European Commission

Blue Bioeconomy Forum

Roadmap for the blue bioeconomy

November 2019

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EUROPEAN COMMISSION

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Roadmap for the blue bioeconomy

November 2019

Publication prepared on behalf of the European Commission's Directorate-General for Maritime Affairs and Fisheries and the Executive Agency for Small and Medium-Sized Enterprises

Foreword

The sea has traditionally been a large source of economic prosperity and it offers large potential to contribute to achieving quite a number of Sustainable Development Goals, including life below water, climate action, decent work and responsible consumption. Fisheries and aquaculture have been important sources of food for a long time, but outside these sectors the use of renewable aquatic biological resources to make products is still in the infancy stage. In order to speed up the developments and achieve the potential of this so-called blue bioeconomy, the Blue Bioeconomy Forum (BBF) was set up in 2018 as a platform for entrepreneurs, researchers, government officials and other stakeholders.

In the past year and a half we organised a process of interaction with more than 300 stakeholders including a starting event in December 2018 in Amsterdam and a roadmapping conference in Brussels in June 2019. The focus of our activities was on better identifying the wide range of initiatives in the sector, identifying drivers and hurdles for the development of the sector, and defining ways forward. As Steering Group of the Blue Bioeconomy Forum we are now proud to present you this Roadmap for the blue bioeconomy that should help the blue bioeconomy fulfil its potential and flourish.

We thank all people that contributed to this Roadmap and the discussions leading to it, and wish this Roadmap is used well!

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Roadmap for the blue bioeconomy

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LAYOUT:
Arctik – *communication for sustainability*

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SUMMARY

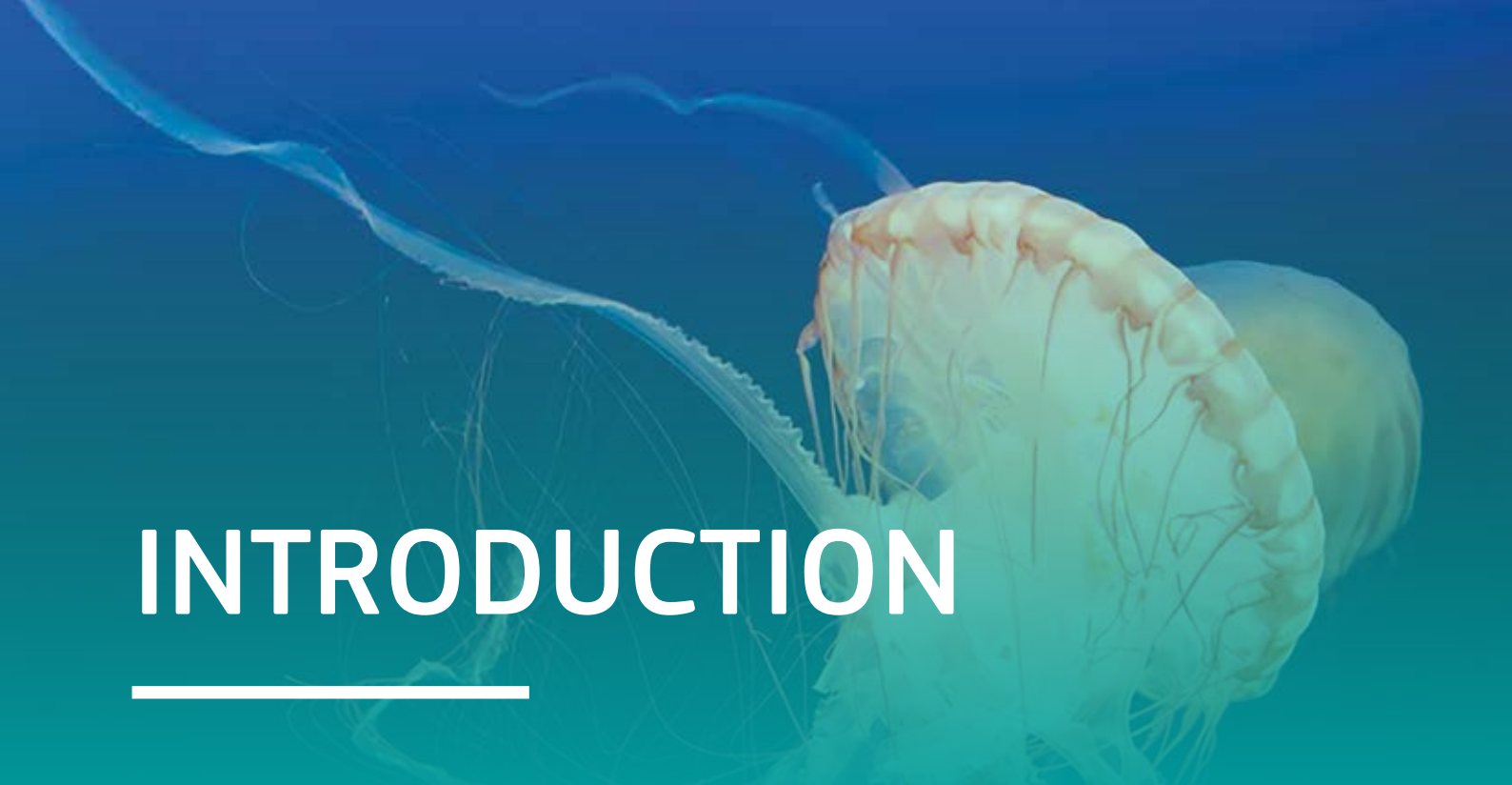
The Blue Bioeconomy Forum has identified 14 challenges that fall within four main themes: Policy, environment and regulation; Finance and business development; Consumers and supply chains; Science, technology and innovation. With the help of the BBF community, solutions were formulated to tackle the challenges. These can be found in the table below. Chapter 4 describes the solutions in more detail, indicating which party (EU, national/regional government, industry or research institutions) should take action.

