolio management systems and an 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 corporates secure their position in the market. SMEs are also looking for funding and support for developing further their ideas into products and place it in the market. However, SMEs and start-ups find that innovation offices of large industry are often "difficult to reach". This innovation barrier has been noticed by large industrial actors, which have tried to create a fertile environment to attract SMEs with relevant technologies. Examples of activities include: organising open innovation events by sharing knowledge (unused patents), organising hackathons, inviting SMEs to solve a challenge, pitching events, or setting up accelerator programmes. Novozymes, BASF, and Møller-Maersk have developed such accelerators on board. As an example, also, the SFTec case was recruited by the second accelerator programme of Stora Enso, a global-scale pulp and paper manufacturer.
- The *Alliance* has not yet collaborated with large industry, however large industry is indeed an excellent and highly important future partner of the *Alliance* both for sponsoring cases or events and for organising joint events for blue biotech innovation.

Figure 31 Photo credit: Gothenburg University / Koster Alg.

4.4 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*

Strengths in the BSR:

- Two *Alliance* tools, the database for cataloguing multi-purpose research infrastructure and equipment and the bioresources catalogue, aim to increase visibility for equipment as well as marine biological resources present at companies and RGD institutions, thus increasing the potential of innovation, product development, the "cross-fertilisation" of new ideas, and the development of new knowledge both in academia and the economic sector. Active dissemination of these available tools is the key for success. Participants in the mentors' forum are the primary users of these two databases, which act as a map for partner networking for both RGD 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 the resources and expertise necessary to complete the journey from idea to finished product. In 2017, the ERA-MBT suggested building national and industry networks, clusters, and public-private partnerships to form a foundation for long-term improvements in research environments 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"[25]. There was, however, no real focus on transnational aspects, which are 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 like laboratories, equipment, pilot facilities and research vessels, also at a 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 programme 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. The ERA-MBT report suggests that "the current and largely informal information and knowledge infrastructures could be developed into a dedicated marine bioresources/biotechnology knowledge portal". 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, intersections 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 also used by other research and technological fields. Creating synergies across sectors within a region will create positive externalities; cross-fertilising knowledge promotes the ability to develop, access and retain talent and skills and provide access to resources, like financial, biomaterial, and infrastructure, which are of critical importance in the research-intensive blue biotechnology sectors. BSR has great prospects to be a blue bioeconomy showcase, as elaborated in the SUBMARINER Roadmap, which the SUBMARINER Network has used since 2013 to develop a platform for collaboration across marine sectors, including blue biotechnology, algae, mussels, and aquaculture, but also multi-uses for 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). Since Baltic Blue Biotechnology Alliance project ended, the *Alliance* is in the transition stage, exploring different pathways to sustain its mentoring programme and service offer. Blue Bio Alliance, a sister innovation platform in Portugal, has introduced an innovation voucher system, in which winners of the Blue Bio Value accelerator programme win €45,000 that they can spend cost-effectively for "buying services" from Blue Bio Alliance associates in a number of technical services such as scientific/technical, legal advice, etc. In the Baltics, introduction of innovation vouchers is a very interesting scheme that will be examined by *Alliance+* and SUBMARINER. However, the introduction of innovation vouchers is regarded as more complex in the Baltics, since the Baltic Blue Biotechnology Alliance is a transnational structure, unlike the Blue Bio Alliance, which has a national setup, and administrative and regional barriers are foreseen. Potentially, costs will be financed by partners or third parties either directly, or via a "blue bio" fund with mixed sourcing, such as crowdsourcing 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 "crowdfund" a case. This is particularly relevant for cases that are in the very early stage of product development.

4.5 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 the *Alliance*, which 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 Union92.

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

- Blue biotechnology is mentioned in and supported by important strategies both at the 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, to be useful in practice these EU strategies should be converted into national policies, for example 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 enabled Life Sciences & Blue Medicine priority fields. From the recommendations of the report "Common elements and lessons learned from RIS3 processes"[93], we highlight that more funds should be allocated for interregional collaboration, as regions often experience the same difficulties or regions have similar projects. Thereby, exchange of lessons learned was regarded as very useful for them. The role of the clusters is strategic for regional development and should be enhanced. For example, the cluster can easily be the forum where private and public resources and funds converge towards the same goal, so clusters should also be 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, nor 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 led jointly by R&D institutions and industry, 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 released an SME-friendly funding call promoting technology transfer and industrial innovation within blue bioeconomy sectors in 2018. The main drawback to this is that only ERA-NET EU countries are eligible for funding. The new Blue Invest Platform is a very interesting and promising mechanism to "pre-seed" SMEs and start-ups, and the *Alliance* is looking forward to providing support via this mechanism for the Baltic Sea Region.

- The forthcoming Blue Bioeconomy Roadmap (2019)94, by taking account of the urgent needs of the sector, aims to inform and influence future policies and innovation support mechanisms, including the Horizon Europe framework programme 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 yet been released, but there are discussions about developing calls for extending the project duration from beyond three years. Such a scenario would have a positive impact on the absorption of benefits associated with building new support structures and mechanisms such as the Baltic Blue Biotechnology Alliance innovation platform and SME accelerator and set a good foundation for the long term process of financial support.

- Europe is strong in terms of coordinating research activities in the early stages of the value chain, but further along the value chain there is a lack of collaboration between those doing the research and initial product development (mainly research institutes and SMEs) and the investors, larger companies with the resources to upscale and commercialise a product, and the industry within which the marine biotechnology application will be used24. 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 sustainable use of marine biological resources. Other mechanisms to expand the role of marine biotechnology in the broader bioeconomy include funding

93 Common elements and lessons learned from RIS3 processes Analysis of Project Partner Regions. Smart Blue Regions Project Synthesis Report. Interreg BSR (2018)

94 https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1355

Figure 32 Photo credit: Kalundborg Forsyning.

to encourage open innovation and the creation of dedicated public-private partnerships (PPPs) where marine biotechnology is recognised as an enabler of enterprise activity21.

