SUBMARINER NETWORK

SUBMARINER ROADMAP BEYOND 2021

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Blue Platform

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NOVEMBER 2021

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Interreg Baltic Sea Region
EUROPEAN UNION
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Blue Platform


Together we improve
the Baltic Sea's blue
environment and economy

The SUBMARINER Network promotes innovative approaches to the sustainable use of marine resources and offers a cooperation platform to related actors and initiatives in the Baltic Sea Region

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Actions for 2021 and beyond for the SUBMARINER Network

Dear Reader,

it is with great pleasure that we present to you our new 'SUBMARINER Roadmap 2021+'.

The recommendations, actions and objectives shown in this document have been defined in an intensive, wide-reaching process, in which we analysed the progress achieved within the Blue bioeconomy in the Baltic Sea in the period since the publication of our first SUBMARINER Roadmap in September 2013. This incorporates the latest environmental findings and developments, which inform the next steps the network should take.

Overall, we are very proud of our achievements over the past eight years. With only a very few exceptions, we raised the necessary funding to implement the strategic actions we had originally planned. As a result, many of the topics, which were still very much in early research stages at the foundation of the SUBMARINER Network, are now being integrated into the market economy and European policies. Algae-based products can be found almost everywhere on the shelves of supermarkets and drugstores. More and more researchers and entrepreneurs are generating ideas for new blue products, supported by our Blue Growth Accelerator programme. Projects like BalticBlueGrowth and GRASS have provided the proof of concept that mussel and algae cultivation is possible in low salinity waters, simultaneously tackling the major environmental problem of eutrophication in the Baltic Sea. An increasing number of large energy companies are increasingly open to multi-use concepts, aiming for smart combinations and environmentally-friendly uses in and around offshore wind parks.

But a lot remains to be done.

Large scale production and effective use of the Baltic Sea Region blue biomass is still far from a reality. Entrepreneurs face severe problems obtaining licences and building cascading value chains. Improvements in cost-effective technologies and practices have to be developed for production, harvesting, processing and monitoring. Monitoring should measure and quantify not only negative, but also positive environmental impacts and ecosystem services. Administrations still lack the necessary capacities to deal with blue innovations. Even though numerous regions have 'blue' approaches in their smart specialization strategies, this is not translated into holistic development plans. Finally, it should be clearer for citizens how to convert a growing interest in sustainable and climate-friendly solutions into positive behavioural change and consumption patterns.

This translates into the following comprehensive set of actions to be implemented in the coming years:

Action 1: Get Pilots to the Next Level

- Identify & monitor sites based on common parameters
- Develop comprehensive regional plans
- Encourage cooperative structures and interregional partnerships
- Establish large-scale demonstration farms/plants
- Undertake cross-cutting assessments: Biodiversity, Ecosystems, Climate Impact

Action 2: Involve Companies of all sizes

- Curate and enhance the SUBMARINER company networking platform
- Continue and expand company services:
- Match-making, co-creation & ideation
- Provision of mentoring & expert services
- Technology development & transfer
- Life Cycle / Ecosystem Assessments
- Identify and communicate new research & innovation needs

Action 3: Strengthen 'The Blue on Land'

- Create Market Push and Pull: Product Development in line with Consumer Needs
- Consider blue resources in Waste Treatment, Food & Feed, Materials, Pharmaceuticals
- Reduce Waste Streams and promote diversification of blue food
- Establish circular business models
- Education & Skills Development
- Improve integration of knowledge from social sciences and information technologies

Action 4: Interlink Baltic with EU wide Communities of Practice

- Business Accelerator
- Mussel Cultivation & Use
- Algae Cultivation & Use
- Sustainable Fisheries & Aquaculture
- Multi-Use
- Marine Litter
- Cultural Heritage
- Ocean Literacy and Citizen Science

We acknowledge and appreciate that numerous new funding streams have been established both at European as well as national level. The Interregional Innovation Investment facility (I3), the Sustainable Blue Economy Partnership (SBEP), the Horizon Mission 'Oceans, Seas and Waters' and the 'Blue Invest' are the most prominent, but not the only instruments through which we hope to realize these next steps on our quest to improve the Baltic Sea environment and economies. We at the SUBMARINER Network are highly committed to making our new Roadmap 21+ into a reality!

The SUBMARINER Network members

with the support of

Fredric Nilsson and Esa Kokkonen

EUSBSR Policy Area Coordinators Bioeconomy and Innovation

The SUBMARINER Network Executive Board

1. s.Pro Sustainable Projects GmbH

- Angela Schultz-Zehden
- Founder / Managing Director
- SUBMARINER Network Founder | Managing Director
- s.Pro – sustainable projects initiates, prepares, manages and follows up on transnational support and cooperation programmes and projects: maritime policy and blue growth, resource efficiency and regional development. Our specific areas of expertise lie in maritime policy and planning; blue growth, resource efficiency and regional development. Our work philosophy is based on the desire to develop projects which not only cover sustainable development but are also sustainable in themselves.

2. Royal Institute of Technology (KTH)

- Fredrik Gröndahl
- Head of Department for Sustainable Development Environmental Science and Engineering (SEED)
- SUBMARINER Network Founder | President
- Royal Institute of Technology (KTH) in Stockholm is the largest, oldest and most international technical university in Sweden. No less than one-third of Sweden's technical research and engineering education capacity at university level is provided by KTH. Education and research spans from natural sciences to all the branches of engineering and includes architecture, industrial management and urban planning. Industrial Ecology at KTH has played a key role in the SUBMARINER project.

3. Gdynia Maritime University

- Iwona Rakowska
- Project Specialist
- SUBMARINER Network Founder
- Gdynia Maritime University is the largest state school of higher maritime education in Poland established in 1920. The University four Faculties offer degree in Navigation, Marine Engineering, Electrical Engineering and Entrepreneurship and Quality Science. At present Gdynia Maritime University provides studies for 5000 students. Within the University operates the Maritime Institute which conducts research work and implementation projects in the field of: ecology, maritime electronics and hydrotechnics, maritime law and economics, operational oceanography, maritime spatial planning and many others.

4. Coastal Research and Planning Institute CORPI

- Nerijus Blažauskas
- Senior Researcher & Manager of international projects
- SUBMARINER Network Founder
- Coastal Research and Planning Institute (CORPI) is a non-profit public research institute founded to carry out R&D activities in order to foster the implementation of maritime policy and development of the maritime economy. The institute has a special focus on marine energy and port development systems, environmental impact and planning of maritime activities.

5. Biocon Valley

- Erik Lohse
- Senior Project Manager Health
- SUBMARINER Network Founder
- BioCon Valley® GmbH is the network of the health economy in Mecklenburg-Vorpommern. The company is its central contact point and driving force and sustainably strengthens employment, growth and competitiveness on a national and international scale. Together with the players in the sector, the state company turns healthy nature and innovative companies into the health state of Mecklenburg-Vorpommern. BioCon Valley® GmbH offers support for established companies and start-ups, and helps to move potential products from research to commercialisation. Business fields include biotechnology, e-health, nutrition for health, healthy aging, health services, health tourism, continuous medical education and bioeconomy. Beyond this, the company maintains several international cluster-to-cluster cooperations.

6. Finnish Environmental Institute (SYKE)

- Paula Kankaanpää
- Director Marine Research Centre
- The Finnish Environment Institute (SYKE) is both a research institute, and a centre for environmental expertise. SYKE Marine Research Centre aims at producing information and new solutions that help decision-makers to promote the protection and sustainable use of the Baltic Sea. SYKE Marine Research Centre leads the Finnish Marine Research Infrastructure FINMARI, hosts Finland's ice class 1A research vessel Aranda, and is nationally in charge of monitoring and research of the Baltic Sea.

7. Kiel Marine Science (KMS)

- Stefan Meyer
- Coordinator Bioeconomy on Marine Sites
- Kiel Marine Science (KMS) – the Centre for Interdisciplinary Marine Science at Kiel University is one of four priority research areas. KMS encompasses research in marine science and geosciences, including expertise from climate research, coastal research, physical chemistry, botany, microbiology, mathematics and computer science, as well as economics, law, social and political sciences. In crosscutting research topics, such as e.g. blue bioeconomy, KMS integrates its expertise to contribute to a better understanding of processes in the ocean and to strategies for the sustainable use and conservation of its resources. KMS has established the Center for Ocean and Society to advance its interdisciplinary research to a more transdisciplinary approach with and for societal stakeholders.

8. University of Southern Denmark (SDU)

- Kristina Siig
- Professor of Private and Maritime Law
- BlueSDU is the maritime and marine biology research cluster at the University of Southern Denmark, focused on industrial and societal collaborations between stakeholders in relevant "blue" sectors to maximise the impact of blue research, technologies and services. Today BlueSDU has 12 active partners including both regional and large private companies in Denmark. Focus areas include maritime law, sustainable marine transport, marine ecology, sustainable aquaculture, resource-based and business economics as well as biogeochemistry and environmental monitoring. BlueSDU's ultimate goal is to strengthen interdisciplinary R&I across Europe, creating value for society sustainably from the ocean.

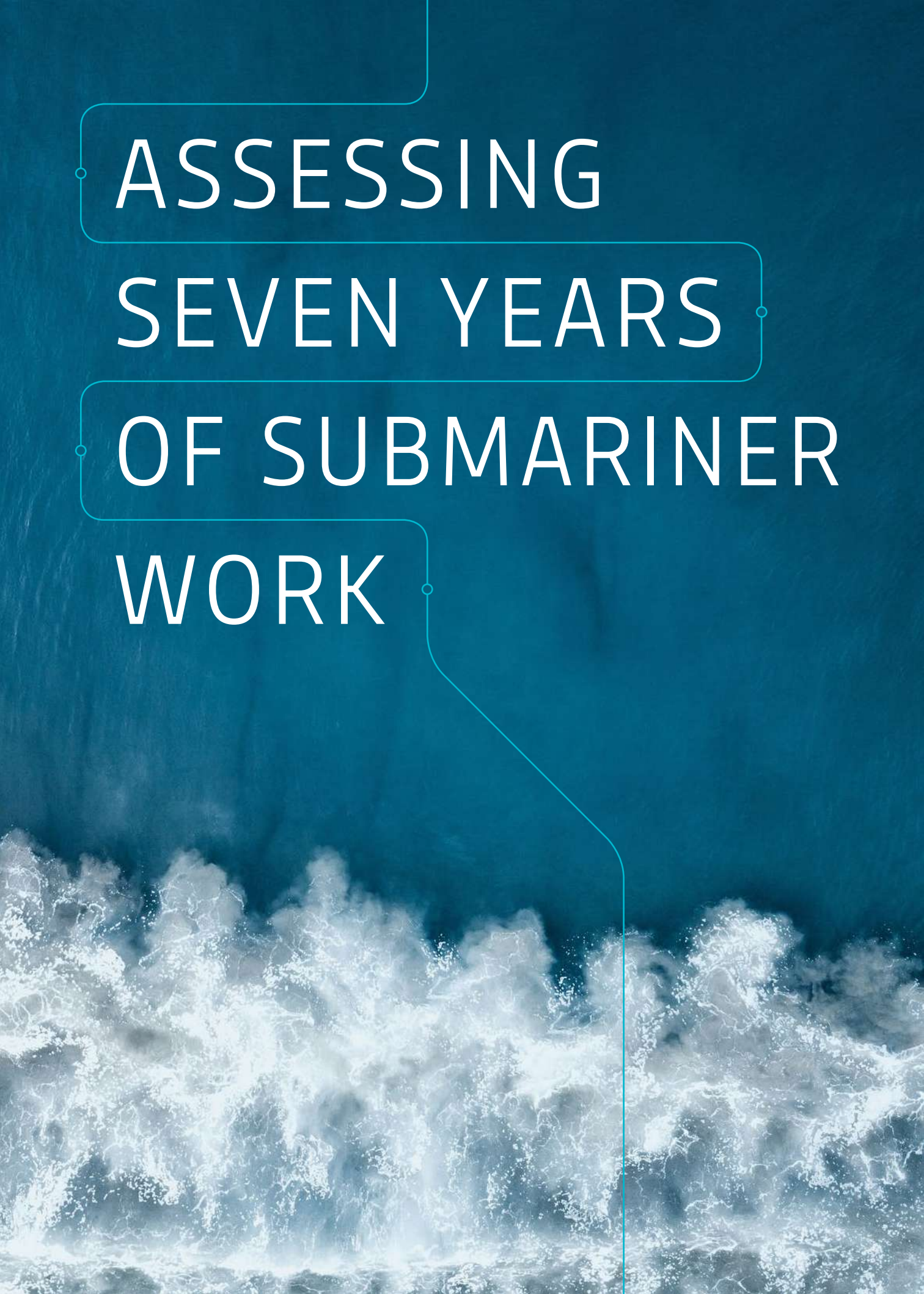
9. University of Tartu

- Jonne Kotta
- Lead Research Scientist Estonian Marine Institute
- University of Tartu is the biggest and most prestigious classical university in Estonia. It was established by King Gustavus Adolphus of Sweden in 1632, thus being one of the oldest universities in Northern Europe. The Estonian Marine Institute of the university has a mission to enhance the knowledge and understanding on the functioning of the Baltic Sea ecosystem and to seek scientific and management solutions in order to improve environmental quality and the sustainability of ecosystem services. Research is focusing on marine biology and biodiversity, sustainable use of marine ecosystem services including the fishery resources, environmental safety of maritime transport, maritime spatial planning as a tool for practical implementation of the ecosystem-based approach.

10. Latvian Institute of Aquatic ecology (LIAE)

- Anda Ikauniece
- Deputy Director
- The Latvian Institute of Aquatic Ecology (LIAE) is a research institute, an Agency of Daugavpils University. Originally dedicated to basic and applied research of ecology and environmental problems in the Baltic Sea, LIAE has become the leading institution in the environmental expertise for marine and freshwater issues in Latvia. In the Latvian part of the Gulf of Riga and Baltic Proper LIAE is responsible for marine environmental monitoring. Recently LIAE has contributed with its knowledge on ecosystem values and services to national maritime spatial plan, to implementation of Ballast water convention with information on invasive species and have pioneered in microplastic research of Latvia.

ASSESSING SEVEN YEARS OF SUBMARINER WORK



1 About the SUBMARINER Network

1.1 The Evolution of SUBMARINER since 2015

The SUBMARINER Network for Blue Growth EEIG, a flagship umbrella project of the EU Strategy for the Baltic Sea Region, was established in 2013. Since then it has developed into the leading transnational hub in the Baltics for promoting sustainable and innovative uses of marine resources. The Network brings together authorities, research and innovation actors – both public and private – across the Baltic Sea Region, integrating perspectives from local to transnational scale and different scientific and economic spheres.

The work of the SUBMARINER Network for Blue Growth EEIG between 2015 and 2020 has been guided by the topics and actions described in the SUBMARINER Roadmap (dated 2013) as necessary to realise innovative and sustainable uses of marine resources throughout the Baltic Sea Region.

SUBMARINER topics and actions as defined in Roadmap 2013

SUBMARINER TOPICS

- Macroalgae Harvesting and Cultivation
- Mussel Cultivation
- Reed Harvesting
- Large-Scale Microalgae Cultivation
- Blue Biotech-nology
- Wave Energy
- Sustainable Fish Aquaculture
- Combina-tions with Offshore Wind Parks

STRATEGIC ACTION FIELDS

Actors	Data	Environ-mental Impacts	Pilot Sites	Energy	Ecosystem services	Technology	Blue Bio-technology	Finance	Regu-lation	Image
Baltic Sea actors and activities	Data sets of Baltic Sea resources	on water quality and habitats	for empirical research	Regional solutions integrating marine resources	Valuation and com-pensation of ecosystem services	Development and transfer of suitable technology for the Baltic Sea	BSR-wide systematic approach to Blue Bio-technology Research	Unlock financing for innovative uses of marine resources	Create bet-ter legal and regulatory frame-work	Create pos-itive image for products & services from marine resources

Starting off from an initial set of seven full members only, the SUBMARINER Network has by now attracted many new relevant institutions and individual experts to join currently counting for ten full members and thirty associate members.

With no statutory support, the Network has over the course of the past years, succeeded in leveraging the membership funding by applying

for project funding under the various Baltic Sea Region INTERREG schemes, Horizon, EMFF projects, EEA Norway Grants as well as national programmes.

1.2 Overview on SUBMARINER Projects (Status 2020)

Until 2020, the SUBMARINER secretariat has initiated 25 transnational projects, of which 20 received funding with a total volume of more than € 41 million, of which almost € 30 million are for activities in the Baltic Sea Region. The projects provided an extra funding of € 1,25 million to the SUBMARINER secretariat; while an additional total volume of more than € 13 million has been allocated to SUBMARINER members. This funding allowed members to implement the activities defined in the roadmap. Moreover – individual SUBMARINER members have also been able to attract additional projects – in line with the SUBMARINER mission and thus forming part of its Baltic Sea wide knowledge and actors hub.