Table 1 - Ways forward for the blue bioeconomy

CHALLENGES	SOLUTIONS
Policy, Environment and Regulation	
Licences / Permits	Simplify licence and permit applications ~ Harmonise regulatory and legislative requirements ~ Improve clarity about activities through the establishment and adoption of standards ~ Provide clarity on the status of underutilised marine biomass ~ Create one-stop-shops where businesses can obtain (free) advice on regulations in blue bioeconomy sector and product requirements ~ Work towards the harmonisation of marine spatial planning and multi-use
Novel food and feed	Offer support for applications under the Novel Food Regulation ~ Conduct the necessary studies for the authorisation of more types of biomass ~ Ensure the accuracy and consistency of the EU novel food list ~ Provide necessary support to novel food applicants
Ecosystem services	Valorise ecosystem services ~ Take stock of ecosystem services pilots and support their deployment ~ Secure high-level support for payments for ecosystem services and create cohesion between Common Agriculture and Common Fisheries Policies ~ EU strategy for an institutional framework for ecosystem services across European sea basins ~ Incorporate marine ecosystem services into macro-regional strategies, projects and initiatives ~ Ensure that ecosystem valuation studies become an integral part in decision models for specific marine management decisions
Finance and Business Development	
Understanding finance	Increase understanding of investment landscape for projects and businesses ~ Provide blue bioeconomy start-ups with advice on business and financing
Funding mechanisms	Promote uptake of existing funding mechanisms and set up new ones to support projects and start-ups ~ Establish investment funds for blue bioeconomy ~ Provide additional support to SMEs in the blue bioeconomy sector
Skills and qualifications	Ensure availability of skilled and qualified human resources ~ Upcoming sectors and start-ups require more flexible skilled people (including basic business skills)

Consumers and Value Chains	
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 Fisheries 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 scientific 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)
Science, Technology and Innovation	
Researcher-industry dialogue	Facilitate dialogue and cooperation between research and industry ~ Develop measures to incentivise researchers / companies to collaborate ~ Launch exchange programmes for students and staff in industry
Marine exploration	Support solutions for marine exploration ~ Facilitate exploration of marine environment
Research infrastructures	Support a network of research infrastructures ~ Mapping: optimise use of research infrastructures ~ Reduce gap of qualified people for running and maintaining research infrastructures – especially engineering profiles ~ Build a European blue bioeconomy ecosystem ~ Build research infrastructure and financial tools to sustainably use / operate (joint) facilities
Access to data	Promote open data and access to research findings ~ Define structure of an open access results database, making use of existing data structures (e.g. EMODnet, EOSC) ~ Construct an open access results database

It should be noted that many challenges of the blue bioeconomy are interconnected and require a holistic approach towards tackling them.



INTRODUCTION

The Directorate General for Maritime Affairs and Fisheries (DG MARE) of the European Commission and the Executive Agency for Small and Medium Sized Enterprises (EASME) have initiated the Blue Bioeconomy Forum (BBF) in 2018 to bring together industry, public authorities, academia, finance and civil society in order to strengthen Europe's competitive position, exploit the potential of renewable resources and ensure the sustainable use of the resources of the emerging blue bioeconomy.