- In the *Alliance* mentoring programme, innovation-specific questions were addressed to mentors in regard to the regulatory and legal constraints that cases face, from implementation of the Nagoya Protocol and Intellectual Property Rights (IPR) issues, to EU product safety standards, food regulations, certifications, and product labelling. These topics are key for promoting innovation and entrepreneurship and are clearly in demand by cases within the 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.

5. RECOMMENDATIONS FOR ADVANCING BLUE BIOTECHNOLOGY R&D

In the previous chapter, we presented an analysis of the strengths and opportunities of the BSR blue biotechnology research, development and innovation ecosystem, and the work was organised around five thematic areas. Based on the analysis, we developed five thematic recommendations for advancing R&D within blue biotechnology in the BSR. The recommendations are organised into 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 is mainly on the initial R&D stages of product development chains, although some innovation opportunities were also included in the list.

Objective 1. Access to aquatic bioresources

Baltic marine and freshwater ecosystems host a thriving biological diversity of organisms, including fungi, micro – and macroalgae, bacteria, sponges, and mussels. During the Baltic Blue Biotechnology Alliance project it became clear that the blue biotechnology field requires access to marine and freshwater bioresources, but these must be secured without destroying the ecosystems. This includes **access to existing biological culture collections (e.g. microbial biobanks, microalgae collections), licensed access to different types of natural resources (e.g. macroalgae) and access to yet undiscovered bioresources (minimising environmental impacts of sampling).**

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 the collections requires competent personnel and resources. To be able to use these collections, the information about them must 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. The catalogue guided mentors and cases to locate the right bioresource in another country. Having a comprehensive bioresources catalogue opens possibilities for collaboration and further advancement across the value chain. Further integration of culture collections and **the 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 throughout the EU. Furthermore, **connections of the *Alliance* with other EU Blue BioBanks** (e.g. see the EMBRC EBB project) could expand the existing *Alliance* catalogue for the mutual benefit of all parties. Notably, the EMBRC EEB project does not have a Baltic partner, and the *Alliance* can cover this region in the future.

The **implementation of the Nagoya Protocol should be easier within the BSR states to facilitate access for research and sampling for organisms**. But the same should also be done for international waters outside the Baltic Sea Region, in waters beyond national jurisdiction that can enrich collections and the innovation potential

Figure 33 Photo credit: Julian Lohmann, Aalto University/DoS.

of the region[95]. In blue biotechnology, the access to bioresources is very important at the earliest 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 and also economic and regional development, contributing to growth and cohesion.

Finally, accessing of natural resources will benefit from **mapping the Baltic Sea marine environment to locate hotspots for sustainable sampling and harvesting of bioresources**. New automated monitoring and sampling devices could be used parallel to traditional ones. For that, the access to research vessels should be secured.

95 http://www.vliz.be/projects/marinegeneticresources/united-nations-convention-law-sea.html

Objective 2. Sustainable integrated production 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 the EU is expected to increase, especially in Central and Eastern Europe, while nowadays on average one EU citizen consumes 25 kilos of seafood[96]. However, 60% of seafood consumed in Europe is imported, and about a fourth comes from aquaculture. Furthermore, aquatic plants and animals can provide ingredients, materials, and services, such as ecosystem services (CO_2 uptake, water purification), sources of nutrients in biofertilisers, nutraceuticals and 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 in which the *Alliance* has established 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, crustaceans, as well as unexploited organisms like jellyfish. Examples of R&D needs are **sustaining and further developing knowledge in the production and processing of aquatic biological resources into added-value products, technology upscaling, as well as biorefining technologies to minimise waste**.

Integrated aquaculture systems for closing nutrient and carbon cycles are sweet spots for bio-circular economy. Recirculating Aquaculture Systems (RAS) fish production on land, combined with microalgae, vermiculture and insect production or aquaponics, have been suggested for recycling nutrients and reducing water pollution. Similarly, open water Integrated Multi-Trophic Aquaculture (IMTA) systems combining fish farming with mussels and seaweed are currently under development

Figure 34 Photo credit: SUBMARINER Network.

in many countries, such as Sweden. 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 of the environmental and socio-economic benefits, risks, and opportunities associated with integrated aquaculture technologies, also at scale. Nutrient circulation is one of the most important issues in sustainable production.** Further advancement of integrated aquaculture technologies prescribes **collaboration of multiple scientific and technological disciplines both for applied science and also for developing auxiliary technologies to scale up the aquaculture sector**, such as harvesting technologies, sensors and optimisation, sustainable aquafeed, animal welfare and health, and micro-filtration systems. Among *Alliance* cases, 28% developed microalgae production technologies, three out of 26 cases developed technologies from processing waste from marine species (macroalgae, algal blooms, and mussel shells), and four cases developed support technologies for the aquaculture sector. SUBMARINER's InnoAquaTech project (Interreg South Baltic), with four production pilots and many business development activities[97], also provided insights to the innovation potential of the region in RAS aquaculture and integrated land-based aquaculture.

96 https://ec.europa.eu/fisheries/6-consumption_en

97 www.submariner-network.eu/images/InnoAquaTech_brochure_Final.pdf

Further, marine aquaculture of low-trophic species has tremendous untapped potential in the BSR, and **local low-trophic biological resources should be mapped and suitable production systems identified for harvesting, processing and biorefining** in cold, shallow brackish BSR waters, also at scale. We can already build upon existing knowledge of brown and red seaweed and blue mussels from projects like GRASS, MACRO CASCADE, SeaFarm, Fucosan, Baltic Blue Growth, and Optimus. Moreover, 38% of *Alliance* cases developed products from macroalgae, many of which had integrated a supply chain of either cultivated or harvested macroalgae, yet the production scale was relatively small and labour intensive. Process optimisation and upscaling can really improve sustainability of a production process. Also, the possibilities of using different wastewater types in the cultivation and the impact of them on the end product need more attention. Finally, more knowledge is needed both in the production and also the processing side to increase ecosystem understanding, impact assessment for open systems (e.g. ALFF project), and also LCA and economy.