The projects have also been a way to reach out and involve many more actors involved within the blue bioeconomy: apart from the 50+ members, more than 150 other parties have participated in one or more of the SUBMARINER projects.

The original set of topics & actions from the Roadmap have over the course of the past years been slightly adapted as to cover new, important areas of work such as **marine litter** and **underwater cultural heritage**. Instead of dealing with reed harvesting only, projects have extended this topic to cover improved use of **beach-wrack** and installation of **artificial lagoons**. Also new policy instruments such as **Smart Specialisation** and **Maritime Spatial Planning (MSP)** have been added. Moreover, **capacity building**, **training and skills development across all levels (i.e. from civil society to public authorities)** have been added as crucial action fields.

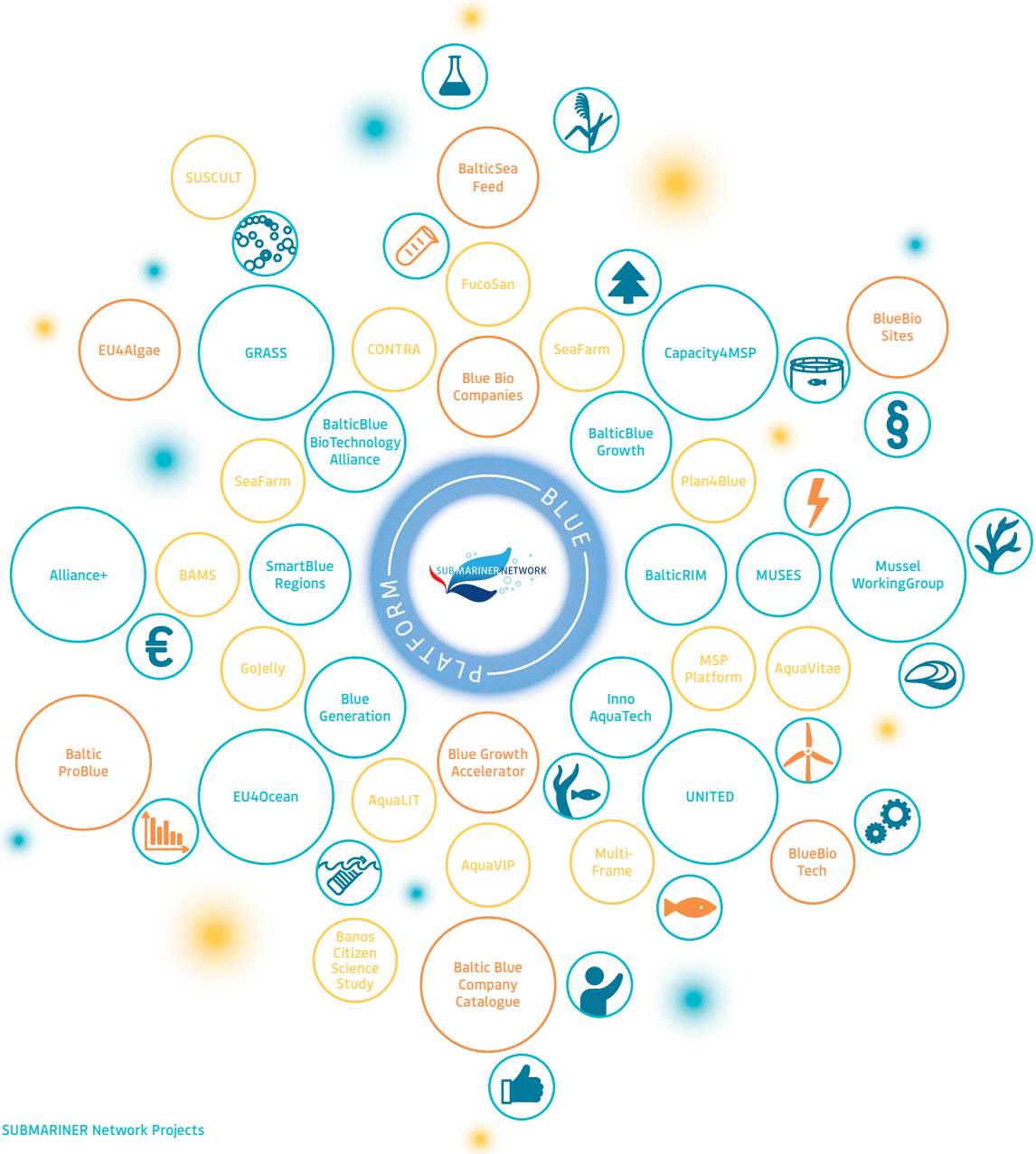
SUBMARINER'S 1ST GENERATION OF PROJECTS (CONCLUDED IN 2019/2020)

- **Smart Blue Regions:** Smart Specialisation and Blue Growth in the BSR
- **Baltic Blue Growth:** Initiating full-scale mussel farming in the Baltic Sea
- **InnoAquaTech:** Cross-border transfer of innovative & sustainable aquaculture technologies
- **MUSES:** Exploring opportunities for Multi-Use in European Seas
- **Baltic Blue BioTech Alliance:** Advancing marine bio-based product development
- **Baltic RIM:** Integrated Maritime Cultural Heritage Management

SUBMARINERS 2ND GENERATION OF PROJECTS (NUMEROUS TO BE FINALISED IN 2021)

- **GRASS:** Capacity building for public authorities on supporting macroalgae production & use
- **Blue Generation:** Inspire & engage young people to stake up Blue careers

SUBMARINER Project Cloud (2015–2021)



- SUBMARINER Network Projects
- SUBMARINER Member Projects
- Seed Money Projects

- **Alliance+:** Advancing marine bio-based product development
- **UNITED:** Demonstrating multi-use in the North & Baltic Sea
- **Capacity4MSP:** Capacity building for MSP
- **Blue Platform:** Advancing blue bioeconomy capacities in the Baltic Sea

SUBMARINER MEMBERS PROJECTS

Some projects, highly relevant to the overall mission of SUBMARINER, involve SUBMARINER members, but not its secretariat. These projects include among others:

- **AquaLIT:** Working with the aquaculture sector to prevent marine litter (s.Pro)
- **AquaVIP:** Aquaculture Virtual Career Development Platform (Uni Gdansk, KSTP, CORPI)
- **CONTRA**: Conversion of a Nuisance to a Resource and Asset (SDU, Uni Tartu)
- **FUCOSAN**: Health from the Sea (GEOMAR, CRM)
- **SeaFarm**: Macroalgae for a biobased society, culture, biorefineries and energy (KTH, UGOT)
- **BAMS**: Bioeconomy for Blue Sites (CAU, CRM, Geomar)
- **SUSCULT**: Sustainable cultivation of seaweed (SYKE, KTH)
- **AquaVitae**: Low-Trophic Aquaculture in the Atlantic (IVL)
- **Multi-Frame**: Developing an Assessment Framework for Multi-Use

In addition, projects like Coastal BioGas and OPTIMUS are directly linked to SUBMARINER Roadmap actions, but are implemented by actors outside the SUBMARINER Network current membership.

UNSUCCESSFUL TOPICS STREAMS

The following project applications submitted by SUBMARINER members were so far not successful:

- Efficient and relevant data & information sourcing to promote the blue bioeconomy
- Wave energy development in the Baltic Sea Region
- Developing sustainable feed systems for aquaculture
- Marketing & labelling of blue bioeconomy products & services
- Promoting blue economy investments & new funding mechanisms
- Promoting blue-green regional solutions
- Streamlining blue biotechnology product biodiscovery

This does not necessarily mean, that the topics in question should no longer be pursued by the SUBMARINER Network. Some research ideas have, however, proven to be too far-fetched as to offer real innovation boost; i.e. whereas 'microalgae cultivations' may play a crucial role in food and high value products and 'wave energy' may still be interesting as an additional source of energy in combination of other offshore installations; both are no longer seen as distinct topic fields. Whereas wave energy is now covered under the 'multi-use' topic; microalgae has been included in the topic of blue biotechnology.

1.3 The Role of the SUBMARINER Network Secretariat

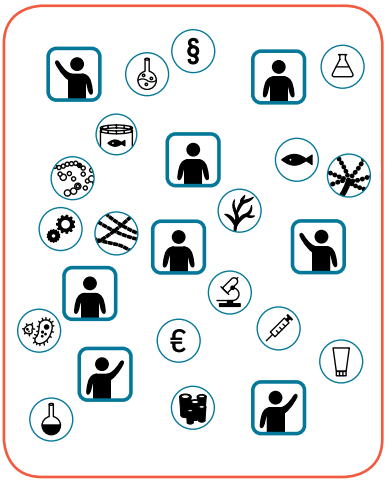
Right from the outset the SUBMARINER Network decided to install a permanent, central secretariat based in Berlin. The number of team members depend on project resources, but have over the past years included between 4–5 multi-lingual professionals with background in project coordination and communication.

All SUBMARINER members benefit from the following services provided by the secretariat:

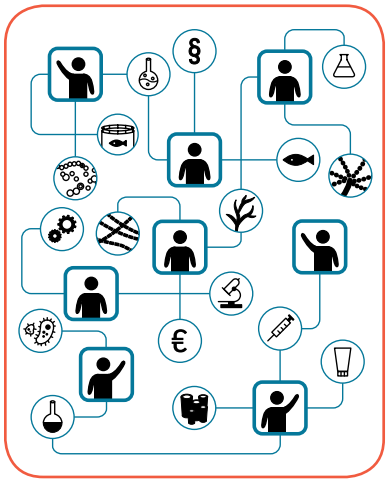
- Promotion and representation of members' competences and interests in news and events via all SUBMARINER Network channels; e.g. website, quarterly newsletter, social media
- Exclusive member access to all internal information; funding opportunities; pitching and matchmaking events; annual members' assembly and specific workshops; study visits and searchable database including more than 3,000 blue bioeconomy actors
- Co-ordinated access and set-up of project development consortia; support, administration and facilitation of projects; thematic Network working groups and set-up of project development consortia
- Joint formulation and dissemination of policy-oriented position papers
- Expert advice and coaching via the secretariat hub and/or direction to relevant Network members

The continuous identification, communication, coordination and match-making between actors as well as ongoing identification of funding opportunities and project development has proven to be the most important overarching service facilitated by the SUBMARINER Network secretariat.

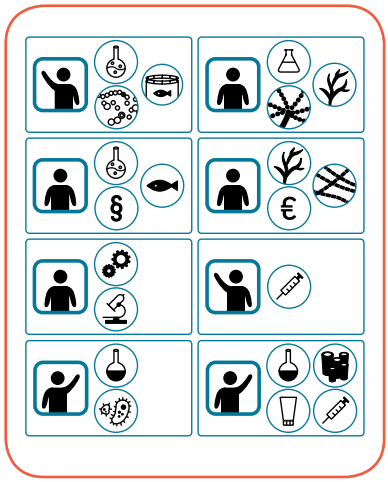
1. Identifying actors, competences and initiatives



2. SUBMARINER match-making: Working Groups, events, projects



3. Members connected to right partners – taking their idea further in joint initiatives



1.4 The SUBMARINER Vision

All activities of the SUBMARINER Network are guided by the strong belief that innovative and sustainable use of marine resources can contribute significantly not only to Baltic Sea Region, but European – if not global, challenges – which have by now been framed within the EU Green Deal and the UN Sustainable Development Goals.

Most notably, SUBMARINER actions aim to address

Reduce Climate Change	→ instruments and measures to reduce Greenhouse Gas Emissions → stimulating more local and regional sustainable production; including renewable energy as well as feed, food and materials
Reduce Pollution	→ new measures for nutrient uptake; including dealing with the internal nutrient load within the Baltic Sea → effective measures to reduce marine litter → sustainable ways of fishery and aquaculture
Increase Biodiversity	→ offering new ways for ecosystem restoration by 'building with nature' → increasing efficiency of use of marine space by promoting the concept of multi-use
Increase Protection	→ extending the concept to nature protection to noise and the seabed → extending the concept of nature protection towards cultural heritage
Address Demographic Change	→ opening up towards new feed, food and material resources derived from the sea, which can be explored sustainably → address important health issues
Foster Competitiveness of the Baltic Sea Region	→ opening new economic activities not only in metropolitan areas, but also in rural; coastal regions offering additional income sources for societal groups, which lose jobs in traditional marine sectors

By 2013, SUBMARINER topics were far from being commercially viable or politically established, but had already been addressed by numerous studies and research projects. The 'SUBMARINER Compendium' published in 2012 represented the very first systematic compilation of these possible sustainable uses of marine resource, all of which aimed for restoring the Baltic Sea's good environmental status as well as providing benefits to humans' well-being. The following SUBMARINER Roadmap provided a strategic and systematic approach towards rolling out the various actions needed, in order to promote them across the Baltic Sea Region.

Seven years later, the 'SUBMARINER Roadmap beyond 2021' provides a first ex-post evaluation of what has been achieved in the meantime; which kind of new developments have to be considered by now and the resulting priorities of SUBMARINER actions for the coming future.

1.5 Benefits Associated with SUBMARINER Topics

Concretely, the following uses of marine resources promoted by SUBMARINER entail the following benefits:

Use	Rationale	Benefits	
Mussel Farming and Use	Additional sea-based measure to deal with the already existing nutrient load. Mussels can be used as a regional protein source in feed as well as other commercial applications.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	+ +++ ++ ++ + + +
Macroalgae Harvesting, Cultivation & Use	Baltic macroalgae can provide an important food and feed source, but also a valuable resource for ingredients, materials and energy. Green, red and brown, algae species can grow inside the Baltic proper providing ecosystem services, e.g. nutrient load reduction, habitat provision and increased localised CO_2 fixation.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	++ +++ +++ + +++ ++ +++
Harvest of Floating Emergent Aquatic Plants	Various ecosystem services are supplied by emergent macrophytes and halophytes on floating structures: Nutrients and pollutants are absorbed from the water column and wave energy attenuated. The root network provides shelter to aquatic fauna and increases microbial biodiversity. The flowering plants can create colourful landmarks, enhance the aesthetic value and benefit tourism. Coastal municipalities have shown much interest.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	+ +++ +++ ++ + +++ +
Collection and Use of Beach-wrack	Wrack along the Baltic Sea coast-line it mainly consists of torn off eelgrass, brown, red and green macro algae, seashells, and dead animals, which are washed ashore on the beach. The methodologies employed and the treatment of this nutrient rich resource do not exploit its full potential for water management and pollution reduction.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	++ ++ - - - +++ +
Sustainable Fish & Shrimp Aquaculture	The importance of aquaculture as a source of animal protein has increased dramatically over the past years as fish stocks are decreasing and agricultural systems cannot keep up with the increased demand for healthy food. Land-based systems such as Recirculating Aquaculture or Aquaponics and Marine systems such as Integrated Multi-Trophic Aquaculture or offshore installations create opportunities for more regional fish & shrimp production.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	- + ++ + +++ +++ +++
Blue Biotechnology	Baltic marine and freshwater ecosystems host a thriving biological diversity of organisms with many possibilities for further advancements across various value chains. Whereas aquaculture can supply blue biotechnology with primary and secondary resources, blue biotechnology is crucial in all steps from growing biological resources to recovering biomaterials from process side-streams.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	- + + + +++ +++ +++
Multi-Use of Marine Space	Ocean multi-use can contribute to a more sustainable and efficient use of ocean resources, by reducing the demand of 'unused' sea space and potentially offering significant socio-economic and environmental benefits.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	++ + +++ +++ + +++ +++
Marine Litter	Marine litter has not only devastating consequences for the marine environment, but also cause serious economic damage: losses for coastal communities, tourism, shipping and fishing. At the same time, valuable material that could be brought back into the economy is lost, once littered.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	- +++ +++ ++ + ++ +
Cultural Heritage	The Baltic Sea Region underwater and maritime cultural heritage (UCH/MCH) forms a rich and diverse assemblage, has cultural and societal values. New forms of dealing with UCH can provide jobs and revenues due to new tourism services; increase public appreciation of the value and significance of UCH sites; while at same time enabling better protection, maintenance and control of them.	Climate Change: ZeroPollution: Biodiversity: Nature Protection: Demographic Change: Regional Development: EUs' Competitiveness:	- - + +++ + ++ +

1.6 Strategic Actions Foreseen to Reap These Benefits

The following strategic actions had been identified in the SUBMARINER roadmap 2013 to achieve the ambitions set out in the SUBMARINER compendium. The following overview shows how the various projects were able to address these actions:

1.6.1 Actors Mapping / Match-Making

Objective: Continuous identification and matching of public and private actors involved in new marine uses as to achieve better and faster results with less resources

	Status	Projects
Collect information, establish and maintain a BSR-wide database on:		
• Research institutions, researchers and experts	🟢	ALL
• Companies	🟢	Blue Platform
• Past and ongoing activities and projects	🟢	Blue Platform
• Intermediaries and transfer organizations	🟠	Alliance
• New research and project ideas	🟠	ALL
• (Bio-)technical equipment	🟠	Alliance
• Available education in various levels	🟠	Alliance
Support actions for:		
• Information and contact exchange among new marine use stakeholders	🟢	ALL
• Networking & coordination with other networks	🟢	ALL
• Organisation of sectoral and cross-sectoral match-making events	🟢	SmartBlueRegion Alliance
• Identify potential linkages between natural and socioeconomic research and introduce research results of both disciplines to each other	🟢	BBG, GRASS
• Communication across EUSBSR stakeholders and related BSR projects	🟠	Blue Platform
• Facilitate good practice transfer from traditional maritime sectors as well as terrestrial bioeconomy stakeholders to SUBMARINER cases	🔴	
Include marine sectors into BSR region wide research and technology development projects, which integrate knowledge for whole the Baltic Sea catchment area, e.g. energy, waste treatment, CO_2 capture and storage, socio-economic aspects.	🟠	

1.6.2 Data / Tools / Environmental Monitoring

Objective: A structured approach to fill the gaps identified in SUBMARINER Compendium 2012 on blue biomass resources and the environmental impacts associated with their increased use.