The aim of the BBF is to develop a common understanding of the current status of blue bioeconomy in Europe and to collectively identify strategic developments, market opportunities, appropriate financial assistance, regulatory actions and research priorities. The BFF seeks to exploit synergies between blue bioeconomy sectors which can benefit from the innovative and optimal uses of aquatic biomass, by sourcing biomass for a particular purpose (e.g. for high-value applications such as cosmetics), but also by valorising by-products and ecosystem services.

For that purpose, the BBF project team, in a joint effort with its Steering Group members, thematic Working Groups and the active involvement of the wider blue bioeconomy community (the Forum) has designed and developed a blue bioeconomy roadmap. A detailed list of the activities undertaken to collect the evidence on which the findings of the Roadmap rely on is presented at the end of this report. There you can also find a list of the stakeholders and organisations involved in the BBF.

The Roadmap will provide a contribution to the industry's future competitiveness, by supporting the main stakeholders to:

- Better understand the market's future regulatory, research, financial assistance and product needs;
- Identify critical gaps between what exists and what is needed;
- Define the short, medium and long-term actions that are required to unlock the potential of the sector.

In this context, it is important to describe our definition of the blue bioeconomy and the fact that for this Roadmap not all sub-sectors of the blue bioeconomy were taken into consideration. The European Commission defines Bioeconomy as:

> *the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy.*
>
> ***(European Commission, 2012)***

The addition of "blue" entails a focus on aquatic or marine environments, especially, on novel aquaculture applications, including non-food, food and feed. Within the scope of the Blue Bioeconomy Forum, the study does not cover "traditional" uses of biomass, such as fisheries and traditional aquaculture that are mainly aimed at food. Marine organisms that are covered include amongst others: microbes (e.g. bacteria, fungi), microalgae, macroalgae (seaweed), invertebrates (e.g. crustaceans, annelids, molluscs, porifera) and discards of fish and other marine organisms that show potential for the development of innovative and high value products as well as valorisation of co-products.

THE STRATEGIC IMPORTANCE OF THE BLUE BIOECONOMY

Underpinning global societal goals and strategic policy objectives of the EU

The relevance and importance of the blue bioeconomy can be indicated in many different ways. First and foremost because the development of the blue bioeconomy underpins large societal goals such as the sustainable development goals (SDGs) and fits within strategic policy objectives of the European Union.

The European Commission, in its Communication "Innovating for Sustainable Growth, a Bioeconomy for Europe" (2012) states that "in order to cope with an increasing global population, rapid depletion of many resources, increasing environmental pressures and climate change, Europe needs to radically change its approach to production, consumption, processing, storage, recycling and disposal of biological resources". Two of the areas the Commission considers as very promising are blue biotechnology (as part of the blue bioeconomy) and aquaculture (European Commission, 2012).

A major global challenge entails finding new sustainable ways to feed a fast-growing world population, which according to the United Nations is anticipated to increase from 7.3 billion people in 2015 to 9.8 billion by 2050. Not only will there be many more people, but today's nutritional challenges (hunger, undernutrition and micronutrient deficiencies), coupled with the expectations of citizens in an increasingly prosperous world, where people are eating more meat and fish in their diets, will intensify the global demand for food and biomass. Given current trends, total food demand is projected to increase by 60% by 2050, according to the Food and Agriculture Organisation of the UN (FAO), unless demand can be managed more effectively (SAPEA, 2017). The evidence collected in the SAPEA report, with a focus on production of food, examines how the oceans can help satisfy the global demand for food, either through the direct production of food or through the harvesting of biomass (wild or cultivated) that can be used as feed in food production. Although food (and consequently feed) is of utmost importance, the development of bio-based non-food products, important for a sustainable life style, is another item that needs to be addressed within the blue bioeconomy.

Blue bioeconomy can play a strategic role in meeting the future global challenges and could improve food security, food safety and the wellbeing of humanity as well as contribute to non-food applications relevant for a more sustainable lifestyle. Increased food production from the ocean could release pressure that has been put on agriculture, as well as support activities associated with the fishing and mariculture industries in meeting the challenges of feeding our future livestock e.g. supplying the required macro nutrients (proteins, fats, carbohydrates) and micronutrients (minerals, vitamins, essential fatty acids). Future marine research priorities may include improved techniques for mass production and processing, for example, of algae, seaweed and novel marine resources for sustainable food, feed or non-food products.