Figure 35 Photo credit: Koster Alg.

Objective 3. Design of new materials supporting the circular economy

On a global scale we are **facing a 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, plastic waste has become a significant problem in many marine ecosystems and for that reason new alternatives to plastic products are urgently needed. Also, different drugs and hormones are released into the 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 better facilitated and traditional industries further developed.** The life cycle of products as well as different processes need 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** (see also Objective 2). For example, nutrients from the wastewater could be used to cultivate algae or shellfish for production of energy or other added-value products. Algae and shellfish could clean the water and simultaneously produce biomass that could be used as a fertiliser. **Aquaculture can provide ecosystem services and contribute to cleaning water or scavenging for nutrients,** and carbon should be better studied. Also, politically, ecosystem services should be better supported. In the *Alliance*, the need was observed by five cases that developed solutions for converting waste bioresources into a resource. Examples included: Biome, which used mussel shells for developing bone tissue substitutes, Biofisk, Movable Biogas Factory, and the University of 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, along with techno-economic barriers (harvesting, conversion) and also the development of value chain pathways. Initial steps have been taken by CONTRA (Interreg BSR) and Coastal Biogas (Interreg South Baltic).

Objective 4. Align 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 that can increase prosperity and stability. As well, if used wisely, it 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 an early stage, for example at the bioprospecting stage, can accelerate product development.** It furthermore increases cost efficiency of R&D by reducing 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 is still 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). This stage needs considerable financing for R&D, for instance to 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, such as sponges. It is well known that **regulatory barriers** can postpone or even stop technological innovation. Regulatory factors should be clear to R&D at an early stage, so R&D is fully aligned with requirements, product standards, regulations, etc.

Furthermore, the majority of large industry, such as food, chemicals and pharma, invests in innovation and has both the 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 even 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 a magnet for large industry. As a result, large industry tends to support SMEs and start-ups via hackathons, sponsor think tanks or open science innovation events in universities, found accelerators with open calls, etc. Since the sector is so small, it is very important **that clusters organise matchmaking events, thus bridging the gap between universities, research institutes, large industry and SMEs, and start-ups**.

Figure 36 Photo credit: Baltic Probiotics.

However, the *Alliance* accelerator 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 matchmaking facilities are serving their purpose in boosting innovation, other mechanisms following a structured development pathway and providing a security net that fosters ideation and risk-taking by start-ups and SMEs are also necessary. The *Alliance* mentoring programme supported by the interdisciplinary mentors' 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, additional financing is needed for the *Alliance* to expand its capacity to support more cases in the BSR.

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

Blue biotechnology is an emerging field with a great potential. It is still in a pre-development stage in the sense that not many entrepreneurial activities exist, most knowledge is still developed within the R&D institutions, not much large-scale infrastructure is available for upscaling technologies and value chains, and large corporations are not very active in blue biotechnology with some exceptions (e.g. extraction of collagen and alginates).

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, which 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 we hereby 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 database is currently available online. In the future **the database should be further enriched and expanded by adding more multi-use facilities and equipment, including pilot and demo scale facilities,** which are available (on demand) by R&D institutions and in the private sector across the BSR. The result is that **the BSR lacks multi-use, open-access, pilot-scale facilities relevant to (blue) biotechnologies.** Testing technological innovation on a large scale facilitates knowledge and data that allows knowledge-based decision-making, affecting impact investment and product development. The mapping exercise of capacities and resources has started. If we continue the work of the SUBMARINER compendium and the *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

Figure 37 Products from the *Alliance* cases exhibited at the European Week of Cities and Regions 2018. Photo credit: SUBMARINER Network.

blue biotechnology research and innovation as well as for developing transnational innovation pathways connecting Eastern Baltic capacities and resources available in R&D institutes with product development chains in large industry throughout the Western Baltic region. Also, we will be able to look at the most urgent technological innovation needs within the Baltic Sea Region.

Furthermore, at EU level **the database should better connect with other similar tools** to increase visibility and access to end users and boost returns 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 that map open-use multi-purpose research infrastructure relevant to the EU bioeconomy.