	Status	Projects
Establish and implement BSR-wide best practices for monitoring and systematic mapping of:		
• Biomass resources (macroalgae, reed)	🟢	GRASS CONTRA
• Nutrient resources and CO_2 sources for microalgae cultivation	🔴	
Conduct systematic research on the role of reed beds and harvesting, macroalgae and mussel harvesting and cultivation on local biodiversity and water quality	🟢	BBG CONTRA GRASS
Assess consequences for nutrient regeneration, biogeochemical cycling and benthic habitat deterioration arising from increased sedimentation and sediment oxygen uptake by mussel cultivations	🟢	BBG Ecopelag Optimus

Develop a system to support the use of existing monitoring data to identify best sites (environmental and cost-effectiveness) for mussel and macroalgae cultivation and fish aquaculture sites	🟠	BBG GRASS InnoAquaTech
Assess the relationship between offshore, attached, living macroalgae stocks and beach-wrack macroalgae in terms of biomass, density and annual production rates to support the derivation of sustainable quantities of beach-wrack and free-floating algal mats that can be removed	🟠	GRASS CONTRA
Identify and recommend institutional structures for permanent monitoring, data-sharing and visualization	🔴	BlueBioSites
Link the data sets with surveys and mapping of other local (terrestrial) resources and demand for biogas or any other biomass refinery process	🔴	
Further investigate feed supply and efficiency for fish aquaculture sites	🔴	RASFeed

1.6.3 Access to Pilot Sites & Facilities

Objective: establish more such pilot sites around the Baltic Sea Region to enable empirical research.

	Status	Projects
Mussel cultivation pilot sites	🟢	BBG / Ecopelag OPTIMUS / German Study
RAS technologies in combination with specific sites around the Baltic Sea	🟢	InnoAquaTech
IMTA: investigate site-specific solutions with varying combinations of fish, algae and mussel farming at one site in order to find optimal technical and economical solutions	🟠	BBG / AquaVitae One case: Musholm / DK
Macroalgae cultivation pilot sites	🟠	SeaFarm / GRASS (only sites at West Coast)
Pilot sites for **reed harvesting**	🟠	CONTRA (use of Beach-wrack)
Microalgae cultivation pilot site(s) for multidisciplinary research around uses for large-scale cultivation, including test sites for nutrient removal from waste streams;	🟠	No project but examples in Sweden / cases in Alliance accelerator
Biorefinery pilot sites	🟠	Macrocascade
Pilot sites for **agar production**	🔴	
Wave Generation	🔴	Wave Project rejected

1.6.4 Technology Development & Transfer

Objective: develop environmentally friendly and cost-efficient technologies suitable for Baltic Sea conditions taking into account knowledge and technologies from terrestrial resources

	Status	Projects
Collect information about technologies and scientific expertise available at national level: • Match-making between technology providers and users • Introduce technologies and know-how available in other BSR countries to national research organisations and companies • Offer study visits, meetings, info websites	🟢	BBG InnoAquaTech Alliance SmartBlueRegion GRASS AquaLIT
Scout for pilot installations and technology providers; enhance information exchange between technology providers and users, foster technology developments:		
• Underwater mussel and macroalgae farming technologies crucial for Baltic Sea conditions (i.e. ice / open coasts)	🟢	BBG / GRASS / SeaFarm
• Environment friendly reed and beach-wrack harvesting technologies	🟢	CONTRA

• Sustainable fish aquaculture solutions; such as multi-use with wind parks and new IMTA / RAS production methods	🟢	InnoAquaTech / UNITED
• Water treatment technologies using blue biotechnology or algae cultivation	🟠	Alliance cases
• Scale-up processes for getting raw materials, valuable ingredients or cells from marine organisms for Blue Biotechnology products	🟠	Alliance
• Microalgae cultivation technology suitable for seasonal fluctuations of temperature and light in the BSR	🔴	
• Adapt and develop biosensors suitable for marine resources	🔴	

1.6.5 Regional Energy Solutions with Marine Resources

Objective: 'encourage appropriate consideration of marine resources in energy planning in order to create markets for climate friendly energy production'.

	Status	Projects
Develop concepts for integration of marine resources in regional plans on renewable energy and climate protection • Introduce concept of smart combinations of uses, where a systematic approach to biomass use beyond the energy sector complements the biorefinery concept • Develop economic models for use of marine resources in renewable energy production and well as regional studies & models	🟠	COASTAL Biogas
Develop a placement strategy for biorefineries using marine resources around coastal regions • Improve networking among biorefineries across BSR • Use experience of forestry and agriculture in blue refinery concepts • Encourage technology development and continue to refine the process of biogas from marine resources • Optimize techniques and logistics for harvesting biomass, transport to biogas plants, and for refining products	🟠	COASTAL Biogas
• Promote use of small scale wave energy generators	🔴	Wave Project rejected

1.6.6 Introduce Ecosystem Service Payments

Objective: 'develop an accepted approach to valuation of ecosystem services and propose compensation mechanisms for the provision of ecosystem services by new marine uses'.

	Status	Projects
Proactively liaise and inform EU, HELCOM and relevant Priority Areas of initiatives related to valuation and compensation of ecosystem services	🟢	Mussel WG
Develop recommendations and proposals for establishment of ecosystem service compensation schemes based on: • Analysis of existing and proposed (if any) compensation mechanisms • Assess the role of private sector and NGOs and get them involved • Consider and assess various possible schemes, i.e. via taxes (polluter pays, provider of ecosystem services gets subsidized), national and transnational models; possible voluntary initiatives (e.g. Baltic Sea friendly coastal municipality); market opportunities (e.g. farmers buy aquaculture products for fertilizer or biomass, N quotas)	🟢	BBG ecosystem service payment study
Generate life cycle assessments and techno-economic models pertinent to local conditions in the BSR to critically examine the costs and benefits of new uses and technologies compared with existing solutions	🟢	BBG ecosystem service payment study
Assess the role of Blue Biotechnology products with respect to benefits to ecosystem services	🟢	ALLIANCE SDG case analysis
Develop a practical BSR-wide methodology for valuation of ecosystem services, as the basis for ecosystem services compensation schemes	🟠	BBG
Assess the applicability of new marine uses on ecosystem services for different sub-regions of the BSR	🟠	BBG / GRASS

1.6.7 Unlock Financing for Innovative Uses of Marine Resources

Objective: 'Improve access to finance for collaborative projects for private and public stakeholders.'

	Status	Projects
Collaborate with investment funds, venture capital organizations: • Establish contacts with public and private financing organizations • Identify offers, interests and needs by financing bodies and fields of cooperation • Raise awareness among researchers, research institutes and other stakeholders on requirements of "bankable" projects • Study and assess innovative forms of knowledge brokerage • Initiate individual and multilateral meetings and consultations	🟢	ALLIANCE+ InnoAquaTech
Improve relationship between public research and private companies: • Raise awareness among industry on project opportunities and benefits to be gained from participation in public funded programmes and seek their active input • Study and assess challenges for private-public collaboration • Identify, assess and disseminate good practices of private and public collaboration, develop "vademecuum / guidelines" • Organize and attend workshops showing case studies on how companies and research can collaborate • Encourage and assist networking and concrete development of Public-Private Partnerships at regional and local level	🟢	ALLIANCE+ InnoAquaTech
Develop applications to both public and private funding programmes: • Inform SUBMARINER Network partners on funding opportunities and their specific requirements and vice versa • Develop strong triple-helix project partnerships based on partner institutions strengths	🟢	ALLIANCE+ UNITED All future projects

1.6.8 Create Better Legal and Regulatory Conditions

Objective: 'Reduce vagueness in legislation and regulations for innovative uses of marine resources'.

	Status	Projects
Assess the existing integration of innovative uses of marine resources in relevant EU Directives and establish a dialogue with national authorities and EU Directorates	🟢	BBG, GRASS
Consider how new uses of marine resources shall be considered in Maritime Spatial Planning (i.e. develop pilot plans in various regions, develop criteria for "suitable sites")	🟢	BalticRIM, BBG
BSR-wide agreement on integrating reed and mariculture cultivations as an environmental remediation measure under the HELCOM BSAP	🟢	BBG
Recommendations on incentives for combinations with offshore wind parks	🟢	MUSES
Assess tools for ensuring the exploitation rights for all actors involved in finding, development and commercialization of Blue Biotechnology products	🟢	ALLIANCE
Foster a joint interpretation on targets set by relevant EU Directives (Natura 2000, WFD, MFSD) with regard to "harvesting" marine resources (e.g. macroalgae, reed)	🟠	BBG, GRASS
Recommendations for a common approach to use fish aquaculture for restocking	🔴	–

1.6.9 Public Awareness

Objective: Create a market in which consumers are aware of the benefits of sustainable blue products and are motivated to contribute to solutions.

	Status	Projects
Carry out public awareness campaigns:		
• Identify and create success stories (local, regional, national)	🟢	Blue Platform
• Produce and disseminate "SUBMARINER" newsletter and/or magazine	🟢	SUBMARINER
• Create information material on potential of new and innovative sustainable marine resources	🟠	All projects
• Undertake campaigns on value of ecosystem services and nutrient recycling	🟠	BBG
• Create cooperation with media to integrate them into public campaign	🟠	BBG

Conduct market surveys on products from marine resources	●	GRASS
Carry out information campaigns, workshops and involve companies on: • New and local fish species (regional level) • Development of new fish, chicken & cow feed • Organic fertilizers • Blue biotechnology applications • Reed / beach cast as ecological insulation material	●	BBG Alliance Blue Platform Fucosan CONTRA
Support establishment of a Baltic Sea brand and distribution network for: • Fish & Algae from BSR aquaculture • Mussel meal products and organic fertilizers • Cosmetics, health care and wellness products	●	Sea2Fork rejected

2 SUBMARINER Topics: Achievements

2.1 Mussel Farming in the Baltic

2.1.1 Projects

Since the publication of the SUBMARINER roadmap (2013) a variety of projects have been funded, which relate to mussel cultivation at the Baltic Sea Region:

Project Title	Funding	Duration	SUBMARINERs
Baltic Blue Growth	Interreg BSR	2016–2019	Östergötland (SE), LIEA (Lat), Ministry SH (DE), MIG (PL), Uni Tartu (EE)
OPTIMUS	BONUS	2017–2020	UGOT (SE)
Rich Waters	LIFE IP	2017–2024	IVL (SE)
AquaVitae	Horizon	2019–2022	IVL (SE)
Combined Marine Aquaculture	MV (DE) Funding	2019–2023	
SNOOP			KTH (SE)
MuMiPro	Danish Innovation	2019–2021	
BalticSeaFeed	Swedish Institute	2020–2021	KTH, Kalmarsund, UGT (SE)

2.1.2 State of Play

By 2020, mussel farming in the Baltic Sea proper is nevertheless still in infancy, with hardly any large commercial farm being operational yet in the region.

The SUBMARINER Network secretariat has taken the role to coordinate and synthesize the results of the various projects dealing with mussel cultivation in the Baltic Sea Region and to continuously update and feed them with new information coming in from research as well as operational farms. The **Mussel Working Group** established and facilitated by the SUBMARINER Network secretariat – through regular online meetings – allows for a regular experience and data exchange among all relevant actors.

The working group has published a policy paper[1], which summarizes the data and results of the simultaneous projects researching the possibilities of mussel farming in the Baltic proper.

The paper provides the following **evidence of the positive results achieved that encourage scaling up**:

1. There is **no difference** in the **total amount of mussel meat** (dry matter) between mussels cultivated in high or low salinity areas.

1 Schultz-Zehden, A et al.; SUBMARINER Network Mussels Working Group, 2019. Mussel farming in the Baltic Sea as an environmental measure. Berlin, Germany.

Areas	Salinity	Meat dry matter%	% Soft tissue	Soft tissue fat %	N (% soft tissue dry weight)	P (% soft tissue dry weight)
Western Baltic	High	15.1 a	58 a	9.5 a	9.5 a	1.41 a
Central Baltic	Moderate	14.2 a	52 b	10.3 a	10.3 a	1.48 a
Eastern Baltic	Low	13.7 a	41 c	9.7 a	9.7 a	1.33 a

2. There is much **less difference** than previously expected between the **nutrient content** of mussels cultivated in lower or higher salinity levels.
3. The sedimentation from the studied mussel farms was highly local and less than expected, and **no oxygen depletion was noted** in the near-bottom waters.
4. The number of mussels produced by farms in the Baltic proper as well as possible negative impacts are heavily **influenced by a number of environmental conditions**, including availability of nutrients, temperature and movement of the water, as well as the occurrence of predators.
5. **Sites should be carefuly selected** in view of
   - investment and production costs
   - pricing and market stability
   - infrastructure to connect to shore
   - lowering the risk of mussels dislodging from the substrate
6. The current projects show that there is **further potential for cost reductions**.
7. Mussel meal is a good raw material and feed ingredient

2.1.3 Conclusions and Recommendations

1. **Complement land-based nutrient reduction measures** with appropriate marine actions for nutrient removal in order to achieve the Baltic Sea environmental goals
2. Consider **restorative aquaculture** for the restoration of declining wild mussel populations and in the long-term supporting the declining Eider duck population, should be considered in potential support schemes
3. **Identify and pick most optimal location**
4. Invest in more and **larger demonstration farms** at these strategically selected sites
5. Develop the mussel market within the **feed industry**
6. Look into **further commercialization options** of Baltic Blue Mussel biomass
7. Allow for the expansion of an environmentally friendly, sustainable marine fish aquaculture industry at selected sites within the Baltic Sea Region coupled with **mussel farms in IMTA systems**.
8. Provide further support to first runner mussel farms

2.2 Macroalgae Harvesting and Cultivation

2.2.1 Projects

Project Title	Funding	Duration	SUBMARINERs
Baltic GRASS	Interreg BSR	2019–2021	KTH (SE), SYK E(FI), Uni Tartu (EE), NMFRI (PL), SUBMARINER Secretariat
FUCOSAN	Interreg DE-DK	2016–2020	SDU (DK), Ocean Basis, CAU, GEOMAR (all DE)
SEAFARM	FORMAS (SE)	2015–2020	KTH (SE), Uni Gothenburg (SE)
TANG.NU	Villum/Velux (DK)	2017–2020	Guldborgsund Municipality
Aquavitae	Horizon	2020–2023	IVL
Macrofields	Horizon		KTH (SE)
Macrocascade	BBI-JU	2020–2021	KTH, Kalmarsund, UGOT (SE)
MABA	BBI-JU		–
Cultivation technology for			
Furcellaria lumbricalis	EMFF Estonia	2017–2019	Uni Tartu, Estonian Marine Institute
Ceramium tenuicorne	EMFF Estonia	2020–2022	Uni Tartu, Estonian Marine Institute
Ulva intestinalis	EMFF Estonia	2020–2022	Uni Tartu, Estonian Marine Institute
Seaweed assessment and management plan Latvia's seacoast	Latvian FLAG	2018	

2.2.2 State of Play

By 2020 production of macroalgae and seaweed is at a nascent phase in the Baltic and almost 100% macroalgae raw material supply come from countries like Norway, Russia, China, and Japan. Due to the reduced salinity levels fewer species with a commercial value can grow in the Baltic proper. The most promising seaweed species are *Fucus vesiculosus and Ulva intestinalis*. In the Western part of Baltic, where salinity is higher, *Saccharina latissima, Laminaria digitata,* and *Palmaria palmata* can also be cultivated, all of which are very popular cultivars in Europe.

Commercial macroalgae production activities in the Baltic are mostly limited to wild harvesting at local radius, with Denmark being the largest seaweed producer (100 tonnes in 2018). Only 6 marine seaweed farms exist; all being located in the Western Baltic and all growing *Saccharina latissima*. In addition to these primary producers, however, already **around 60 commercial companies are active in processing and producing seaweed products marketed in the Baltics**.