The EU policy framework on blue bioeconomy

From a policy perspective, the blue bioeconomy has been included in EU policies for more than a decade. It was introduced in European strategies as a promising area in terms of research breakthrough and highly-skilled employment, which needed significant support in both research and market development to reach its potential. Six years after the publication of the Blue Growth and Bioeconomy strategies, a number of initiatives have been undertaken to strengthen the sector, but several issues still need to be addressed.

For example, some environmental concerns are included in the strategies, which aim toward sustainable exploitation of resources and the restoration of fragile ecosystems. However, environmental aspects are not the main focus. Further effort is needed in supporting ecosystem-based management, the recognition of the value of ecosystem services, and coordination with environmental policies.

In addition, it is important to mention that Europe is dependent on overseas land resources for its own livestock production (European Environment Agency, 2018) and especially for protein. This makes the search for sustainable alternative resources, for example from the marine environment, a policy necessity and is expected to stimulate

the European blue bioeconomy, to increase the accessibility of unused or underutilised (protein) sources, and nutrients of lower trophic levels (e.g. seaweeds, invertebrates).

The blue bioeconomy now takes a higher position on the policy agenda, with the revised EU Bioeconomy Strategy and the release of several national bioeconomy strategies. At the EU level, strategies and their action plans focused primarily on supporting research and developing partnerships to support the market. Research has benefitted most from policy support, with increased public funding through FP7 and Horizon 2020. A number of initiatives have also been launched to create new higher education programmes, but skill development remains an issue in fulfilling the sector's potential. Although public investments in research have had a leverage effect on both public and private funding, it remains a sector in need of public support. Regarding market development, policy strategies have mostly focused on supply-side aspects, aiming at shortening lengthy process from research to commercialisation. The demand side remains largely unaddressed (Blue Bioeconomy Forum, 2018).

Jobs and growth

The blue bioeconomy contributes to a very diverse set of applications: pharmaceutical, agricultural, industrial, energy related, etc. Given its status as an upcoming sector, it is difficult to obtain reliable figures for social and economic impact.

In its attempt to capture the economic effects of the blue bioeconomy, the EU Blue Economy Report 2019 compiled available information and data. The limitations of the available data are clear and not consistent: the algae sector (so only part of the blue bioeconomy) in Europe is said to employ over 17,000 people (direct and indirect activities), with an estimated turnover of EUR €1.5 billion – while at the same time the global algae market is estimated at US$ 1,073 million with Europe only representing 1% in terms of mass. An ECORYS study suggested that between 11,500 and 40,000 people worked in the blue biotechnology in 2014. This needs to be compared to an estimated 4 million jobs in the blue economy as a whole or 571,000 jobs in the marine living resources subsector (2017 numbers).

BBF participants (in a poll during the 7 December 2018 event) foresee the blue bioeconomy market growing to about EUR €10 billion in 2030. The 2018 EUMOFA report includes references to studies that quote growth in aquaculture of 77% between 2008 and 2030 (compared to a modest 4% in capture fisheries).

Types of biomass and products

The European Market Observatory for Fisheries and Aquaculture (EUMOFA) recent Situation Report provides a comprehensive overview of the sector in the European Union.

The blue bioeconomy biomass can be classified into different types as presented in the table below:

Table 2. *– Types of biomass.*

Type of Biomass	Description
Finfish	These form the majority of capture fisheries and aquaculture activities and the majority of international trade. The biomass they produce for potential non-food uses includes: ~ Whole fish ~ Initial processing by-products such as body slime, wash-waters, scales ~ Fish trimmings ~ Specific tissues and rest raw materials ~ Processing waste-waters ~ Fish trimmings and rest raw materials may arise on-board vessels, on-shore at markets or with primary purchasers, or further along the supply chain with secondary processors
Cartilaginous fish	These include shark, skate, rays and dogfish, all from marine capture fisheries.
Molluscs	The highest tonnages of mollusc fisheries and aquaculture are for clams, oysters, mussels and scallops; other important species include gastropods such as whelks. The biomass they produce for potential non-food uses includes shells, flesh-waste adhering to shells and processing debris including trimmings, viscera and other inedible material. The utility of flesh-waste from molluscs for non-food uses is totally overshadowed by the challenges of making good use of the shells. An unknown amount of shells is discarded at sea.