6. EIGHT CROSS-CUTTING RECOMMENDATIONS FOR THE CONTINUATION AND EXPANSION OF THE *ALLIANCE* (VISION FOR THE *ALLIANCE*)

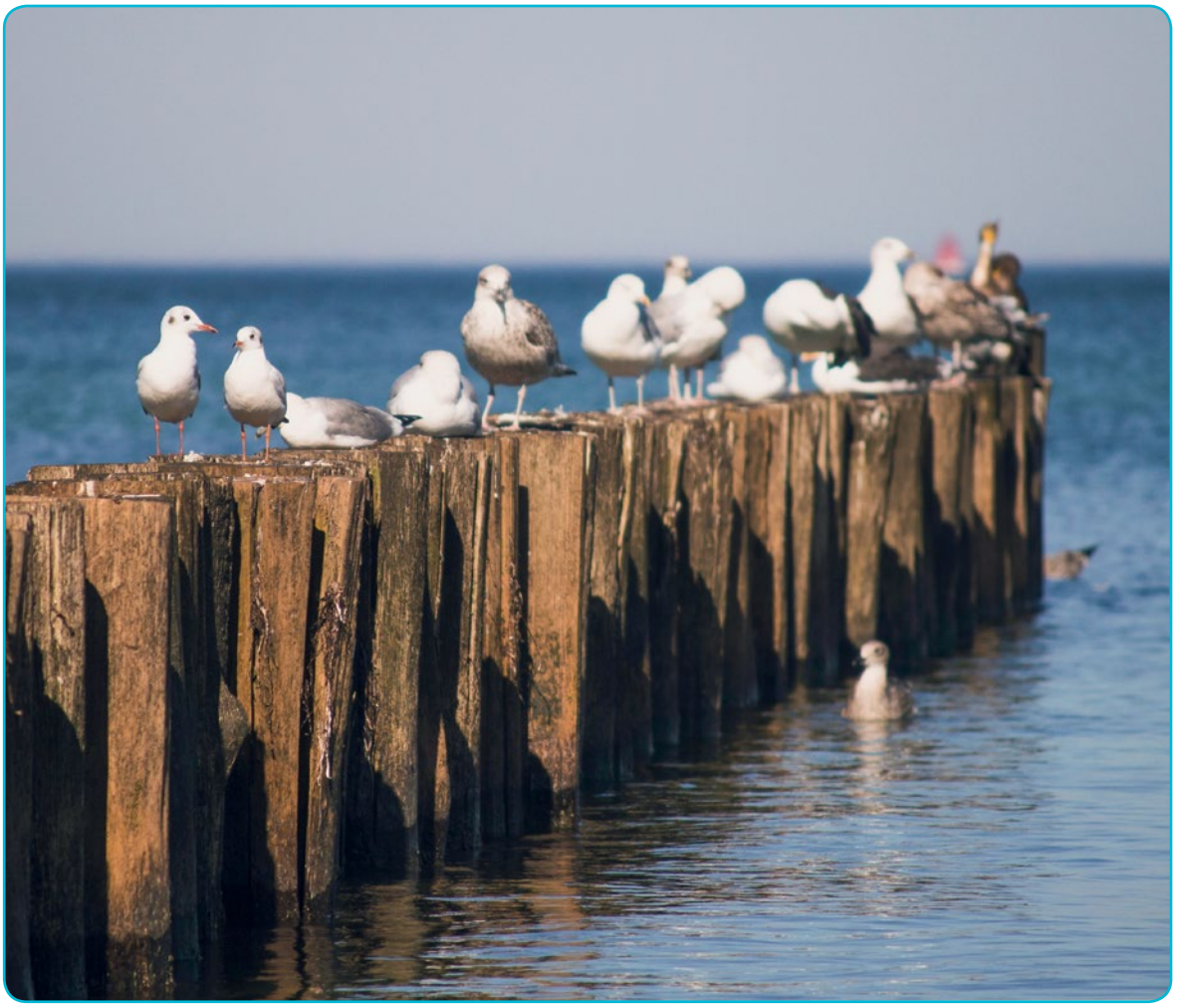


Figure 38 Photo credit: Mariam Soliman / Unsplash.

A critical mass of blue biotechnology actors and activities is necessary for the sustainable development and support of blue biotechnology innovation in the BSR. To tackle innovation challenges, intensive clustering is needed. Even though national blue bioeconomy clusters are slowly evolving also at sub-regional or national level[98], there is also the concrete need for tight and unimpeded transnational collaboration between these actors and activities in order to enable cross-fertilisation of ideas and support of this highly specialised sector. Transnational network hubs play a key role in connecting partners and creating complete value chains, transferring the technologies, creating innovation banks, and fostering cross-cutting innovation.

Networks support regional clusters in attracting skills and investors, and they "operate the tools". The *Alliance* has proven that these carefully developed tools and processes only work when there is a lively and active network of people using them. For example, in the *Alliance*, a cornerstone of success was the performance of the blue detectives and mentors who proactively reached out to recruit new cases as well as good experts and partners driven by the cases' demands. The network's functionality was a result of good tools but also the hard work and expertise of the blue detectives and mentors to reach out, expand, and invite their networks into the *Alliance*. This was only possible because blue detectives and mentors had the personal interest, availability, capacity, and support for reaching out.

98 e.g. in Germany the "BaMS" association (a 5-year long innovation project on "Bioeconomy at Marine Sites" financed by the Federal Ministry of Education and Research) and in Sweden the 'National Blue Economy cluster at the Marine Station Kristineberg'

Figure 39 Baltic Probiotics. Photo credit: SUBMARINER Network.

Figure 40 Hilary Karlson from DTI with Guldborgsund Municipality's mayor, John Brædder. Photo credit: Guldborgsund Municipality.

Cross-cutting recommendation 1: Enlarge and broaden the Alliance network

As noted above, it is important to continuously broaden the scope of the *Alliance* partnership as to intensify collaboration and incorporate:

- The additional set of 15-20 R&D institutions throughout the Baltic Sea Region active in fields relevant to blue biotechnology,
- The relevant business support institutions including incubators and technology parks,
- The general 'spin-off' and 'start-up' assistance offices, often part of the universities or chambers of commerce, so as to raise their awareness that they can send any relevant 'blue clients' to the *Alliance* accelerator,
- Companies, who are the potential end-users and/or clients for the start-ups and SMEs in view of blue biotechnology products and services developed,
- Business angels, funding agencies as well as investors to provide the necessary finance to the start-ups and SMEs.

Cross-cutting recommendation 2: Continue to integrate outputs and results from specific research projects

It is vitally important to jointly capitalise on knowledge generated in the *Alliance* and other projects, especially topic-specific knowledge, by integrating tools and findings into the knowledge base of the *Alliance's* 50+ partners. Projects produce, in the short-term, new data, information and knowledge that have a data management plan beyond the time of the project's lifetime. The SUBMARINER Network, acting as an umbrella "blue-cluster" coordinating the *Alliance* actors, leverages generated data and knowledge for triggering future action, hence empowering key actors to make knowledge-based decisions.