The market potential of seaweed in Europe is estimated as high as € 9,3 bn with high potential for feed, food, pharmaceuticals, cosmetics, biofertilizers, biofuels and ecosystem services. About 30% of this market could be met by European supply by 2030 by producing as much as 8,3 million tonnes fresh weight seaweed, thus increasing the EU production of 2015 27-fold. **Also in the Baltic, it is expected that seaweed cultivation activities will grow exponentially in Denmark, Germany and Sweden in the next 3–5 years.**

The EU Novel regulation can potentially pose a barrier for new algae food products entering the EU market. *Furcellaria lumbricalis*, is for instance not included, even though it has been used to produce gelling agents for decades. **Among the few countries with specific regulations on seaweed harvesting and cultivation the only Baltic Sea country is Denmark.** Estonia and Germany have at least some rules on seaweed harvesting. The general aquaculture permit procedures apply as well as the water environment and water law. Permit paths are different in each country and are generally very lengthy and complicated.

2.2.3 Conclusions and Recommendations

For the Baltic, the SUBMARINER Network is making the following recommendations:

1. Make marine space available for seaweed production
2. Develop safety standards for the marine environment, and also product, and workers occupation health
3. Collaborate with EU novel food regulation authorities to remove from EU novel food list of species consumed in the Baltic
4. Develop the Baltic seaweed market
5. Raise awareness on the benefits and potential of seaweed
6. Test cultivation of Furcellaria and pilot / demonstrate cultivation of Fucus and Ulva in the Baltic Proper and also cultivation of Palmaria in Western Baltic
7. Improve economy and reduce investment risk of seaweed farming e.g. reduce production costs of *Saccharina latissima* by at least 5 times
8. Incentivize investments that support environmental sustainability and ecosystem services
9. Strengthen education and training in blue biotechnology, aquaculture and entrepreneurship
10. Taking the use / applications of algae a step further

2.3 Harvest of Floating Emergent Aquatic Plants

2.3.1 Projects / State pf Play

Project Title	Funding	Duration	SUBMARINERs
LiveLagoons	Interreg South Baltic	2017–2021	Klaipeda Uni (LT)
Halophytes and other macrophytes for filtration of nutrient-contaminated waste and surface water	BMBF / BAMS (Germany)	2020–2021	CAU, CRM (DE)

The first floating wetlands in the Baltic Sea were installed in 2018 in three different lagoons (Darss-Zingst, DE; Curonian LIT and Szczecin lagoon PL). Emergent macrophytes have been harvested since then on an annual basis. Harvested emergent macrophytes can be utilized in various ways; as construction material inter alia for insulation, for herbal medicinal. Halophytes, also known as salt plants, are still underestimated as high-quality products in the food, cosmetics and medical sectors.

2.3.2 Conclusions and Recommendations

Further installation sites in different environments will be necessary to broaden the experience, to improve the technique and to support the achievement of market-readiness. The market potential for macrophytes and halophytes cultivated on floating islands in the Baltic Sea has not been researched yet.

1. Awareness-raising of floating technologies for the cultivation of emergent macrophytes and halophytes as one option to remove nutrient from eutrophicated waters
2. Study the impact of floating wetlands not only on nutrient removal but also on other pollutants such as the bacterium Escherichia coli.
3. Harvesting techniques offshore on floating structures are challenging and need technological advancements and innovative ideas
4. Utilization concepts of harvested biomass from these floating green technologies in blue environments are just emerging and need further research
5. Knowledge transfer on site selection, legal requirements, installation process, growth and harvest of the biomass as well as commercialization

2.4 Sustainable Trophic Aquaculture

2.4.1 Projects

Some projects have been implemented over the course of the last years. However, none have taken a Baltic Sea wide approach and/or had a Baltic Sea wide comprehensive coverage.

Project Title	Funding	Duration	SUBMARINERs
AquaCross	H2020	2015–2018	none
InnoAquaTech	Interreg South Baltic	2016–2029	BioConValley (DE), University of Gdansk, MIG (PL), CORPI, KSTP (LIT), DTI (DK)
AquaLit	EMFF	2019–2021	s.Pro
FLAVOPHAGE	BONUS	2017–2020	
CLEANAQ	BONUS	2017–2020	
Waseabi	BBI-JU	2019–2023	
AquaVIP	Interreg South Baltic	2020–2023	KSTP, Klaipeda University (LIT) Uni Gdansk (PL)

2.4.2 State of Play

The technical development of environmentally sustainable forms of production is progressing rapidly in the field of aquaculture, both in view of making the more traditional open systems more environmentally friendly as well as the more recent, semi-closed and closed production systems

- In 2021, there are by now more and more commercial RAS plants installed throughout the Baltic Sea Region (7 in DE; 9 in Fi; 5 in PL; numerous in DK). In addition, the InnoAquaTech project tested the farming of new species and innovative combinations of RAS with plant production and/or renewable energy at 4 pilot demonstration sites:
  - Denmark: Fish and macro-algae production under controlled conditions
  - Germany: The 'FishGlasHaus': innovative aquaponics in Mecklenburg-Vorpommern
  - Lithuania: Zero emission RAS system combined with geothermal energy
  - Poland: Farming shrimp in Poland: increasing the potential of RAS

The main challenge remains the commercial viability of these RAS; which need low cost energy sources as well as having to be closely aligned with the development of a local high value market.

- Aquaponics are also no longer an artificial endeavour: the scientific idea has entered the mainstream, albeit sometimes seemingly more of a marketing play rather than a commercially viable idea on its own.

- On practical level, also more IMTA systems start to become operational: SUBMARINER member, CRM in Kiel (DE), has established the first organic mussel and macroalgae farm in the Baltic Sea, 'following the principles of IMTA' with the ambition to start fish aquaculture in the coming years. In Denmark, Hjernø Havbrug was the first to establish combined fish, mussels and algae production farms under IMTA principles.

So far, however, algae and mussel farms are not accepted by Denmark as compensation for the nutrient outflow from the fish aquaculture production measures. This is also the case for other Baltic Sea Region countries. In fact, also sustainable aquaculture is hampered by environmental objectives, most notably the eutrophication status of the Baltic Sea, the need for cumulative impact assessments and a general lack of nutrient offset/compensation schemes for the sector.

The SUBMARINER position paper on aquaculture legislation highlights how in countries without a unified law on aquaculture (SE/DK), separate orders can be contradictory and licensing processes being unclear, whereas in other countries, definitions, regulations and guidelines for the sector are missing or incomplete. **A positive exception is Finland**, which foresees to provide incentives to aquaculture farms, which reduce nutrient loading and apply circular economy principles, like RAS; IMTAs or use of Baltic Sea Fish Feed.

2.4.3 Conclusions and Recommendations

Increasing the environmental sustainability of aquaculture, together with a wish to grow the sector, has been on the agenda of Baltic and Nordic countries for many years. However, issued licenses are not corresponding to novel aquaculture production methods, which have by now been increasingly achieved 'proof of concept', and consequently do not encourage investors or industrial producers to invest in growing the sector.

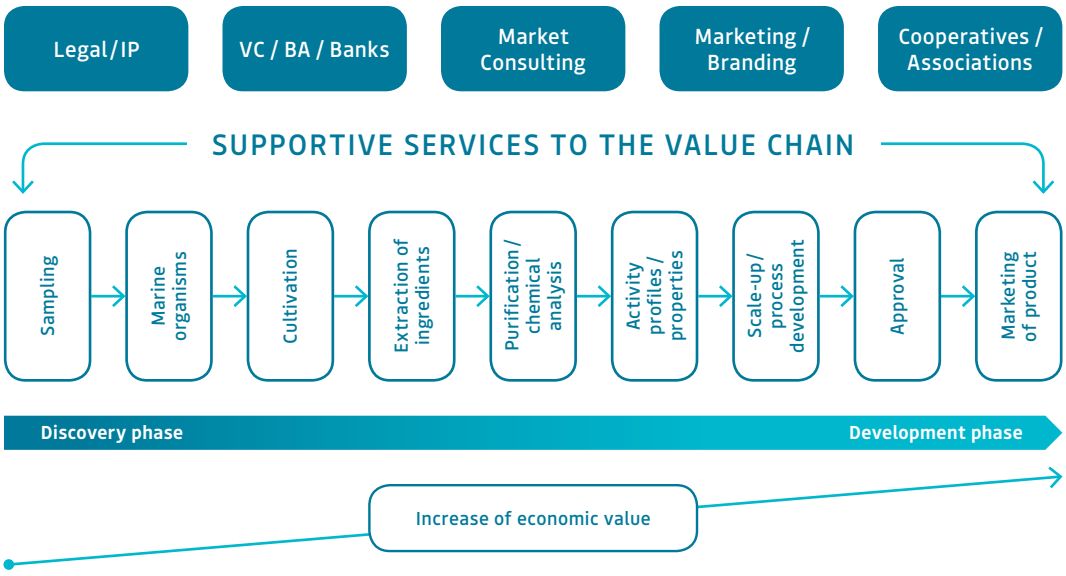
What is needed is a harmonized definition of aquaculture throughout the legislative system, as well as improvements of legislation of licensing by including compensatory tools and a fair assessment of nutrient output calculations (separate from land-based nutrient sources).

1. Innovative aquaculture systems such as RAS, IMTA and other combined uses must be carefully examined for each country and region across the Baltic
2. Interdisciplinary collaborations are needed to scale up the aquaculture sector in the Baltic, with a specific focus on the harvesting, processing and biorefining technologies
3. Finding the right location for a fish farm is not only a matter for marine farms; also RAS systems – in order to be economically viable should, for instance, be close to energy plants
4. Investments, projects and support for entrepreneurs are needed to deliver new pilots and demonstration sites to showcase the feasibility of innovative sustainable aquaculture in the Baltic Sea Region

2.5 Blue Biotechnology

2.5.1 Projects / State of Play

The **Baltic Blue BioTech Alliance and Alliance+** (INTERREG, 2016-2019-2021) initiated and implemented by the SUBMARINER secretariat and numerous of its members (GEOMAR, SYKE, KTH, KSTP, Tartu BioTech) has been the core Blue Biotechnology project throughout the region over the past years, The SUBMARINER Network is therefore by now the reknown Baltic partner for the numerous networks, which have been established in parallel across Europe.



Network / Scope	Activities / Scope
BioMarine Global	Yearly BioMarine Conventions (congress with exhibition, B2B, workshops) Sub-Activities: BioPlastics Consortium, Blue International Coop, Blue Fund
EMBRC-ERIC Europe with Norway No Baltic partners	Cluster, which supports fundamental and applied research activities for sustainable solutions in the food, health, and environmental sectors • CORBEL: platform for harmonised user access to biological and medical technologies, biological samples and data services • EMBRC BioBank: Organisms, cultures, strains, specific cell lines, tissues, tissue cultures and their DNA are available on-site or remotely
BlueBio Alliance Portugal	Network covering the entire marine biotechnology value chain: raw material producers, R&D units, biotechnology SMEs, transforming centres and manufacturers, public sector entities, support companies, final product developers; organises once a year Blue Bio Value accelerator programme
European Algae Biomasss Association (EABA)	Promotes exchange and cooperation in algae biomass production and use incl. biofuel. Defends members' interests at EU level; organises annual AlgaEurope Conference
Pilots4U / Europe KTH (SE); VTT (FI)	Network (database) of open access pilot and multipurpose demo-infrastructures for the European bioeconomy
Ocean4Biotech / Europe GEOMAR, CAU (DE), RUC (DK), Uni Tartu (EE), Uni Gdańsk (PL)	• platform for sharing experience, knowledge and technologies • designs a roadmap for a more efficient and rapid development of marine biotechnology research in Europe and beyond
Microbial Resource Research Infrastructure / Europe / Uni Gdansk (PL)	Pan-European platform adding value to known and yet unknown microbial biodiversity and exploiting novel sources and knowledge to discover and disclose for the bioeconomy and bioscience. Provides overview on culture collections

2.5.2 Conclusions and Recommendations

A survey done within the Alliance across 24 R&D Baltic Sea Region institutions showed:

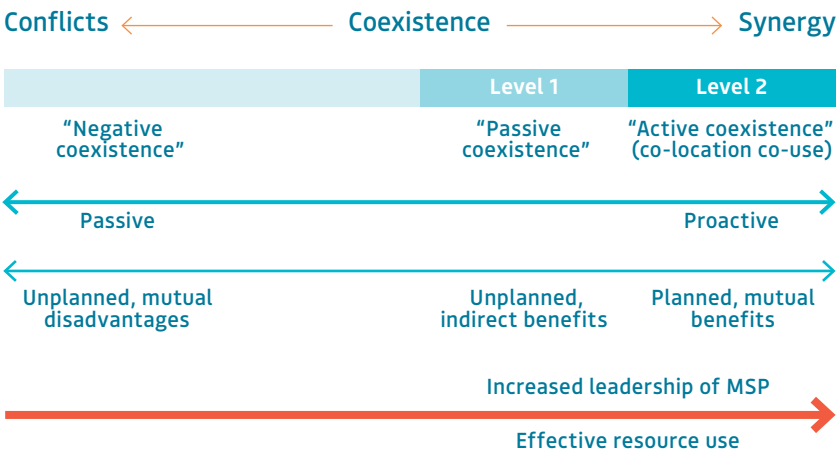
1. **A wide spectrum of competencies, resources and interests within blue biotechnology.**
   Among the most popular fields of study were production of algae and bacteria for applications from food and feed to highly specialised markets and bioremediation.
2. **Interesting aquatic biological resources**
   Baltic marine and freshwater ecosystems host a large biological diversity of organisms, including fungi, micro – and macroalgae, bacteria, sponges, and mussels with good possibilities for further advancements.
3. **Integrated biomass production systems**
   Aquaculture and blue biotechnology are two distinct but highly intertwined sectors. Aquaculture can supply blue biotechnology with primary and secondary resources; whereas blue biotechnology is crucial in all steps from growing biological resources to recovering biomaterials from process side-streams. It is a key quality, that the SUBMARINER Network covers both sectors under one roof.
4. **Design new materials supporting the circular economy**
   On global scale, there is a shortage and cost increase for many raw materials. In addition, materials are produced that withstand degradation over long time scales and may harm the environment in general and the Baltic Sea environment in particular (see marine litter), calling for local and closed material circles.
5. **Align blue biotechnology R&D with product market trends, challenges and opportunities**
   Linking R&D 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 R&D by reducing costs and minimising risk of failure.
6. **Increase transnational access to pilot-scale facilities**
   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 and VTT facilities within the Baltic, but they are often not accessible and others are not modular.
7. **Blue biotechnology study programmes are very rare in the BSR.**
   In many BSR countries, teaching in blue biotechnology is realised by offering elective courses or specialised modules within other study programmes in (industrial) biotechnology or marine biology.

2.6 Promoting Multi-Use in the Baltic Sea

The concept of ocean multi-use has gained attention in the last years as an approach that can contribute to a more sustainable and efficient use of ocean resources by **reducing the demand of 'un-used' sea space** and potentially offering significant **socio-economic and environmental benefits**.

What is ocean multi-use?

Multi-use stands for an intentional combination of different ocean uses both in close proximity, through joint operations (e.g. shared human resources), and/or the same platform (e.g. shared installations). Implementation of multi-use requires a radical change from the concept of exclusive resource rights to the inclusive sharing of ocean resources by two or more uses. Whereas the original concept often focused primarily on multi-use of off-shore installations, research in past years has also pointed to benefits of combining 'soft uses' with each other (e.g. small-scale fishery, tourism & environmental protection).



2.6.1 Projects

Project Title	Funding	Duration	SUBMARINERs
Multi-Use with Offshore Wind & Soft Use Combinations			
MUSES	H2020	2016-2018	SUBMARINER Secretariat, MIG (PL), KTH (SE), DTI (DK)
UNITED	H2020	2020-2024	SUBMARINER Secretariat, FuE-Zentrum Kiel (DE)
MULTI-FRAME	Belmont	2020-2023	s.Pro (DE), KTH (SE)
Projects on "soft" multi-use combining Underwater Cultural Heritage and tourism			
BalticRIM	Interreg BSR	2017-2020	SUBMARINER Secretariat, MIG (PL), Uni Tartu (EE), CORPI (LIT)

- Nordic Blue Parks Denmark, Finland and Sweden
- Vikingeskibsmuseet (Viking Ship Museum) / Højklint underwater trail in Denmark

Additional examples of underwater cultural heritage and tourism include:

- Trips to ship wrecks from Polish ports
- Kronprins Gustav Adolf (Finland)
- BALTACAR Project sites in Sweden, Finland (Hanko, Hauensuoli) and Estonia
- Dalarö underwater park (Sweden)

2.6.2 State of Play & Conclusions

Despite a whole series of theoretical studies conducted on multi-use on additional uses of offshore wind parks; especially for tourism as well as ecosystem restoration; **in reality, there has not been a major uptake of the multi-use concept throughout the Baltic Sea within the past seven years.**

The Multi-Use concept especially of interest for countries only starting now with Offshore Wind

- The studies have shown that **it is much more difficult to integrate a new 'secondary' use within an existing offshore wind farm**, for which a single use permit has already been awarded and insurance premiums agreed upon, than integrating a secondary use right from the onset, i.e. at the design and pre-planning stages, when insurance, permitting and ownership are clarified.
- **Countries where the development of offshore wind is still at its inception may benefit most** by integrating the multi-use concept already in the design and planning stage of future offshore wind farms.
- **Good stakeholder processes are needed due to competition among the 'secondary users':** fishery, aquaculture or marine protection compete for the space within or around offshore wind farm.
- **Small-scale multi-use developments focusing on tourism** may hold significant benefits for certain regions and may pave the way for potential future large scale rollout.
- For existing offshore wind farms due to be decommissioned, **early consideration of concepts of re-use and re-purposing** may allow for the operationalisation of circular economy concept in these economies.