Type of Biomass	Description
Crustacea	The main crustaceans are prawns, shrimp, crab and lobsters; planktonic crustaceans such as krill are also harvested in increasing amounts. The biomass they produce for potential non-food uses includes shells (carapaces), flesh-waste adhering to these and processing debris including trimmings, viscera, roes and other inedible material. This biomass may become available on-board harvesting vessels or may arise further down the supply chain.
Invertebrates	The majority of invertebrates in the seafood chain are cephalopods–octopuses, squids and cuttlefish. Octopus produce only 10-20% biomass for non-food use, squid as high as 52%: cuttlebones, squid pens, ink sacs, viscera, eyes and beaks.
Seaweeds	The European market is small and consists mainly of wild harvests. Small and large cultivation projects are progressing.
Microalgae	Pond culture in high sunlight areas of carotenoid and omega-3 fatty acid rich algae and Cyanobacteriaceae. Closed systems for high specialty products.
Marine microorganisms such as bacteria and fungi	Bioprospecting: Genetic information or biomolecules for high value applications (e.g. pharmaceutical applications).

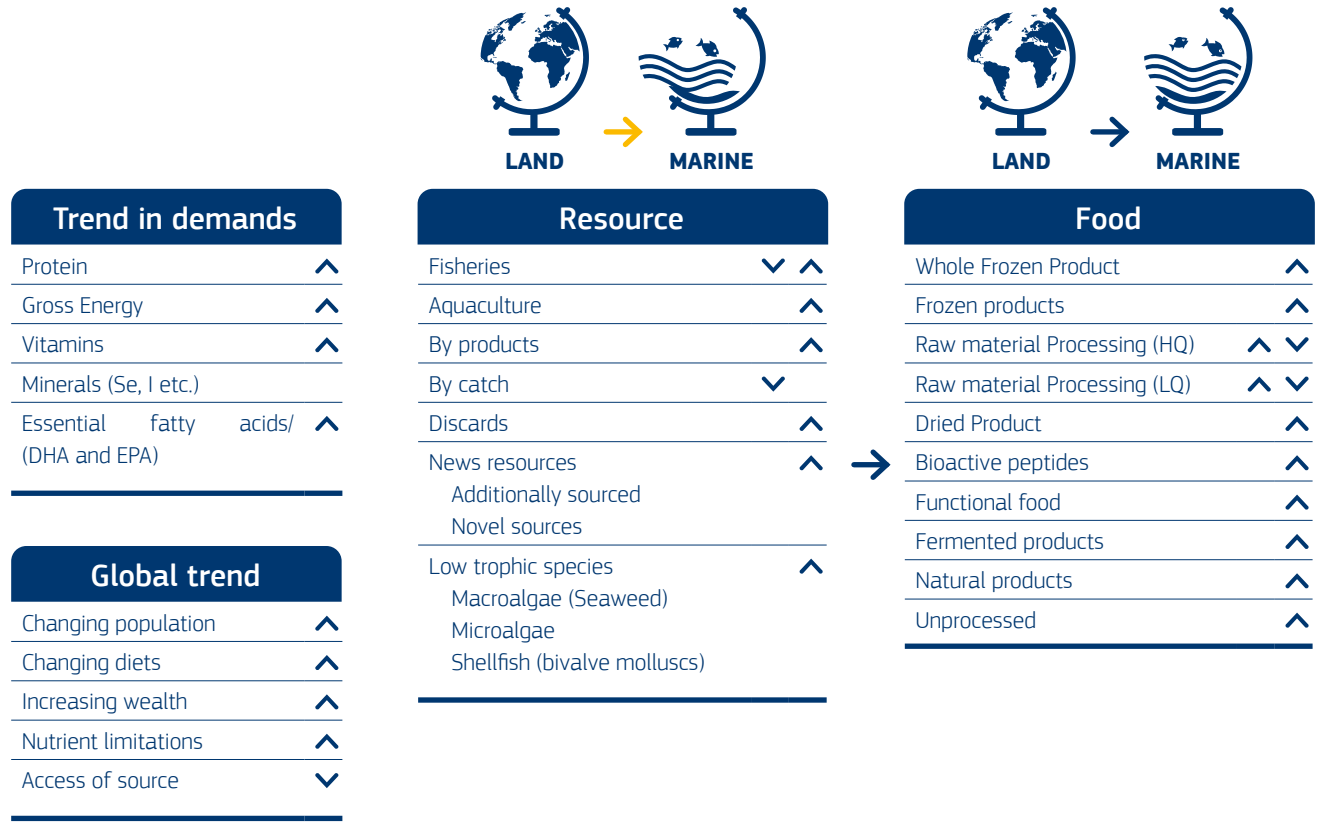
Source: *Adapted from EUMOFA 2018 and extended with microalgae, marine microorganisms*

We distinguish three main categories of products from biomass, namely: non-food, food and feed.