Supported through the Blue Platform project (2018–2021, Interreg BSR), coordinated by the SUBMARINER Network secretariat, members currently analyse and combine findings of several thematic BSR-related "blue bioeconomy" projects, including the *Alliance*, to increase visibility of project achievements as well as providing recommendations for alignment of future funding and legislation.

Cross-cutting recommendation 3: Continue to remove communication barriers among actors across the value chain

As already pointed out by the ERA-MBT project, lack of communication among actors across the value chains can be a major innovation barrier. As part of the ERA-MBT, a tool was also developed called **"Preferred mechanism for bringing ideas to market"** with the aim of addressing the communication challenges among the actors in the value chain[99] and improving communication, thereby increasing the success rate of cases. The varying expectations of institutions can create obstacles in the product development stage. The terminology across the value chain may be quite different and the length of time expected for the completion of a TRL step can vary widely. For example, R&D projects can last three to four years, but companies need results faster. Furthermore, researchers need to publish scientific results but companies cannot allow this due to patent regulations and trade secrets.

The tool has been integrated into the 'training package for mentors' under the currently ongoing follow-up project Baltic Blue Biotech Alliance+. Indeed, mentors have an important function as mediators and translators between the various actors across the product development chain, as match-making can only work out if the various actors involved properly understand each other's needs and expectations. Experience shows that communication barriers do not only exist among actors from different countries or between researchers and entrepreneurs; but also, between different science disciplines.

Even though the *Alliance* has already managed to improve this communication and thus accelerate innovation development, more work still needs to go into streamlining expectations, communication and language between the actors.

99 http://www.marinebiotech.eu/communication-guidelines

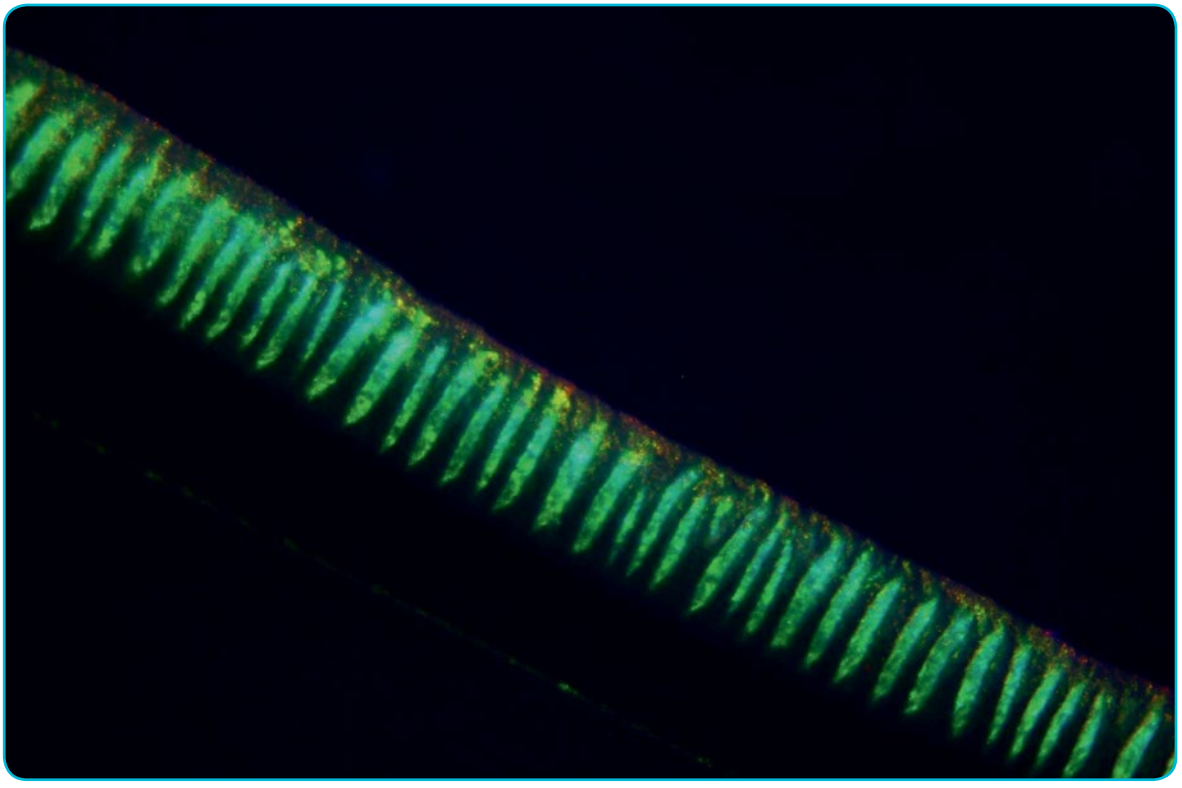


Figure 41 Photo credit: Hoekmine.

Cross-cutting recommendation 4: From project to a continuous transnational blue assistance programme

The SUBMARINER Network plays an important role in coordinating efforts towards knowledge integration on a more systematic and long-term basis.

On the political level, the current update of the EU Strategy for the BSR (EUSBSR) and HELCOM Baltic Sea Action Plan, which in turn will influence the future ERA-Net, Interreg, and BANOS funding programmes – are creating an important foundation to enable the long-term continuous support ecosystem. With that in mind, we highly support any move, which would allow for extended durations of support projects from three-year periods to longer durations (e.g. within Interreg). Such scenarios would enable a continuous absorption flow of benefits across all relevant actors within the Baltic Sea Region.

The business plan scenarios developed under the *Alliance* project show that basic network and matchmaking services may be possible to be financed at low scale on a self-sustained basis through contributions from the network members. The sustained operation of the accelerator services will, however, require strategic public or private funding.