BEYOND OFFSHORE WIND: LOCAL OPPORTUNITIES FOR COMBINATIONS OF 'SOFT USES'

Multi-use of selected UCH sites with tourism and environmental protection have already been piloted especially in Finland. They can provide new jobs and new revenues due to new tourism services, such as marine museums and information stands. Public appreciation of the value and significance of UCH sites may be increased, while at the same time enabling better protection, maintenance and control of them.

Combinations between tourism and small-scale fishery or shellfish / seaweed cultivations may benefit

Soft use combination face multiple barriers:

- better exchange of suitable regulation.
- lack of data on underwater cultural heritage and related tourism activity
- lack of awareness about and interest for underwater cultural heritage
- lack of investments and financing.

local communities around the Baltic Sea. However, these have not been sufficiently explored to date.

Marketing the whole region as a cultural heritage tourism destination, may be a good option to increase the visibility and attractiveness of such tourism offers.

2.7 Beach-Wrack

2.7.1 Projects

Project Title	Funding	Duration	SUBMARINERs
CONTRA	Interreg BSR	2019–2022	SDU (DK) and University of Tartu (EE))
Coastal BioGas	Interreg South Baltic	2018–2021	NO SUBMARINERs: FNR (DE), Roskilde University (DK), University of Rostock (DE), etc.
BioFisk	Alliance case	2018–2020	Guldborgsund municipality (DK)
Beach-wrack anlaysis	Island of Gotland		KTH (SE)

2.7.2 State of Play

Beach-wrack can cover Baltic Sea beaches for weeks after storms, rotting to a smelly soup that leaches back into water until the next storm. It is a specific problem for coastal communities, particularly those whose economies rely on beach tourism. It is already regularly removed as part of community beach cleaning routines in most touristic regions along the southern and western Baltic coast. **The methodologies employed and the treatment of this nutrient rich resource do not exploit its full potential for water management and pollution reduction.**

Beach-wrack-production peaks at late autumn. Clear hotspots of beach-wrack-production emerged throughout the whole Baltic Sea area (including Kattegat). The highest production values (up to 4 kg per m^2 per month) were observed in Sweden, the southern coast of Finland, west coast of Estonia and in Gdansk Bay.

Beach-wrack is organic by nature albeit at different stages of decay, but it can be contaminated with litter and can land overnight in voluminous quantities reaching thousands of tons. With regards to costs, the most recent figures from within project CONTRA indicate that beach-wrack management is costing municipalities between 20€–40€ per m of beach length annually.

2.7.3 Current Challenges and Knowledge Gaps

- Costs and cost factors for local authorities, specifically for those in 'beach-wrack hotspot' areas
- A confusing legal framework – particularly with respect to non-market reuse options on the beach for e.g. coastal protection and the waste classification
- Further research on the amount of nutrient reduction from the Baltic Sea by removal of the beach-wrack
- A lack of knowledge about the environmental pros and cons of beach-wrack removal incl. contamination levels, ecosystem service provision, and
- Societal costs and benefits from beach-wrack harvesting and use.
- Time pressure relating to public demand for its removal and storage/ degradation of beach-wrack material for recycling.
- Lack of means to cooperate with neighboring municipalities and private recycling companies/industry
- Lack of knowledge about trends and climate change impacts on beach-wrack quantities

All solution ideas to improve beach-wrack recycling have so far faced legal constraints as beach-wrack is still classed under the European Waste Catalogue (EWC) as 'municipal wastes not otherwise specified'.

2.7.4 Conclusions and Recommendations

- Validate and control the environmental and biodiversity risks of intensive beach cleaning and wrack removal against the MSFD and the new Biodiversity Strategy
- Pilot and demonstrate sustainable beach-wrack reuse options that meet local needs for coastal protection and sand erosion
- Encourage and reward resource-oriented beach cleaning
- Explore technological means for avoiding sand uptake
- Develop a market for local products and short value chains, esp. for fertilizers, building and feed

1. **Develop cost-efficient collections** methods with as little environmental impact as possible
2. Work further on **suitable technologies for upscaling** as well as better harvesting and drying techniques
3. Analyse and improve details of the **technological procedures** for collection and processing
4. Investigate methods for **harvesting floating macroalgae** and eel grass at sea
5. Address major **gaps in long-term monitoring** of seasonal and spatial differences of beach-wrack composition and amounts

The recycling and re-use options for Baltic Beach-Wrack include:

- Insect production
- Anaerobic Digestion
- Fertilizers
- Waste Water Treatment
- Carbonisation
- Gasification and anaerobic digestion
- Landfill biocovers
- Coastal Protection
- Insulation mats for housing

6. **Study micronutrients and probiotic qualities** of beach-wrack for feed applications
7. **Remove legal obstacles** associated with recycling problematic coastal biomass have to be removed
8. **Improve public/private cooperation**
9. Change tourists' expectations of so-called clean beaches through extended **information campaigns** to draw more attention to near-natural beaches and the importance of beach-wrack for the beach ecosystem
10. For commercial uses continue more profound investigation of basic properties of beach-wrack, especially concerning potentially harmful substances and the regional variation in its properties

3 Additional Topics Covered

3.1 Marine Litter

3.1.1 Projects / State of Play

The HELCOM Action Plan on Marine Litter, decided in 2019, is structured around land-based (73%) and sea-based (27%) sources of marine litter. It also tackles the issue of education and outreach on marine litter. The actions are divided into regional, collective HELCOM actions and voluntary national actions.

- The **HELCOM Expert Network on Marine Litter** (i) facilitates the implementation of the Regional Action Plan on Marine Litter and (ii) develops core indicators.
- The **PRESSURE group** leads the work on marine litter in HELCOM addressing sources on land and coordination of implementation of the HELCOM Regional Marine Litter Action Plan.
- On **national level**, environmental agencies/ministries coordinate the work to achieve the GES under the MSFD and other EU legal frameworks on marine litter, which is currently changing rapidly.
- These national and regional bodies are in close cooperation with actors at **international level**, such as UNEP/SDGS, G7/G20, FAO, EU KOM TG Marine Litter Plastic Strategy, IMO, CBD, EPA-Network.

Numerous initiatives were implemented at Baltic Sea level during the last years:

Project Title / Actor	Duration / Funder
Plastic Free Baltic / Coalition Clean Baltic	2017
Plastic Free Ocean / Coalition Clean Baltic	2019
Keep Sweden Tidy / KTH (SE), Uni Gothenburg (SE)	2015–2020
Plastic Engineering Day 2020 / Aarhus University	2020
BLASTIC / Turku (Fi); Södertälje (SE) Tallinn (EE); Liepaja (Lat)	Interreg Central, 2020–2023
Fanplesstic-sea / LUKE (FI), LKIAE (LTV), KU (LT)	INTERREG BSR, 2019–2021
MircoPoll / IVL (SE), NMFRI (PL), KU (LT)	BONUS, 2017–2020
Cooperative Projects / Ministry for Research (DE)	2016–2020
MareLitt / WWF, Keep Sweden Tidy, fish producer & divers associations	Interreg BSR, 2016–2019
Fishing for Litter / KIMO international	
Study: Incentives for collection and treatment of derelict fishing gear / s.Pro (DE)	National Funding, 2018
AquaLit / s.Pro (DE)	EMFF, 2018–2020
GoJelly / SDU (lead), GEOMAR, CAU Kiel, CRM)	H2020 2019–2021
Study: Legal feasibility of 'Extended Producer Responsibility' concept / s.Pro (DE)	Environmental Agency, 2019
Support: German National Round Table on Marine Litter / s.Pro (DE)	National Funding, 2020–2022

3.1.2 Conclusions

The **impact of the projects described above should not be under-estimated**. They have started to support the assessment of political willingness, institutional frameworks and capacity in the BSR.

- Studies fostered the **adaptation of national law** to EU framework legislation and strategies
- Blastic/AquaLit informed about monitoring gaps and **new monitoring/ assessment approaches**
- Plastic Free Oceans/Marelitt **raised awareness and build capacities** in regions and municipalities; which also serve as good models for other regional cooperation between fishermen and recyclers
- Cooperation projects promoted **sustainable production**, establishing research-company networks
- Innovative projects like GoJelly show the opportunity and range of **new applications for start-ups and well-established companies**, in close cooperation with research

With the **new Single-Use Plastic Directive** (2019/904/EU) it can be expected that informed consumer choice and the change of consumer behaviours is gaining more attention in projects and will open discussions about new approaches like nudging. **New concepts like „Cradle-to-Cradle"** or so-called **"Un-Packed" shops** are offering opportunities for innovative companies and start-ups.

3.2 Maritime Cultural Heritage

3.2.1 State of Play / Projects

The BSR Underwater Heritage Working Group of the CBSS has been engaged with various projects dealing with management and research of underwater cultural heritage in the Baltic Sea or at European level. Projects, such as MoSS[2], Rutilus[3], MACHU[4], Nordic Blue Parks and SASMAP[5] have followed each other.

These projects brought forward a regional awareness of the underwater cultural heritage. The generated insight and valorisation of the significance of the underwater heritage has been gradually infiltrated through governmental management levels and planning processes bringing forth MCH as an important issue to be considered when developing plans for other sectors, maritime uses, technology and recreation.

BalticRIM (INTERREG BSR, 2017-2020) initiated with the help of the SUBMARINER Network, was the logical continuation of these processes, linking the preservation of maritime heritage of the Baltic Sea to the development of maritime spatial plans in the Baltic Sea assessing data and tools suitable for MSP purposes.

SUBMARINERS: MIG (PL), CORPI (LT), Klaipeda University (LT) University of Tartu (EE), SUBMARINER secretariat.

2 Monitoring, Safeguarding and Visualizing North-European Shipwreck Sites; EU Culture 2000 Programme 2002–2004.

3 Strategies for a Sustainable Development of the Underwater Cultural Heritage in the Baltic Sea Region, Nordic Council of Ministers 2004–2006.Lead Partner: Swedish National Maritime Museum.

4 Managing Cultural Heritage Underwater; EU Culture 2000 Programme 2006–2009. https://www.machuproject.eu/

5 SASMAP Collaborative Research Project; EU 7th Framework Programme 2012–2015. http://sasmap.eu/

4 Strategic Actions Fields: Achievements

4.1 Actors Mapping / Match-Making

One of the most important activities identified for the SUBMARINER Network secretariat in the 2013 Roadmap was the continuous identification and matching of public and private actors involved in new marine uses as to achieve better and faster results with less resources.

We have identified and mapped almost 3000 individuals in the Baltic Sea region working in more than 1.700 different institutions.

	SE	DE	LV	PL	DK	LT	FI	EE	RU	Total
Institutions	233	265	112	357	285	44	226	79	103	**1704**
Actors	497	551	211	526	381	72	462	155	119	**2974**

Organization type	SE	DE	LV	PL	DK	LT	FI	EE	RU	Total
Association/ network	48	23	22	56	33	2	22	18	4	**228**
Business support	12	20	2	35	10	3	18	5	0	**105**
Company	63	108	11	105	166	5	126	23	70	**677**
Public authority	56	25	31	87	32	14	23	16	11	**295**
Research	46	81	26	66	28	17	27	10	15	**316**
Total	225	265	112	357	285	44	222	76	101	**1687**

Company	SE	DE	LV	PL	DK	LT	FI	EE	RU	Total
Algae	8	32	2	37	29	2	3	6	0	**119**
Blue biotechnology	9	53	3	20	31	4	8	10	0	**138**
Energy	2	7	1	19	8	0	59	3	1	**100**
Environment	2	18	0	1	1	0	2	1	0	**25**
Fish aquaculture	24	52	1	30	110	0	33	0	23	**273**
Mussels	16	9	0	3	8	–	–	1	0	**37**
Other	14	23	3	31	10	1	5	0	0	**87**
Reed/beach-wrack	0	7	1	2	4	–	–	3	0	**17**
	75	212	14	150	207	7	130	29	51	**875**

Out of these institutions, we have by now already identified more than 650 companies working within the blue bioeconomy throughout the Baltic Sea Region.

The largest number of companies identified come from the traditional fish aquaculture sector (mainly in DK). But a remarkable number

of companies have also been identified, which work with algae and/or blue biotechnology.

Even though the number of companies working in this sector throughout the entire Baltic Sea Region is still low. It presents an enormous relative growth as compared to the figure a decade ago, where it was difficult to identify any company involved in this sector.

At the same time the figure points to the fact, that it is worthwhile for the SUBMARINER Network to act as the **overarching association of these companies** as national blue bioeconomy clusters are still mainly missing.

4.2 The SUBMARINER Accelerator

Over the course of the past years – supported by the ALLIANCE projects – SUBMARINER with its members has developed a systematic transnational science-business cooperative approach to create the critical mass of actors to converge and convert **science outputs into marketable products**. The SUBMARINER **accelerator programme** is continuously searching for "cases"[6], organises pitching and matchmaking events as well as offering flexible support through a dedicated **mentoring programme**, successfully establishing a new niche **innovation and product development support mechanism** operating across borders in the BSR.

Until today, the SUBMARINER Alliance has successfully identified and provided advice to more than 34 start-ups originating from all around the Baltic Sea Region. Cases joined at all stages of the value chain, from bioprospecting to full commercialisation, with the majority (66%) using algae as the biological resource for developing their products. Products target a broad spectrum of market applications, from food and food supplements to healthcare and cosmetics, bioremediation, materials, and energy.

CONCLUSIONS / FINDINGS FROM THREE YEARS OF MENTORING PRACTICE

- **A blue economy – rather than a blue biotechnology – network:** matchmaking led to partnerships across all elements of the value chain, from biomass sourcing to necessary equipment to market access. Against this background, the Alliance is part of the entire SUBMARINER Network, offering transnational networking across all blue bioeconomy sectors and actors
- **Without 'blue detectives' – no new cases:** Ideas have to be pro-actively recruited
- **Finding the right mix of mentors is crucial:** Without interested mentors – no accelerator

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

- **Networking and matchmaking** among blue specialists are in high demand by all
- **Scientific/ technical support** is SUBMARINERS unique service offer as opposed to investment-oriented accelerators
- Companies need large scale biomass rather than biobanks
- **Business knowledge is vital** also in early stages of the product development chain

4.3 Data / Tools / Environmental Monitoring

4.3.1 Projects / State of Play

Numerous projects implemented within the SUBMARINER Network have addressed the issue of improved data sourcing enabling better environmental impact assessments.

Mussel related projects have provided better evidence on the sedimentation caused by the studied mussel farms, which was highly local and less than expected with no oxygen depletion noted in the near-bottom waters. It is important to **continue the environmental monitoring at the mussel farms** with the focus on bottom conditions, e.g. oxygen levels and benthic fauna.

The **Operational Decision Support System** (ODSS) developed by SUBMARINER member University of Tartu/Estonian Marine Centre showing areas for **macroalgae and mussel growth potential** throughout the Baltic Sea Region has been one of the key outputs of projects implemented **facilitating the start of a more systematic blue bio sites mapping.** No such mapping has, however, been undertaken so far for nutrient & CO_2 sources for microalgae cultivation.

Possible (marine) fish aquaculture sites have been assessed in Finland and Denmark. Whereas the Finnish 'fish aquaculture' spatial plan is still taken as basis for current decision making, the sites identified in open Danish sea have, however, been contested on political level.

To promote a systematic and cost-efficient approach for environmental monitoring of blue biosites, the project application 'OperationalPilots' was submitted in 2016, which was however not funded. SUBMARINER members also applied to carry out a study (funded by DG MARE) to assess the **potential of shellfish and macroalgae to recycle nutrients and greenhouse gas emissions** from their production and thereby to add to the evidence base supporting the planning of low-trophic aquaculture in European sea regions. Also in this case, the preparation of this study was, however, granted to another consortium.