Non-food products are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilised (European Commission, 2018). This includes diverse categories such as pharmaceuticals, cosmetics, chemical building blocks, lubricants, detergents, inks, fertilisers, textile, furniture and bioplastics. Although biofuels and bioenergy can also be biobased products they are not included in this study.

Although the ocean accounts for almost two-thirds of the earth's surface area, they account only for about 2% of overall calorie intake and 15% of protein intake in human **food** (SAPEA, 2017). Options to increase food and biomass production in the ocean and strengthen the contribution of the blue bioeconomy, include: (1) improvements in management and increased utilisation of wastes (side streams) in traditional capture fisheries, (2) mariculture of organisms that extract their nutrients directly from the water, and (3) mariculture of organisms that require feed (e.g. fish). A way to obtain significantly more food and biomass (> 100 million tonnes) from the ocean is **to harvest aquatic organisms that, on average, are from a lower trophic level than today** (SAPEA, 2017).

***Figure 1 -**. Overview trends in demand, resources and applications in food from the blue bioeconomy (vertical blue arrows indicate an expected increase or decrease in volume of demand). See text for further explanation.*

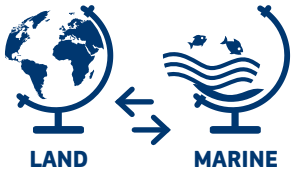


The "blue" resources currently used for feed are mainly fish meal, fish oil, fish hydrolysates, fish solubles, krill meal and oil, shrimp (head) meal and squid meal with the major volumes represented by fish meal and fish oil (4.5 and 1 million tonnes, respectively). One of the major constraints for (aqua) food production is the limited availability of feed ingredients with the right characteristics. Inclusion levels of land animal, plant-based protein meals and lipids are limited due to nutrient imbalances, palatability issues and/or deficiencies of specific nutrients (e.g. essential fatty acids). Moreover, inclusion of land animals' protein can create challenges with consumer acceptance. Alternative sources, such as soy, insects, algae, single cell protein from fermented wood or single cell oils, to replace fishmeal and fish oil in aqua feeds are an ongoing topic of research and (industrial) implementation. Although discards should not be caught, if once captured they should be efficiently used in the human food or animal feed chain to produce fishmeal, fish oil and other valuable products.

In general there is a trend to apply terrestrial based sources in marine production systems. Globally there is also a trend to produce more low trophic species and convert these into valuable feed resources. By relieving higher trophic marine resources by exchange of lower trophic resources, availability of marine resources for human resources increases. Therefore, the combination of a circular terrestrial and marine value chain will contribute to both feed availability as well as food availability.

In figure 2 an overview of trends in demand, resources and application in feed from the blue bioeconomic is given. The global trends suggest increase in demands for feed ingredients and increase in limitations. According to the "Food from the Ocean" report resource availability is not yet fully developed or optimised.

Figure 2 – *Overview of trends in demand, resources and applications in feed from the blue bioeconomy (the vertical blue arrows indicate the expected increase or decrease in volume of demand). See text for further explanation.*



Trend in demands

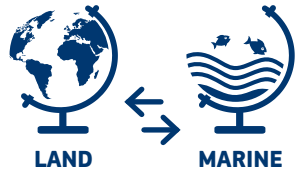
- Protein ↑
- Gross Energy ↑
- Vitamin ↑
- Minerals (Se, I etc.) ↑
- Essential fatty acids/ (EPA and DHA) ↑

Global trend

- Fish oil (limitations) ↑
- Fishmeal (limitations) ↑
- Fish meal substitution ↑
- Fish meal exchange ↓
- Functional Feed ↑

Resource

- Fisheries ↓ ↑
- Aquaculture ↑
- By products ↑
- By catch ↓
- "Recovered" discards ↑
- News resources ↑
  - Additionally sourced
  - Novel sources
- Low trophic species ↑
  - Macroalgae (Seaweed)
  - Microalgae
  - Shellfish (bivalve molluscs)
  - Krill
  - Invertebrates (e.g. worms)
  - Insects
- Land based sources ↑
  - Animal by products
  - Plant based products



Aquafeed

- New "blue" resources ↑
- Altered "blue" resources ↑
- Altered processing ↑
- Substitution of inefficient sources ↑
- Performance increase ↑
- Functional ingredients ↑
- Anti oxidants (natural) ↑