In blue biotechnology, the challenges in funding are related to the high innovation costs and the long time needed to get new applications to 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 and use it to tackle common challenges and difficulties. EUSBSR flagships, like SUBMARINER Network, already have the mandate to help the EUSBSR reach its targets, but they do not receive any financial support for doing so (SUBMARINER Network is funded through membership fees and participating in publicly-funded projects). A common fund could help maintain the flagships.

In regard to the *Alliance* service, **a trans-national innovation voucher system** would benefit blue biotechnology start-ups and SMEs in the BSR and beyond, as it would allow financing the *Alliance* pre-acceleration services. The innovation voucher system could be financed by European Regional Development Funds from the Baltic and Nordic regions and states. A new mechanism has been examined by the EU since 2018 and is fully aligned with Research and Innovation Smart Specialisation Strategies (RIS3). It is called #Component5, and it is a promising opportunity that would enable the long-term existence of the *Alliance* and its innovation support ecosystem, that is currently not covered by any transnational funding scheme.

Finally, funding agencies should also be part of the blue biotechnology networks and clusters in order to align long-term strategies.

Cross-cutting recommendation 5: Funding the *Alliance*, its mentors and cases is an investment into the sustainable development of the BSR

The *Alliance* has shown that the support services developed really do accelerate the blue economy business development throughout the region. They have also proven to be of high value to the research itself – in view of providing a continuous feedback on what is required by the market and society. Moreover, as shown above, all cases contribute to the achievement of the UN SDGs within the region.

Financing the *Alliance* is therefore an investment of the Baltic Sea Region countries into their future.

Cross-cutting recommendation 6: Increase and improve coordination and cooperation with other blue accelerators

In parallel to the SUBMARINER Network and the *Alliance*, numerous new niche networks and specialty accelerator programmes exist or have emerged since 2016. Instead of

creating yet another network infrastructure, intensification of collaboration between existing accelerators appears to be the most pragmatic way forward. The *Alliance* has already teamed up with other spear-heading networks, such as the EMBRC-ERIC, BioMarine, and the BlueBio Alliance of Portugal. Our *Alliance* plans to intensify these existing collaborations in the near future and is open to new ventures.

For example, we hope that the Blue Invest Platform, which is a promising new EU-wide innovation and investment support mechanism for blue economy-related SMEs, is open to true collaboration. The *Alliance* would be a great potential ally to the Blue Invest Platform, especially in view of the on-going recruitment of cases and the pre-acceleration services offered by our blue specialists.

Cross-cutting recommendation 7: Strengthen education and training in blue biotechnology and blue entrepreneurship

Education plays a strategic role in equipping future scientists and bio-entrepreneurs with necessary expertise but also in the vocational training of the industry's future workforce. Currently, few training possibilities exist for scientific fields within blue biotechnology – mainly there are options for separate courses or specialisation options as part of biotechnology programmes.

- To raise awareness for the impact blue biotechnology may have in a future bio-based economy, more high-profile educational programmes are needed to teach the relevant methods and techniques and encourage the young generation to engage in blue biotechnology. The inspiring success stories of the BBMBC[100] or ACES[101] programmes should have a beacon function and may lead to similar future initiatives in the BSR.
- Additionally, more bio-entrepreneurship education opportunities are recommended for future managers and business developers. This is especially relevant for important biotechnology city-clusters, for example in Kiel, Tartu, or Helsinki, thus copying the success of Copenhagen Business School. Joint transnational Master's and PhD programmes are needed, including specialty MBA programmes for training scientists in entrepreneurship and business.
- There are also knowledge gaps in special issues, such as IPR and legal issues in different countries. Finally, we identified there is a lack of basic knowledge, especially connected to the harvesting, purification, and extraction of biomass among non-research professionals / workers.

Cross-cutting recommendation 8: Prepare a 'blue economy' funding guide

Actors along the (blue) biotechnology value chain are dependent on different types of financing. Financing depends on the specific needs (e.g. RGD, prototype development, upscaling, etc.) and funding sources can have geographical restrictions. Therefore, a **funding guide** within blue biotechnology would be of great value to assist the actors in finding appropriate funding solutions for their specific needs.

100 The ‚Blue Biotechnology Master Course for a Blue Career' (BBMBC) was an EMFF funded project (2017-2018), which developed a Master's degree in La Rochelle University addressing skills gaps in the Blue Biotechnology sector in Europe

101 ACES was an Erasmus Mundus two-year Master's Degree in Aquaculture, Environment and Society.

7.

THE *ALLIANCE* FROM PROJECT TO SERVICE OFFER: SUBMARINER NETWORK

The Baltic Blue Biotechnology Alliance was a flagship project funded by Interreg BSR (2016–2019). After three 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 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**, including start-ups, SMEs, business support organisations and R&D, and as a business accelerator programme for product development. The *Alliance* comprises more than 50+ actors who are experts in blue biotechnology providing services. In the last three years, the *Alliance* has proven that the applied approach is exactly the right path to bridge the gap between development and business. So far, we have mentored 26 cases at all stages of the product development chain, and we are specialising in "pre-seed" cases that are developing a prototype and a MVP.

For the upcoming 18 months until January 2021, a selected number of core partners from the original *Alliance* will receive continued funding from Interreg BSR under Baltic Blue Biotech Alliance+, with the aim to familiarise and recruit other relevant blue biotechnology actors to join

Figure 42 *Alliance* project partners, cases and judges at picthing event 2018. Photo credit: SUBMARINER Network.

the *Alliance* to offer as well as receive services framework, and make *Alliance* financially sustainable by receiving funding for its services offered from sources other than Interreg. As shown in the *Alliance* business plan, the general networking and coordinating aspect, inherent in the *Alliance*, could be financed from a critical mass of SUBMARINER Network members and also sponsors and supporters. The extent to which it will be possible to provide dedicated pre-acceleration services to cases by *Alliance* members will depend on whether it will be possible to attract payments of investors for such services.