4.3.2 Recommendations / Next Steps

- Merge the various spatial planning models and tools available to derive to a Baltic Sea wide application

- Improve data sourcing and availability not only in view of environmental parameters, but also in view of other factors such as production yields; socio-economic conditions; climate effects
- Expand monitoring from mainly negative impacts, towards measuring also positive impacts
- Involve and engage current and future site operators as to agree on a minimum common set of measurements to be collected at pan-Baltic scale

4.4 Access to Pilot Sites & Facilities

By the time of the SUBMARINER Roadmap launch 2013, only some pilot mussel farm and recirculating aquaculture sites existed; but not one single macroalgae cultivation or multi-use case. The overall objective was to establish more such pilot sites around the Baltic Sea Region to enable empirical research.

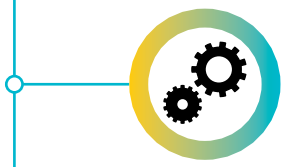
4.4.1 Projects / State of Play

A number of pilot sites have successfully been established over the past years. However, for all applications, actual site development is still lagging behind, mainly due to legal and financial barriers and insecurities, which increase the high risks associated with such new farms anyhow for entrepreneurs.

Mussel Cultivation (Baltic Sea Proper)	1. Musholm, DK (8 ha – depth 0–3 m) 2. Limfjorden, DK 3. Horsens Fjord, DK 4. Kiel Farm, DE (0,21 ha – depth 0,5–3 m) 5. Greifswald Bay, DE 6. St Anna Farm, Kalmar, SE (4 ha – depth 1–10 m) 7. Byxelkrok, Kalmar Sound, SE (1,2 ha – depth 3–6 m) 8. Västervik, SE (960 m² – depth 0–4 m) 9. Hagby Farm, SE (1380 m² – depth 1.5–5m) 10. Ecopelag Stockholm, SE 11. Pavliosta, Latvia (625 m sizal rope – depth 5–7 m) 12. Vormsi, Estonia (126 m rope – depth 0–3,5 m)
Macroalgae Cultivation Saccharina latissima (all Western Baltic)	2 farms in Germany 3 farms at the Swedish Western coast 2 farms in Denmark
IMTA	1. Musholm, DK: Fish and Mussel Cultivation (see above)
Recirculating Aquaculture Systems / Aquaponics	1. RAS for fish and microalgae production (DK, Guldborgsund Zoo) 2. Aquaponic: FishGlasHaus (DE, Rostock) 3. RAS for shrimps with geothermal energy (LT, Klaipeda) 4. RAS for shrimps (PL, Gdansk)
Multi-Use	1. Offshore Wind & Tourism (Copenhagen, DK) 2. Several cases related to UCH & Tourism
WasteTreatment by Algae	SwedishAlgaeFactory – but unclear whether a real pilot site yet

4.4.2 Recommendations and Next Steps

As indicated across all chapters, all these pilot sites need to be upscaled to real demonstration size. Whereas the empirical research has shown good and promising results at pilot scale. It is necessary in the next years to transfer these results to full scale, in order to cross-check,whether the same results can be achieved. Moreover, there is still a dramatic lack of concrete sites especially around the Baltic Sea proper.



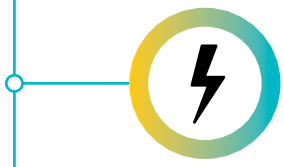
4.5 Technology Development & Transfer

The objective as set out in the 2013 SUBMARINER roadmap was to 'develop environmentally friendly and cost-efficient technologies suitable for Baltic Sea conditions taking into account knowledge and technologies from terrestrial resources'.

4.5.1 State of Play

All SUBMARINER projects have fostered an exchange and transfer of suitable technology as well as adaptation of technologies suitable to Baltic Sea region conditions. **Most notably, new technologies used within BBG substantially increased the production and harvest of blue mussels within the Baltic Sea proper.**

Despite achievements, there is still an enormous need for developing and finding better technology solutions, which enable a financially as well as environmentally sound blue bioeconomy to develop further within the Baltic Sea region. Thus, the effective methods established on technology transfer need to be maintained within the coming years.



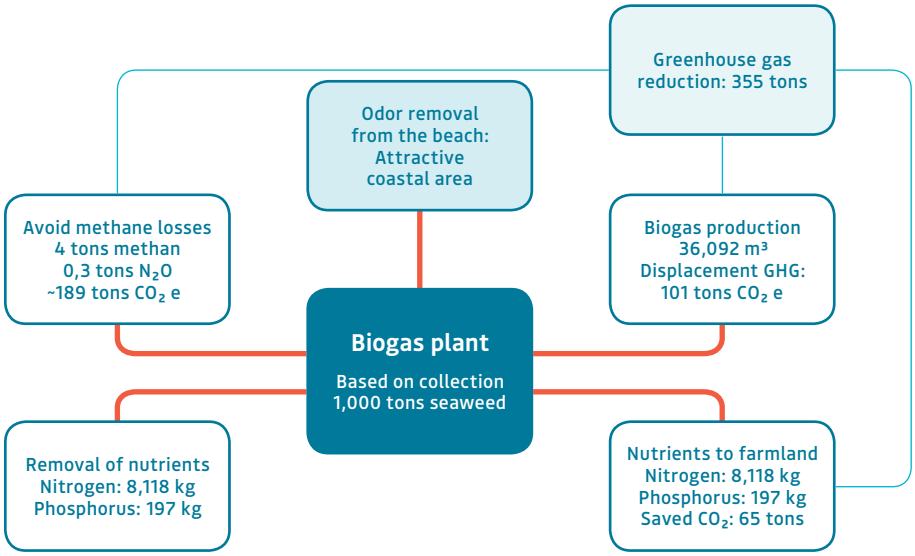
4.6 Regional Energy Solutions with Marine Resources

4.6.1 Projects / State of Play

The COASTAL Biogas concept is implemented at full scale at Solrød biogas plant in Denmark with 1500 tons of cast seaweed were collected and co-digested in the plant in 2019. In this way nutrients are physically removed from the Baltic Sea. The nutrients are recycled through the anaerobic digestion process and utilised as an organic fertiliser, offsetting the use of synthetic fertilisers. Problems with odours from rotten seaweed are eliminated for the benefit of tourism and recreation and the water quality is improved. Carbon dioxide and methane emissions arising, when the seaweed decays on the beach or in the waterline, are eliminated as well. Instead, a high-quality biogas is produced in the controlled anaerobic digestion process.

What could the biogas plant do for the sea

Be a cost-effective instrument for the reduction of the nitrogen load



It is important to collect the beach-cast when it is still wet, as if it decays and dries ashore about half of biogas is lost to the atmosphere. However, currently the high content of Cadmium in the seaweed hampers the possibility to use seaweed for co-digestion and obtain the associated socio-economic benefits.

4.6.2 Recommendations / Next Steps

- Development of heavy metal removal techniques would open the possibility to use marine biomass as a resource, independent of whether it is used for energy production, nutrient recovery, animal feed products, or for contributing to lower levels of heavy metals in the Baltic Sea.
- In order to be able to implement the concepts in development in a holistic manner further investigation into the challenges, which were discovered during the projects is needed.

4.7 Introduce Ecosystem Service Payments

The ambition as set out in the 2013 SUBMARINER Roadmap was to 'develop an accepted approach to valuation of ecosystem services and propose compensation mechanisms for the provision of ecosystem services by new marine uses'.

4.7.1 State of Play

As part of the BBG project, the SUBMARINER Network secretariat undertook a very comprehensive study on the introduction of possible ecosystem payment schemes[7]. The study focused on mussel cultivations as a possible sea-based measure to deal especially with the already existing internal nutrient load as well as continuous nutrient inflow from non-point sources. Even though the study concentrated on mussel cultivations, it could also be transferred to e.g. algae cultivations, which show similar results in view of nutrient uptake.

4.7.2 Conclusions and Recommendations

- Mussel farms need to be officially accepted as an additional measure at given sites to reduce nutrient load and thus being part of the accepted mix of supported abatement measures.
- Mussel farming can be included in a cost-effective abatement mix.
- Ensure that land-based incentives to reduce nutrient leakage are not impeded.
- Examine the financial instruments, which are already available in the region / country.
- Provide support to overcome 'first movers' to reach critical mass
- A payment scheme in which the benefactor pays is a good alternative for success.
- Go local (or regional) backed by national support
- Let the beneficiary be the owner or buyer of the services of the mussel farm
- Mussel farm operators have to organise themselves as to speak with one voice !

Whereas we currently still lack the showcase, that such payment scheme has been realized in one of the Baltic States; the efforts of SUBMARINER and contributing projects have led to progress within the political arena:

The Ministerial Declaration adopted at the 'Our Baltic' Conference, held 28th Sept 2020, postulates:

We will PROMOTE ecologically sustainable sea-based measures, where appropriate with potential for eutrophication abatement such as mussel cultivation and blue catch crops.

Moreover, there are indications that mussel farming may become an approved sea-based measure under the Water Framework Directive.

7 Angela Schultz-Zehden, A. Steele, B. Weig: 'How to turn payments for ecosystem services provided by Baltic Blue Mussel farms into reality?', 2018, Study / Fact Sheet

4.8 Unlock Financing for Innovative Uses of Marine Resources

SUBMARINER has attracted so far more than 40 applications to its Accelerator services and has reached out to more than 60 public and private investors. Five investors[8] have already participated in one or more of our pitching events. As a result, numerous cases having succeeded in raising additional finance. Where possible, SUBMARINER also approaches companies to be included in public funding projects (esp. Horizon).

The past years have shown that the challenge is not so much a lack of venture capital, but that there is a **lack of suitable companies**:

- For some companies the administration coming with public funding (e.g. Horizon, Interreg) is too high, or the time frame of applications is too long to meet the company development needs. Also, some regulations obstruct financial support to companies (e.g. de minimis regulation for aquaculture/seafood producers). In some cases, companies were also not willing to provide open access to results (share Intellectual Property) achieved with that funding.
- On the other side are the early start-ups, which are not yet 'investment ready' and thus require the pre-acceleration and incubation services. In these cases, it would be more important that the SUBMARINER Network would get the funding necessary to provide 'innovation vouchers', which the start-ups could use in order to pay for the accelerator services required to bring their venture to investment readiness stage. Such a scheme would be compatible with Smart Specialization Strategies (S3) and the newly installed Interregional Innovation Investment mechanism (I3).

4.9 Create Better Legal and Regulatory Conditions

Legislation, regulation and maritime spatial planning (MSP) were or are at the core in numerous SUBMARINER projects: BBG and GRASS assess, how mussel or algae cultivation are covered in the various EU Directives and whether those promote or place a barrier to them. BBG, GRASS, MUSES and BalticRim have developed guidelines for how to consider mussel or algae cultivation, multi-use as well as maritime cultural heritage aspects within MSPs. Under the Capacity4MSP and BlueBioSites projects, the SUBMARINER secretariat together with its members examined to what extend the newly adopted MSPs cover for blue bioeconomy sites within the Baltic Sea.

8 Research Council Norway, NewCo Helsinki, Valinor, Kroslid Invest, European Circular Bioeconomy Fund

Only in view of Fish Aquaculture, the SUBMARINER Network did not pursue a dedicated project; but merely organized two workshops (within Blue Platform) to showcase best practices, differences and problems of how Marine Fish Aquaculture is treated within Baltic Sea region countries' legislation and regulation.

Real positive change achieved within this field was, as expected, minor, but nevertheless remarkable:

- Mussel cultivation is noted as a sea-based measure under the new HELCOM Baltic Sea Action Plan
- The Finnish government is pursuing a pro-active policy for promoting sustainable fish aquaculture considering the use of Baltic Fish Feed and other compensatory measures
- Algae – and Mussel Growth Maps were at least considered in the preparation of the Estonian MSP
- Multi-Use and Underwater Cultural Heritage are increasingly noted by Maritime Spatial Planners
- The possibility to open space for blue bioeconomy activities and sites (esp. low-trophic aquaculture) is mentioned in many MSPs, however, almost always with the hint that there was so far not sufficient evidence available to earmark specific areas.

Thus, there is still substantial need to address the various ongoing challenges related to advocate for a legislative and regulatory framework, which enables innovative and sustainable uses. It is of key importance that more support is provided to identify, open up and promote optimal sites for sustainable blue bioeconomy uses (i.e. low-trophic aquaculture) as well as multi-use applications within the Baltic Sea – as to rapidly increase sustainable blue biomass production not only for product development but also provision for ecosystem services (such as nutrient and CO_2 uptake).

4.10 Public Awareness

4.10.1 The Ambition

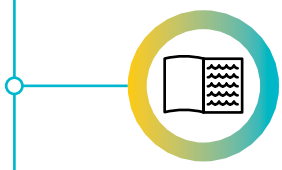
The SUBMARINER Network's declared view has long been that products from innovative and sustainable uses of marine resources will fall on fertile ground only in a market in which consumers are aware of the benefits of sustainable blue products and are motivated to contribute to solutions.

The need for a targeted public awareness campaign in cooperation with relevant Baltic companies was reiterated in 2017 as a result of the large-scale stakeholder process leading to the Implementation Plan for the Baltic Blue Growth Agenda as well as in the SUBMARINER 'Better of Blue' (2017) conference declaration.

4.10.2 Projects / State of Play

Public awareness activities have been part of numerous SUBMARINER projects over the past years. Within the GRASS project a detailed market survey has been carried out on the interest and acceptance of consumers for seaweed-based products. The BBG mussel cultivation project received substantial media attention. **Nevertheless, all this is far from a full scale public awareness campaign, which is very much needed.** However, so far, all project applications submitted focusing on joint public awareness campaign did not receive funding.

4.11 Ocean Literacy



4.11.1 Ambition

The concept of Ocean Literacy aims to increase this awareness and understanding of the relationship between people and the ocean and goes one step further. It provides the tools, methods and approaches for taking action – not only in a formal educational context, but also targeting society as a whole.

4.11.2 State of Play

Ocean Literacy is a hot topic and worldwide many initiatives are already in existence, including the recently launched EU4Oceans coalition and the IOC Ocean Literacy Portal and online Toolkit. It is set to be promoted during the United Nations Decade of Ocean Science for Sustainable Development.

At a grassroots level, there is a huge amount of activity in Ocean Literacy across the Baltic, run by SUBMARINER members and beyond. An initial, non-exhaustive mapping of OL activities found 78 organisations and projects already active in the topic.

4.11.3 Ocean Literacy Projects with SUBMARINER Involvement

Project Title	Duration / Funder	Purpose	SUBMARINER
EU4Ocean coalition	DG Mare, 2020–2023	EU-wide initiative to promote ocean literacy by connecting actors Topics: Climate, Food and Clean Ocean Targets: Schools, Youth	s.Pro acts as Baltic Focal Point
Blue Platform	Interreg BSR, 2018–2022	Online hub on Baltic Blue Bioeconomy Better of Blue workshop series	Secretariat, Uni Gdansk (PL) SYKE (Fi), SBA (SE), Uni Tartu (EE) KSTP (LIT), LAIE (LAT), Guldborgsund (DK)
Blue Generation	Norway Funds 2018–2022	Inspire and engage young people to pursue a career in the Blue Economy	SUBMARINER secrtariat
Ocean Blues	National Funding, 2021	Showcases science activities to address the climate crisis	Uni Gothenburg
Ocean literacy in schools	none	Promote Blue projects & curricula in schools	Secretariat, UGOT SYKE, Havhoest, NMFRI

4.11.4 Recommendations and Next Steps

Using its involvement in the EU4Ocean coalition, SUBMARINER Network has initiated the informal Baltic Sea working group on Ocean Literacy. Our recommendations for actions are the result of discussions with the working group as well as consultation with the wider community of actors.

Use SUBMARINER's position as an information hub for blue bioeconomy to enhance the visibility of Ocean Literacy and its integration into existing awareness raising activities

- Establish a library of existing Ocean Literacy material
- Develop a network between education centres (incl. museums, aquaria) and schools - coordinated by our OL partners Gdynia Aquarium and European Association of Marine Science Educators.

Work on a unified approach targeting consumers as a key group for the promotion of ocean literacy

This is a way of connecting OL to established efforts in citizen science and a starting point with an obvious, engaging and practical application.

- Work towards a European "blue food movement"
- Work with NGOs, influencers and retailers to achieve this

Integrate Ocean Literacy into the funding logic of programmes

- Adopt OL in the evaluation criteria for proposed projects' communication and exploitation activities.
- Create a dedicated Coordinating and Support Action for this field.

Involve the media and arts sector

4.12 Smart Specialisation for Blue Growth

In 2015, at the time of the elaboration of the follow-up actions to the 2013 SUBMARINER Roadmap, the need to facilitate network initiatives at the regional level became evident. These initiatives are as necessary as networking at the pan-Baltic and European levels, as they serve to connect the levels with one another.