Poulty feed

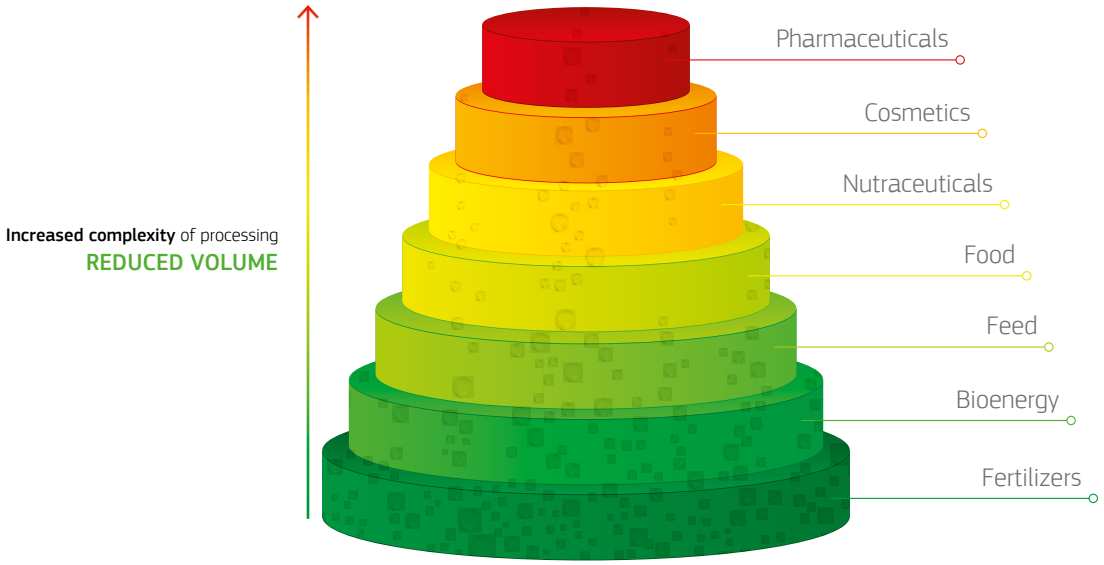
- Seaweed resources ↑
- New "blue" resources ↑
- Performance increase ↑

Ruminants

- New "blue" resources ↑
- Seaweed resources ↑
- Climate positive effects ↑

For the remaining (post-processing) part of raw materials of the blue bioeconomy, the focus has been at the high-volume part (the bottom of the pyramid in the figure below). However, as fisheries resources have become more sparse and their value has increased, there is an increasing focus towards the high value part (EUMOFA, 2018).

Figure 3 – *Volume-value pyramid.*



Products	Time to market (Years)	Cost of development	Resource availability	Need for documentation	Potential market value	Skills and competencies
Pharmaceuticals	10 – 15+	Very high	Limited	Very high	Very high	Extensive medical and market
Cosmetics	3 – 5 +	Low to high	Fair	Medium	High	Toxicology, effects
Nutraceuticals	3 – 5 +	Medium to high	Fair	Medium to high	High	Nutrition and medicine
Food	2 – 5 +	Low to medium	Good	Medium	Medium to high	Nutrition, food science
Feed	2 – 5 +	Low to medium	Very good	Medium	Medium to high	Nutrition, animal science
Bioenergy	2 – 5 +	Low to medium	Very good	Low to medium	Moderate	Energy
Fertilizers	1 – 2	Low	Very good	Low to medium	Moderate	Agriculture, agronomy etc

Source: *based on Whitaker and Fylling-Jensen, Nofima*

Forces driving change

The blue bioeconomy is a strategic sector, essential for the future of humankind that is also exposed to various risks as well as opportunities (OECD, 2016). This has led us to identify below which forces could hinder and which could boost the blue bioeconomy.

The main issue is to contain **human activities which generate negative impact for the climate**, mainly through the increase in atmospheric CO_2. **Unsustainable growth leads to unsustainable increase in atmospheric CO_2**, increasing greenhouse gas emissions and atmospheric disturbances. **These alterations have a direct impact on the oceans**, by increasing the **acidity of the water** (IUCN, 2017) and the **ocean temperature** (Speich, Reverdin, Mercier, & Jeandel, 2015; Meyssignac, 2015) - which disturbs coastal ecosystems and results in migration of certain species (and extinction in the worst case) (OECD, 2016).

Such dangers not only harm human life but puts the blue bioeconomy activities at risk by rendering businesses uncertain and vulnerable. Drastic changes in the ocean environment could threaten the development of the blue biomass (e.g. fish, shell, algae,...) on which these businesses rely, thus ruling out the biomass and its renewable potential as a biological resource.