We welcome new cases, partners and supporters from the Baltic Sea Region but also throughout Europe. Even though the *Alliance* already gathers a critical mass of blue biotechnology actors across the Baltic Sea Region, we are aware that there are many more that we want to reach; be it those who want to offer services as well as those who require them to advance their ideas. Capitalising on the achievements and progress of the past years, we therefore continue to search for new *Alliance* members as well as cases. Through a whole series of pitching and matchmaking events, specialised workshops and seminars, and joint conferences throughout 2019 and 2020, we provide numerous opportunities for new cases as well as *Alliance* members to present themselves and to familiarise themselves with the existing *Alliance* network and its proven *Alliance* mentoring methodology and related support material; to co-create new project partnerships as well as link with investment and funding programmes.

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

Figure 43 Poster from the *Alliance* pitching and match-making event in January 2020 in Helsinki.

- Mentors, business coaches, and blue detectives with experience and ability 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 Master's programmes on blue biotechnology

Strategic partners are sought to support our *Alliance* platform and "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 and **fully customised mentoring and service provision** to cases, driven by a case's needs, thus boosting innovation capacity in the region(s), and creating new opportunities. Also, the *Alliance* seeks out strategic **funding** to enable background operations, such as the very successful and influential *Alliance* **mentors' forum** that is THE blue biotechnology innovation community of experts supporting each other and the cases, and the *Alliance* **blue detectives** that provide visibility for the *Alliance* services and scout "around the clock" for new *Alliance* cases. Both actors played a huge role in the *Alliance* and were so effective that we strongly aim to continue these services, which have become the heart of the *Alliance*.

If you are interested to learn more and support our activities, please visit the SUBMARINER Network website or follow us in the media:

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

https://www.linkedin.com/company/submariner-network-for-blue-growth-eeig

https://twitter.com/submnet

ANNEX

Table 5 BSR actors relevant to the Baltic Blue Biotechnology Alliance. Some of the actors have participated in the R&D capacity analysis (described in Chapter 3).

Country	Organisation	Department/division/center	Type of organization	*Alliance* Project Partner	Part of the R&D Capacity Analysis
Denmark	Technical University of Denmark	National Food Institute	Institution		✓
		National Institute of Aquatic Resources	Institution		
		Chemical Engineering	Institution		
	Roskilde University	Department of Science and Environment	Institution		✓
	Aarhus University	Department of Bioscience	Institution		
	Danish Technological Institute	Bioresources and biorefinery	Institution		
	University of Copenhagen	Department of Plant and Environmental Sciences	Institution		✓
	University of Southern Denmark	Blue SDU	Institution		
	Danish Shellfish Centre		Institution		
	NordShell		Company		
	Dansk Akvakultur (Danish Aquaculture Association)		Association		
	European Environment Agency		Agency		
	Aarhus University	Department of Bioscience	Institution		✓
	Danish Technological Institute	Division Agrotech, Bioresources and biorefinery	Institution		✓
		Division Agrotech, Plant Technology	Institution	✓	✓
	Danish Fishermen's Association		Association		
	Aalborg University	Innovative Fisheries Management	Institution		
	Agency for Water and Nature Management		Agency		
	Aalborg University	The Danish Centre for Environmental Assessment	Institution		
	Danish Nature Agency		Agency		

Country	Organisation	Department/division/center	Type of organization	*Alliance* Project Partner	Part of the R&D Capacity Analysis
Estonia	Estonian Fish Farmers Association		Association		
	Estonian University of Life Sciences	Institute of Veterinary Medicine and Animal Sciences, Chair of Aquaculture	Institution		
	Baltic Environmental Forum Estonia		Association		
	Estonian Ornithological Society		Association		
	Estonian University of Life Sciences	Institute of Agriculture and Environmental Sciences, Chair of Hydrobiology and Fishery	Institution		✓
	Tallinn University	School of Natural Sciences and Health	Institution		✓
	University of Tartu	Estonian Marine Institute	Institution		✓
	Estonian University of Life Sciences	Institute of Technology	Institution		
	Estonian Association of Fishery		Association		
Finland	Finnish Environment Institute (SYKE)	Marine Research Centre	Institution	✓	✓
		Freshwater Centre	Institution		
		Programme for Sustainable Circular Economy	Institution		
		Centre for Sustainable Consumption and Production	Institution		
	Natural Resources Institute Finland (LUKE)	Blue Bioeconomy	Institution		
	University of Helsinki	Faculty of Biological and Environmental Sciences	Institution		
	Natural Resources Institute Finland (LUKE)	Bioeconomy and environment	Institution		✓
	VTT Technical Research Centre of Finland Ltd.	Solutions for Natural Resources and Environment	Institution		✓
		Smart Industry and Energy Systems	Institution		
		Renewable chemicals	Institution		
		Bioeconomy and circular economy	Institution		
		Development of production organisms	Institution		
		Protein discovery and engineering	Institution		
		Bioprocess development	Institution		