4.12.1 Projects / State of Play

Six regions from across the Baltic Sea: Schleswig-Holstein (DE), Skane (SE), South West Finland, Ida-Viru County (Estonia), Riga (Latvia) and Pomorskie (PL), joined forces within the **Smart Blue Regions project (BSR INTERREG, 2016–2019)**, initiated by SUBMARINER, to generate "Blue Growth" for their regions. The involved public authorities aimed to increase their capacity to

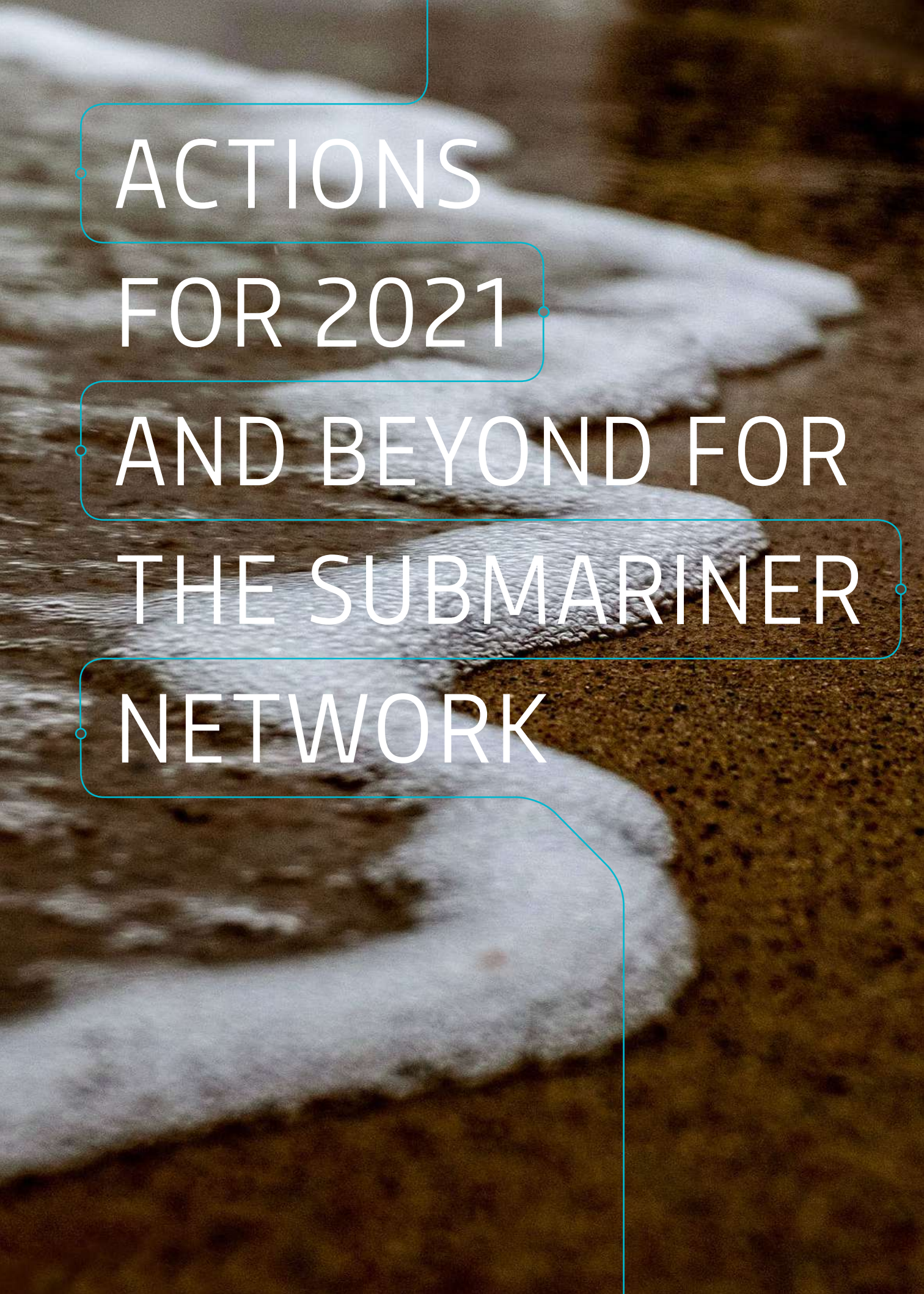
implement specifically RIS3 targeting Blue Growth in order to benefit the blue sectors in their specific regions.

1. **Riga Planning Region** developed a Maritime and Coastal Smart Specialization Strategy (MCSSS).
2. **Southwest Finland** developed a "Blue Growth" RIS3 implementation plan with regional stakeholders.
3. **Ida-Viru region** revised the "Regional Development Strategy 2019-2030" by establishing a 2.5 km^2 business park suitable for aquaculture production and the development of a small harbour network.
4. In **Skane** the innovation strategy was updated in 2018/2019 with significant input from the SBR project.
5. In **Pomorskie** two companies developed through the project idea for "A multi rotor system for offshore wind turbines" and identified international partners to build the prototype.
6. In **Schleswig-Holstein** a monitoring system for blue growth was introduced and tested.

4.12.2 Conclusions and Recommendations

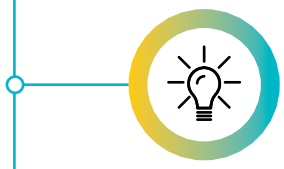
The lessons learned from the Smart Blue Regions project include the following recommendations:

- Working with RIS3 should include a **broad and frequent dialogue with stakeholders** to get more ownership and cooperation.
- It is necessary to **spread the message of the benefits RIS3 and Blue Growth** strategies that are intended to accomplish for regional development.
- The RIS3 implementation should be made **more flexible** during its 7-year implementation.
- **Clusters are crucial**, and their role should be further developed.
- More resources should be dedicated to interregional collaboration and collaboration.
- New methods strengthening the innovation capacity within industries connected to the blue sector and **cooperation between large and small companies** within the blue industries play a crucial role.



ACTIONS FOR 2021 AND BEYOND FOR THE SUBMARINER NETWORK

1 Latest Developments to Be Taken into Account



All topics and strategic actions fields covered already within the SUBMARINER Roadmap 2013 will remain valid for the years to come. However, activities have to be refocused taking into account the following essential developments of the past years.

No Longer Only Research

By now most of the innovative and sustainable approaches promoted by SUBMARINER since 2010 have entered the business reality. As shown, we have now earmarked around 650 companies around the Baltic Sea region, which are active in the field of blue bioeconomy. Not all, but many of them make use of Baltic marine resources, and are committed to offer products / services based on a sustainable use of these resources.

The size of the start-up scene is not comparable to that of the IT / web-development sector, but is continuously growing in size and power. It is characterised by highly educated and engaged (not necessarily young) people, who want to contribute and make a change to how Europe and in particular Baltic Sea resources are used. What is more: Their ideas for new products and services are gaining increasing interest also by the existing big industrial and retail players.

Proof of Concepts

Projects and initiatives implemented within the Baltic Sea Region area have provided evidence, which were in 2013 merely theoretical concepts, can be transferred and applied within the real environment.

Thus, it has been shown that:

- **blue mussels and various native algae species can be cultivated** not only in the Baltic Sea region, but also the Baltic Sea Proper (i.e. in areas with lower salinity levels)
- **local short product value chains can be developed** with input from these resources which show good market potential (for feed, food, cosmetics, material, etc.)
- low-trophic aquaculture and fishery offer **cost-effective ways of nutrient removal**, where needed
- data collected at current low-trophic aquaculture sites **did not show other negative environmental impacts** (i.e. sedimentation, oxygen depletion)

- an increasing number of operational **recirculating aquaculture or aquaponic** companies produce high value products sold at regional markets

What is urgently needed in the coming years is to scale these pilots up to real demonstrators to provide the large-scale biomass needed by companies engaged in transforming them into valuable products as well as to achieve a contribution to the achievement of good environmental status in the Baltic Sea (Region).

Successful Structures and Services Established

Over the past years, SUBMARINER and its members have succeeded in developing a set of services, which has led to a **highly improved blue science-company interface**. Not only is research taken up by businesses, but researchers have gained a much better understanding of the needs / priorities of the companies and entrepreneurs involved.

Moreover, SUBMARINER has established itself as the **Baltic knowledge and data hub**, which continuously collects and transfers relevant information from across a wide variety of project resources, intelligently tagged according to a wide range of categories.

The usefulness and need for these structures and services do not stop once the funding period for a project has come to its end. On the contrary: In almost all cases, these services develop their full impact only after a project is finished. And even more: In order to maintain the value of the original project investment in developing these structures and services, they need to be continuously curated, updated and enhanced.

A More Positive External Environment

Compared to 2013, the SUBMARINER Network sees itself embedded within a more positive external environment with the **UN Sustainable Development Goals** and the **EU Green Deal** acting as the overarching policy drivers.

Within Europe these are supported by numerous interlinked blue initiatives based on its newly defined approach towards a 'sustainable blue economy'. The 'EU4Ocean / Ocean Literacy' campaign; the 'EU4Algae' initiative, the 'BlueInvest' facility, the 'sustainable EU Aquaculture Guidelines', the Horizon Mission 'Ocean, Seas and Rivers', the 'Sustainable Blue Economy Partnership' as well as the newly established 'Interregional Innovation Investment Fund 13' are only a few of the strategies and instruments, which have been established in the meantime.

Whereas the SUBMARINER Network endorses and actively supports all of these strategies, it should be understood, that all of them can only

thrive, if they are also fully supported by regulatory bodies and the public at all levels. What remains to be seen is to what extent these strategies as well as funding opportunities can remove existing regulatory barriers – either at European or national scale – which do not yet take into account the numerous positive developments, which have been achieved through new evidence, knowledge and highly improved technologies.

2 Overview of Next Steps and Actions

Based on these overarching conclusions, it has been decided, that the SUBMARINER Network shall strive to implement the following next steps and actions in the coming years:

Action 1:

Get Pilots to the Next Level

- Increase production, harvesting and effective use of sustainable blue biomass
- **Identify & monitor sites based on common parameters**
- Develop comprehensive regional plans
- Establish large scale demonstration farms / plants
- Encourage and coordinate new cooperative structures
- Undertake cross-cutting assessments: Biodiversity, Ecosystems, Climate Impact
- Improve regulations & licensing procedures

Action 2:

Increase Company Involvement

- Curate and expand the SUBMARINER Blue Economy Product and Company Catalogue
- **Address the need for a company networking platform**
- Continue and expand company specific services:
  - Accelerator / match-making / coaches & mentors
  - Co-creation & ideation
  - Technology development & transfer
  - Life Cycle / Ecosystem Services Assessments and Validation
  - Full Value Chain Establishment

Action 3:

Consolidate 'The Blue on Land'

- **Create Market Push and Pull:** Product Development – Consumer / Public Awareness
- Education & Skills Development
- Consider blue resources and opportunities in Waste Treatment, Food, Feed, Health and Materials
- Address land-sea interactions with regard to Marine Litter and Tourism
- Expand integration and uptake of knowledge from social sciences and information technologies

Action 4:

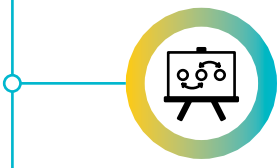
Connect Baltic Working Groups and Projects with EU-wide Initiatives

Continue to engage the entire community of science-policy-business-technology not only within specific projects (involving smaller groups of directly engaged partners) but also cross-cutting working groups to stimulate knowledge exchange, generation and ideation.

Where and if possible, integrate and represent these Baltic working groups, within EU wide networks (i.e. the EU4Algae, EU4Ocean, EATIP, Blue-Invest, Horizon Mission 'Ocean, Sea and Rivers' stakeholder groups). Adapt thematic groups according to needs and demand.

Current themes foreseen for Working Groups:

- Mussel Cultivation & Use
- Algae Cultivation & Use (Sub-group: Beach-Wrack)
- Sustainable Fish Aquaculture
- Multi-Use
- Marine Litter
- Cultural Heritage
- Ocean Literacy and Citizen Science
- Start-up Accelerator



2.1 Action 1: Get Pilots to the Next Level

This action is organised around the following work streams:

Identification & Monitoring of Sites

- Establish a Baltic Sea wide system to **identify optimal blue bio sites** depending on purpose and integrating a variety of perspectives (i.e. environmental benefits / impacts; production costs and yields; socio-economic criteria; conflicts and/or synergies with other uses both within the marine space as well as in view of connections to land-based activities)
- Collect minimum set of **joint parameters** at operational farms in central platform (i.e. ODSS) to validate environmental benefits, effects on and by climate change, alleviate risks, assess production yields as well as socio-economic benefits
- Validate and **control the possible environmental and biodiversity risks** of large-scale production against the Marine Strategy Framework Directive, the Biodiversity Strategy as well as other baselines
- **Update monitoring standards** as to take into account **also positive** rather than only negative impacts; i.e. contribution of low-trophic aquaculture

as a nutrient uptake measure; benefits of integrated multitrophic aquaculture systems (algae / mussel / fish combinations)

- Use opportunities provided by novel, but already available monitoring technology (i.e. drones, underwater robots); agree on common **monitoring technology** standards
- Use existing offshore structures & activities (OWFs; Ships; Fishery; Aquaculture) to provide open access environmental data
- Test, validate and **establish tracking systems** for blue biomass (i.e. fishery & aquaculture products) to increase transparency, consumer trust as well as individual quality criteria of different batches

Increase Production and Better Use of Sustainable Blue Biomass in the Region

- Develop knowledge on farming of the algae species **"Fucus, Ulva, Furcellaria and Palmaria"** in the Baltic environment
- Continue to enhance and improve technology for 'blue mussel sites'; including **submerged systems**
- Work on **Valorization of Waste from Aquatic Sources** (i.e. production of fish oil from fish waste)
- Develop suitable products from currently **underutilized, low trophic species** such as small pelagic fish (i.e. Round Goby, Sprat), sea cucumber or JellyFish – in view of the environmental benefits associated to their increased uptake
- Develop **strategies for disease control** and strain selection

Organise National / Regional Roundtables

- Including industry, R&D and regulators to **remove legal barriers**; i.e. waste and zero pollution definitions; novel food regulation; single & multi-use sector licenses
- Address the lack of global **food safety standards** and ensure safe working conditions
- Agree, support and establish suitable demonstration sites; incl. specific multi-use areas
- Advise national and local planning authorities about the integration of the multi-use concept into planning, zonation and permitting of an offshore wind farm and analysis of suitable institutional arrangements to enable this (i.e. **combined permitting procedure**)
- Establish **ecosystem payment pilot schemes** based on validation of these services at concrete sites
- Develop **comprehensive regional development** plans with focus on Biodiversity; ZeroPollution, Carbon reduction, Circular and Regional Economy; i.e. regional specific plans integrating the various options (land and sea-based; floating structures, at source; overall reduction of use) for nutrient removal as to achieve optimal mix of measures

- Showcase various **scenarios**; outlining e.g. minimum and maximum solutions

Encourage and Coordinate New Cooperative Structures

- Promote ongoing **sharing and collection of monitoring data** from existing farms to create an empirical basis on the positive environmental impacts of these low trophic cultivations
- **Share costs** for joint equipment & knowledge and establish full 'short / regional' value chains
- Secure **joint contracts** / foster direct interaction with relevant larger companies
- Develop regional (business) plans to show how many farms are needed to **achieve critical mass to industry** as well as to contribute to environmental targets
- Take a collective and coordinated approach towards **lobbying** for changes in legislation and funding programmes and cooperation with certification bodies

Consumers and Value Chains

Challenges	Solution
Consumer acceptance	Increase consumer awareness and acceptance • Improve understanding on the value of blue products • Define a communication strategy to raise consumer awareness of blue products • Design more supportive regional policies on blue sector • Support the blue sector advocacy groups in the EU
Side products	Increase the valorisation of rest raw material from fisheries and other aquatic biomass • Enforcement of the landing obligations given by the EU fishery policy • More research on use of underused fish and other marine biomass • Develop regionally: pilot plants for proof of concept at semi-industrial scale, bio-refineries as 'lighthouse' projects to encourage further investment
Production costs	Support the reduction of blue production costs • Provide partial coverage of R&D costs for entrepreneurs in the blue sector • Planning and building of clusters of blue production in the EU with biorefineries and other production / research facilities • Provide investment in silos and biorefinery facilities that can stabilise the input into processing industries
Logistics and seasonality	Support solutions for biomass processing • Support further scentific research on: impact of seasonality on biomass characteristics; crops and harvesting optimisation; logistical challenges and pre-processing techniques (biomass specific) • Set up knowledge exchange on developing system of distributed production of marine biomass • Open data platform with data (e.g. from ongoing monitoring of water quality)

Table: Challenges in BlueBio Value Chains: EU BlueBioEconomy Roadmap, 2019

2.2 Action 2: Increase Company Involvement

Continuous Scouting for Ideas & Entrepreneurs

- Provide **1st point of contact** for any kind of companies
- Offer a 365 days enrolment service; marked by interim specific calls
- Quick assessment / **mentors** match-making
- Bi-annual **pitching and match-making** events
- **Link to other business accelerators** and funding programmes
- Increase collaboration with **big companies** as potential clients and thus supporters of start-ups