Country	Organisation	Department/division/center	Type of organization	*Alliance* Project Partner	Part of the R&D Capacity Analysis
Finland	Aalto University	Clean Technologies	Institution		
		Department of Bioproducts and Biosystems	Institution		
		Biomolecular Materials	Institution		
		Bio-based Materials Technology	Institution		
		Microbiology	Institution		
		Biobased Colloids and Materials	Institution		
		Biorefineries	Institution		
		Bioproduct Chemistry	Institution		
	University of Turku	Department of Biochemistry	Institution		
	University of Oulu	Water Resources and Environmental Engineering	Institution		
		Environmental and Chemical Engineering	Institution		
	University of Jyväskylä	Natural Resources and Environment	Institution		
		Biosciences	Institution		
	LUT University	Energy Efficiency	Institution		
		Resource Efficiency	Institution		
		School of Engineering Science	Institution		
		School of Energy Systems	Institution		
		Laboratory of Energy Technology	Institution		
	University of Turku	Archipelago Research Institute	Institution		
	Helsinki Region Environmental Services Authority HSY		Institution		
	Finnish Transport Safety Agency		Agency		
	John Nurminen Foundation		Foundation		
	Parks & Wildlife Finland		Company		
Germany	Bavarian Research Alliance GmbH		Company		
	CRM - Coastal Research & Management		Company		
	GMA – Society/ Association for marine aquaculture Ltd.		Company		
	Leibniz Institute for Baltic Sea Research Warnemünde (IOW)		Institution		
	University of Rostock		Institution		

Country	Organisation	Department/division/center	Type of organization	*Alliance* Project Partner	Part of the RGD Capacity Analysis
Germany	German Marine Research Consortium (KDM)		Association		
	Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz Schleswig Holstein (LKN.SH)		Agency		
	Leibniz Association		Association		
	Union of German Cutter Fishery		Association		
	Thünen Institute	Institute of Baltic Sea Fisheries	Institution		
	National Association of Cutter and Coastal Fishermen Mecklenburg-Vorpommern		Association		
	GEOMAR Helmholtz Centre for Ocean Research Kiel	Research Unit Marine Natural Products Chemistry/GEOMAR-Biotech Centre for Marine Biotechnology	Institution	✓	✓
	Fraunhofer-Institution for Marine Biotechnology and Cell Technology	Marine Biotechnology	Institution		✓
	University of Applied Sciences Flensburg	Faculty of Energy and Biotechnology, AG Bio and food technology	Institution		✓
	University of Applied Sciences in Saarbrücken (htw saar)		Institution		
Latvia	Environmental Development Association		Association		
	Institute of Food Safety, Animal Health and Environment (BIOR)		Institution		
	Investment and Development Agency of Latvia		Agency		
	Daugavpils University Agency	Latvian Hydroecology Institute	Institution		
	Latvian Academy of Sciences	European Programmes Centre	Institution		
	Cleantech Latvia		Buisness support organisation	✓	✓
	State Inspection for Heritage Protection of Latvia		Agency		
	Latvian Fisheries Association		Association		
	Latvian Institute of Aquatic Ecology		Institution		
Lithuania	Lithuanian State Pisciculture and Fisheries Research Centre		Institution		
	State Food and Veterinary Service		Agency		

Country	Organisation	Department/division/center	Type of organization	*Alliance* Project Partner	Part of the R&D Capacity Analysis
Lithuania	Coastal Research and Planning Institute		Institution	✓	✓
	Klaipeda University	Marine Research Institute	Institution		
	Environmental Protection Agency	Marine Research Department	Agency		
	Lithuanian Coalition of Environmental Non-Governmental Organizations		Network		
	Lithuanian Association of Hunters & Fishermen		Association		
	Lithuanian Institute of Agrarian Economics		Institution		
	Lithuanian Ornithological Society (LOD)		Association		
	Fisheries Service		Agency		
Norway	Norwegian Directorate for Nature Management		Agency		
	SINTEF	Fisheries and Aquaculture	Institution		
Poland	West Pomeranian University of Technology, Szczecin		Institution		
	Polish Academy of Science in Gołysz	Institute of Ichthyobiology and Aquaculture	Institution		
	Polish Trout Breeders Association		Association		
	Ecological Association EKO-UNIA		Association		
	University of Gdansk	Hel Marine Station	Institution		
	Polish Academy of Sciences	Institute of Oceanology	Institution		
	University of Gdansk	Institute of Oceanography	Institution		
	Association of Fishermen's of Sea		Association		
	Fishery Local Action Group "Rybacka Brać Mierzei"		Association		
	National Chamber of Fish Producers		Association		
	National Marine Fisheries Research Institute		Institution		
	University of Gdańsk	Intercollegiate Faculty of Biotechnology UG & MUG	Institution	✓	✓
	Maritime Institute of Gdańsk	Department of Environmental Protection	Institution		✓

Country	Organisation	Department/division/center	Type of organization	*Alliance* Project Partner	Part of the R&D Capacity Analysis
Poland	Regional Sea Fisheries Inspectorate		Agency		
	Ministry of Maritime Economy and Inland Navigaton	Fisheries Monitoring Centre of the Department of Fisheries	Agency		
	Seamen's & Fishermen's Trade Unions Federation		Association		
Sweden	Swedish University for Agricultural Sciences		Institution		
	The Royal Swedish Academy of Sciences		Institution		
	AquaBiota Water Research		Institution		
	Linköping University	Centre for Climate Science and Policy Research	Institution		
	Swedish Geotechnical Institute		Institution		
	The Swedish Agency for Marine and Water Management		Agency		
	The Swedish Environmental Protection Agency (EPA)		Agency		
	Swedish Fisherman Association		Association		
	Swedish Professional Fishermen's Association		Association		
	Swedish Sportfishing Association		Association		
	The Fisheries Secretatiat		Agency		
	Vinnova		Agency		
	Swedish Board of Agriculture		Agency		
	Linnaeus University		Institution		
	KTH Royal Institute of Technology	Department of Sustainable Development, Environmental Science and Engineering (SEED)	Institution	✓	✓
	University of Gothenburg	Department of Marine Sciences	Institution	✓	✓
	RISE Research Institutes of Sweden	Chemistry and Materials	Institution		✓
United Kingdom	Scottish Association for Marine Science (SAMS)		Institution	✓	✓

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