SUBMARINER Online Company Interface

- Promote enrolment of sustainable blue companies into the SUBMARINER online **company & product catalogue**
- Continue to **enhance functionalities** of this interactive interface; i.e. by adding technologies
- Expand catalogue and thus cooperation towards companies **outside the Baltic Sea Region**

Support Sustainable Product & Service Development

- Continuously promote active involvement of companies (from micro- to large scale) in SUBMARINER activities and provide, improve and enhance relevant engagement tools
- Screen and map opportunities for development of **new products and services** based on blue resources (see the table)
- Do so also for areas, which do not yield short term gains – but are of relevance for society (i.e. **medical applications**) and/or **environmental restoration** (i.e. seagrass fields)
- Consider also better and higher value uses of waste and side streams;
- Develop business canvas and suitable **business models** (incl. how financial returns can be achieved for ecosystem services provided)
- Showcase full value chains needed; identify possible gaps at all levels
- Promote **multi-use concepts** and interlinkage between different types of industry
- Identify and escalate **urgent R&I needs** into relevant calls

Blue (Bio) Resource from Fishery / Aquaculture	Products / Services	Ancillary Services / Users
• Finfish • Cartilaginous fish • Side Streams /Rest Raw Materials • Molluscs • Crustacea • Invertebrates • Seaweeds / Macroalgae • Microalgae • Marine microorganisms • Halophytes • Reed • Beach-Wrack • Marine Litter	• Food: Fresh, Frozen, Processed (i.e. filets), Prepared, Ingredients • Feed for Fish, Chicken, Cows, Pets • Pharmaceuticals, Nutraceuticals, Medical, cosmetics • Chemical building blocks, lubricants, detergents, inks • Fertilisers, • Textile, furniture, jewellery (e.g. from plastic waste) • Bioplastics • New Bio Materials (i.e for building, medical applications) • Biofuels and bioenergy • Water Treatment / Bioremediation	• Restaurants • Tourism (Experiences, Wellness, Health Treatment, Landscape) • Aqua- and Agriculture • Regional Energy Production • Regional Waste Treatment • Regional Products: Cosmetics, Clothes, Homeware, Furniture • Local Building Style / Art • Technology & Manufacturing Providers

Table: Blue Bioeconomy Elements

Offer a Continuous Blue Assistance Programme

- Act as the **communication and dissemination hub** across science-business-technology-policy-society
- Regularly screen and **promote outputs and results from research** and other projects as to stimulate their exploitation and transfer
- Facilitate the **development of partnerships** for concrete demonstrators / investments (i.e. within the interregional innovation investment programme I3)
- Establish a **transnational innovation voucher system** (for providing start-ups/SMEs access to relevant research facilities and expertise within and outside the Baltic Sea Region)
- Prepare and maintain a **blue economy funding guide**
- Assist the offshore wind companies in **mediation processes** with other uses and local governments and in identifying benefits that certain multi-use combinations may bring depending on the local conditions

Foster Co-creation / Ideation

- Develop and showcase **foresight reports and future business canvas scenarios** for various areas within the blue (bio) economy
- Facilitate **Innovation Bootcamps**, Hackathons, Creative & Disruptive Workshops
- Increase involvement / inter-action with marketing, **social science, IT**, non-blue sector specialists
- Organize Study Tours / **inspiration** from more advanced
- Foster **regional circular economy** value chains and various forms of multi-use, e.g. with tourism

Facilitate Technology Development and Transfer

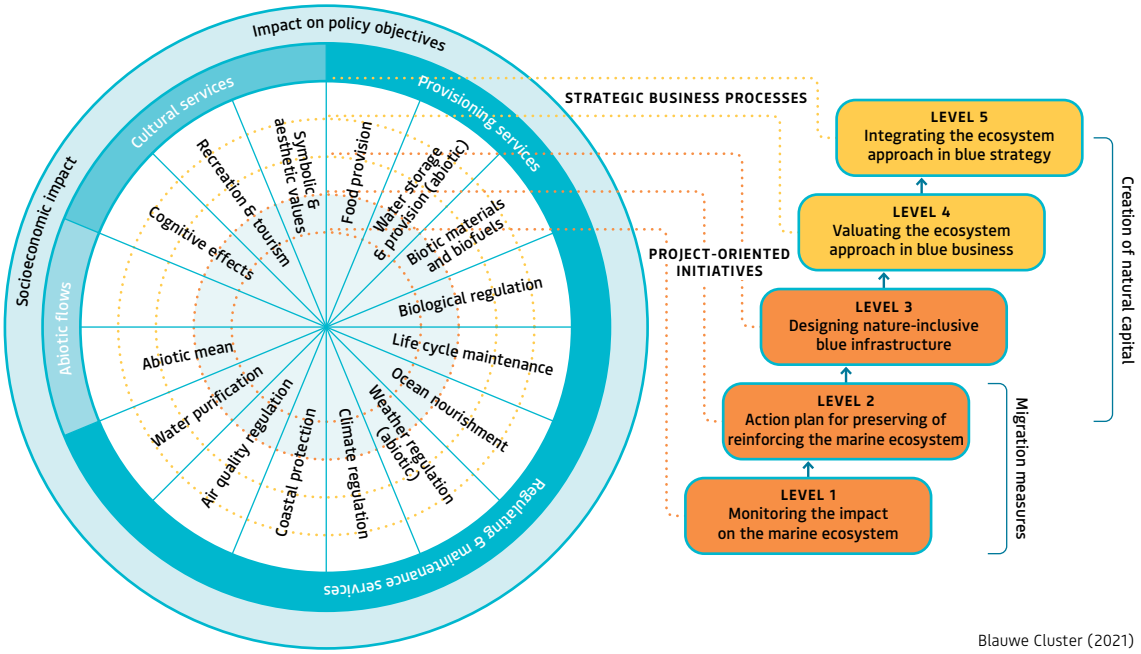
- Identify relevant **technology gaps**
- Screen & scout for possible solutions available outside the Baltic Sea Region
- Assess how **solutions from other bioeconomy sectors**; i.e. forestry (which are more advanced)
- Provide for an online inter-active technology collaboration platform, promoted and enhanced by regular **workshops** and other forms of company 'come together'
- In long term **aim towards the introduction of comprehensive tracking systems**, which enhance information on source, quantity and quality of biomass available both for business clients as well as end-consumers

Environmental / Life-Cycle Assessments and Ecosystem Payments

- Assist companies / regions to **calculate their contributions** to ecosystem services and climate goals
- Thus, help companies to assess **their performance** also in comparison with others; to increase credibility towards consumers as well as authorities
- To that end advance / adapt the **EA wheel tool** developed in 2021 by the Belgium Blauwe Cluster as to suit Baltic Companies' and Regions needs
- Promote the establishment of **ecosystem payment** schemes at regional and local level as part of circular economy approaches
- Continue to **expand assessments**, which consider the entire life cycle of a given product approaches

Technology gaps already identified:

- New automated/mechanized; submerged and/or more offshore systems to open new, less conflicting spaces
- Intelligent combinations of renewable energy with aquaculture (both at land for RAS as well as offshore-multi use)
- Site management technologies: AI & sensor technologies to optimize and reduce costs for monitoring and operating farms; better control of health and growth of the respective fish or plants; due to improved logistics; boat visits and potential accidents or disturbance
- Improved seedling and cultivation technologies; incl. use of environmentally friendly substrates
- Drying, harvesting, processing techniques and upscaling of low-trophic aquaculture species; incl. cost-effective shell removal from small blue mussels
- Nobbing, gutting, filleting technologies for improved blue food productions
- Blockchain technology, improved tracking and digitalization / apps may have a substantial effect on improved consumer communication



Blauwe Cluster (2021)

The EA wheel is made of different building blocks: (1) a classification of the marine ecosystem in different domains or partial aspects that can be impacted (positively or negatively) by economic activities; (2) a ladder with five performance levels that reflect ecosystem approach engagement; and (3) an a posteriori estimate of the impact on society and policy. This allows determining whether the ecosystem efforts also have a positive socioeconomic impact. In addition, it is possible to assess the contribution to policy objectives at different levels (e.g. SDGs).

2.3 Action 3: Consolidate 'The Blue on Land'

Work with Blue Regions as well as NGOs

Coastal sub-regions, municipalities; their business clusters and civil society organisations play a role in all SUBMARINER projects and actions, as they are crucial for the actual implementation / realization of our ambitions. Hence, we advocate for the following future actions:

- Revive the close connection to the **CPMR Baltic Sea Commission** as well as the **'Blue Economy' ERINN** working group and jointly identify activities to be taken on board by regions
- Offer regional networks created under specific projects; e.g. from the CONTRA (beach-wrack) or Coastal Biogas project, the SUBMARINER Network as their post-project 'roof' to continue their cooperation and better link to other related blue bioeconomy initiatives

- Strengthen collaboration of regions at blue cluster level within the Baltic as well as with other **European Blue Clusters** (such as Pôle Mer Bretagne, Flanders Blue Cluster, Portuguese Blue Bio Alliance)
- Support the introduction of 'regional, climate friendly' **public procurement** standards and criteria
- Build **'communities of practice'** and work with them to develop a 'blue-green vision' building on the concrete challenges and opportunities in the given region
- Develop & support implementation of **comprehensive regional blue climate and restoration measures & plans**; including projects that support 'building with nature solutions' that can contribute to increased climate change resilience and resource efficiency (e.g. offshore wind farm artificial reefs, coastal erosion protection solutions, re-use of offshore structures for marine life monitoring and restoration, attractive design for tourism all-year round, etc.).
- Foster **interregional innovation investments** (making a.o. good use of the new 13 funding programme) by creating strategic, coherent partnerships among companies, regions and experts for a concrete blue bioeconomy project

Continue Basic as well as Applied Research for

- Biodiversity, pollution and climate concepts
  - Improve understanding on marine biodiversity decline
  - Exchange and develop knowledge & tools to address ecosystem restoration
  - Assess blue economy contribution to climate change reduction and mitigation
- Blue Biotechnology, Blue Health
  - Use of marine bio-components in new pharmaceuticals and therapies, esp. in view of chronical diseases (i.e. cardiovascular-problems, joints, breathing, diabetes mellitus, Alzheimer, macular degeneration, cancer)
  - Establishment of inter-disciplinary research groups; also in view of improved prevention and therapies
  - Improved cooperation with large pharmaceutical, health clinics and insurance companies

Ocean Literacy, Citizen Science and Public Awareness

- Offer Baltic Sea wide knowledge exchange & cooperation platform for all actors involved
- Create and maintain an open access **'Ocean Literacy / Citizen Science Library'** of initiatives and relevant material to promote better uptake and exploitation by similar actors
- Increase and **improve citizen science initiatives**; promote involvement of companies / policy

- Establish, support and strengthen a network and concrete actions between knowledge providers / public spaces (i.e. **aquaria & museums**) and schools
- Arrange and promote **consumer awareness and public engagement actions**: exhibitions, cook books; blue movement week; tastings; sea gardens; debate clubs; open science labs
- Collaborate with **retailers, chefs, influencers, food & sustainability apps**
- Enhance the intelligent use of communication opportunities offered by **social media**

Marine Litter Action Support

- Continue mapping marine litter and plastic waste actors / stakeholders
- Facilitate cooperative actions at regional-national-Baltic Sea wide level (i.e. organise single use plastic round tables with industry, policy makers, NGOs)
- Promote research and innovation measures & efforts to **substitute or modify plastic products**; reduce microplastics & plastic waste and other circular economy solutions related to reduction of land- and sea-based marine litter
- Foster knowledge about **sources of marine litter** and microplastics
- Support solutions to remove existing marine litter i.e. by establishing **'fishing for litter'** concept & funds
- Work towards introduction of **sustainable fishing gear** and **improve waste management** of ships and ports

Education / Skills

- Create & foster closer **collaboration between companies & educators**
- Assess needs & create formal education and training programmes to address company needs
- Consider a Baltic Sea wide collaboration for a joint or aligned set of Master Programmes
- Educate and **train future aquaculture practitioners** and entrepreneurs, incl. retraining fishermen, develop apprenticeship, vocational and further education programmes i.e. in marine biology and blue bio entrepreneurship
- Continue & expand Baltic Sea wide internship / job / **career exchange service**

2.4 Action 4: Connect Baltic Working Groups and Projects with EU-wide Initiatives

The SUBMARINER Network will continue to connect players and actors across the quadruple helix and across individual, specific projects through the organisation of informal working groups. While it is the ultimate goal that some of the cooperation and ideas from these working groups may feed into the development of new specific projects; working groups shall facilitate informal communication and transfer of knowledge among actors without necessarily following the logical line of projects.

Topics currently suggested for working groups are shown in the box. These topics may, however, evolve over time depending on demand and interest within the Baltic Region community of actors. Thus, they may also follow popular concepts such as "circular economy''; 'IMTA'; "climate change mitigation"; 'environmental protection & restoration services' or 'blue-green infrastructure'. As such there are numerous cross-connections between the various working groups; with specific meetings being promoted to members from more than one working group.

Whenever possible, SUBMARINER will seek to integrate the concept of working groups into its set of funded projects; i.e. enabling regular meetings / workshops with actors outside the immediate project partnership.

Current themes for Working Groups:

- Mussel Cultivation & Use
- Algae Cultivation & Use (Sub-group: Beach-Wrack)
- Sustainable Fish Aquaculture
- Marine Litter
- Multi-Use
- Cultural Heritage
- Ocean Literacy and Citizen Science
- Start-up Accelerator

Moreover, while it is important to maintain the notion of smaller, informal 'virtual spaces' for mutual exchange of players within the Baltic Sea Region community, SUBMARINER will also seek to reflect the topics / interests of these Baltic working groups in the wider scope of pan-European networks:

- Integrate the Aquaculture Group as a Mirror Platform within the European Aquaculture Technology Innovation Platform, **EATIP**
- Promote active involvement and participation of SUBMARINER Algae Working Group members in EU wide activities and working groups of the **EU4Algae** initiative
- Act as the Baltic Focal point for Ocean Literacy initiatives within the **EU4Ocean** platform
- Link the Baltic aquatic biological resource database to EU wide databases (i.e **CORBEL, EMBRC BioBank, MIRRI**) and strengthen collaboration of blue biotechnology research and innovation in the BSR with EU wide networks; esp. the **EMBRIC**.
- Form and facilitate an International **Ocean Multi-Use Community of Practice** to maximize collaboration and project opportunities between the industry and research community
- Improve communications and interlinkages between the Council of the Baltic Sea States '**CBSS** Underwater Heritage Working Group' with European wide projects and initiatives (esp. in the Mediterranean)

THE BLUE PLATFORM PROJECT

has analysed and promoted the work of numerous projects dealing with the evolution of the Blue Bioeconomy in the Baltic. One major channel of continuous promotion being **the Blue Platform website**, which has been established as a one-stop-shop for everything related to the Baltic Blue Bioeconomy. The website offers easy access to projects, topical papers, relevant actors, data, tools & methodologies as well as continuously updated news sections on relevant events, trainings or academic papers.

The information is organised by **topic** (i.e. Mussels, Macro-algae, Aquaculture, Blue Biotechnology, Multi-Use, MSP, Maritime Cultural Heritage, Marine Litter and two recently added categories Ocean Literacy and Fisheries); by individual Baltic countries, with **country profiles** presenting key facts on the current status and interests of the given country in relation to the blue bioeconomy; networks and actors; relevant funding and legislation, as well as a selection of **Good Practices** for each country. Work is currently being undertaken on the Blue Platform website to secure a better overview of the many resources and bugfixes.

The Blue Platform partnership has also undertaken a thorough exercise to collect a comprehensive **list of all relevant actors** in the Baltic Blue Bioeconomy including not only national, regional and local authorities, but also companies, service industries, research institutes and university departments. Key to this mapping exercise is that actors can be filtered according to their specific involvement in blue bioeconomy topics, showing both individual actors as well as institutions.

This massive database has been transformed into a publicly accessible and user-friendly visual map via **https://submariner-network.eu/actorsmap**. An online company catalogue complements this actors' map, showing products, services and blue resources currently used by blue bioeconomy companies throughout the Baltic Sea. SUBMARINER members will continually add to and update these databases.

In the first half of 2021, findings from the Blue Platform topics (summarized in two key output papers: SUBMARINER Status Quo Report 2021 & SUBMARINER Roadmap 2021+) were presented in a series of six transnational **'Better Off Blue'** online events. These were complemented by a series of national (online / hybrid) events designed to better align the various efforts and objectives within the given countries and sub-regions.

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RECOMMENDED REFERENCE
Schultz-Zehden, A.; Arvaniti, E. & Lukic, I. 2021: SUBMARINER Roadmap Beyond 2021. Berlin.