Atmospheric warming also leads to the melting of glaciers and ice which causes a **rise of the sea level** (Meyssignac, 2015). This modification of the environment can have severe consequences such as coastal erosion, saltwater intrusion in freshwater sources, habitat destruction and growing occurrences of cataclysms, as well as impacts on coastal human settlements including land-based activities, overfishing, deep-sea mining and coastal development.

This already on-going threat hinders the sustainability of any marine-dependent activity and the many benefits we may draw from the marine ecosystem, such as carbon storage, oxygen-, food- and income generation. Given that these coastal ecosystems store carbon better than forests (Bopp & Bowler, 2015), if they disappear or get destroyed by climate change, they will release the stored CO_2 in the atmosphere and impact the marine biomass as a whole.

If the blue bioeconomy sector is to thrive in the coming years, it will only be possible through tackling climate change and **reversing the cycle** to **restore and compensate the damages** already done to the environment. This endeavour will be achievable only through **sustainable management and thorough conservation** and restoration of marine ecosystems.

THEMATIC CHALLENGES OF THE BLUE BIOECONOMY SECTOR

This section of the Roadmap describes the main challenges identified by the Blue Bioeconomy Forum. The specific challenges are described per thematic area in the following sub-sections: Policy, environment and regulation; Finance and business development; Consumers and value chains, and; Science, technology and innovation.

The findings presented are based on the evidence collected via desk research and several consultations with BBF stakeholders. A detailed list of the activities undertaken to collect the evidence on which the findings of the Roadmap rely on is presented at the end of this report. A list of the stakeholders and organisations involved in the BBF is also presented there.

Many of the challenges are cross thematic, especially issues relating to data and knowledge, and skills and education. Access to data was first addressed from the angle of research data, biobanks and project results (therefore under Science, Technology and Innovation). However, access to data is also an issue or part of the solution in other thematic areas including ecosystem services; monitoring seasonality or to assess logistical challenges and processing costs. Lack of skills and qualifications is relevant for both Finance and business development, as well as for Science, Technology and Innovation. The Roadmap shows that multidisciplinary skillsets are required to run blue bioeconomy businesses, including the combination of multiple technical skills and entrepreneurial/managerial skills. The long term sustainability of research infrastructures is an issue in the sector; part of the solution is found in ensuring that there is sufficient availability of qualified personnel to run the facilities.

All in all, the concept of the "blue bioeconomy sector" is not yet widely understood and leads to:

- Different interpretations of existing rules and regulations, multiple, insufficiently coordinated and lengthy processing streams;
- Difficulties in matching entrepreneurs and investors and barriers to funding opportunities;
- No sectoral culture and community and no common language or associations.

Policy, environment and regulation

Obtaining licenses and permits to set up activities is difficult for companies

Many elements of the blue bioeconomy are still relatively immature which translates into a certain opaqueness as far as policies, regulations and license to operate are concerned. In other words: blue bioeconomy activities lack clear definitions and thus find themselves underdefined, leading to legal uncertainty. This can be seen as both an opportunity and a hindrance. The opportunity of low legislative pressures allows a certain freedom of growth for a business, encouraging innovation and experimentation. On the other hand, lack of clear guidelines and uncertainty leads to inefficient procedures or also, in a wider European context, potential inequality (see Text box 1).

Text box 1 – *Complexity of licensing.*

In many countries, to operate a business means fulfilling requirements that are captured in specific licences or permits. Licences are not always fit for novel applications: activities such as aquaculture (open/closed/multitrophic), harvesting, operational scales (industrial versus farming), processing and freezing may all require separate and different licences. Very similar activities at sea, depending on whether they are considered "constructing" or "building", require different (or no) licences. In more mainstream activities, the most apparent inconsistencies will have been remedied – in novel applications, these remain to be discovered and filtered out.

Improvements in licensing that are needed include less administration, less time required to fill out forms and less travelling.

For resolving unclarity of definitions, one strategy is to follow an official standardisation procedure. The algae sector is a case in point: recent research on the definition of algae in EC legislation (Monard, 2018) has found 365 acts in which the term is used, but often in different contexts. With the broad range of applications/services provided by the algae sector (aquaculture, industry, agriculture, environment, maritime planning) this can lead to confusion. Upon request of the European Algae Biomass Association, further work on standards for the industries are currently under way (Text box 2).

Text box 2 –*. CEN Technical Committee 454.*

On the basis of the Commission's request (M/547), a technical committee (TC/454) has been established by the European Committee for Standardisation CEN to work on standards related to terms and definitions on functions, products, and properties of algae and algae products. This includes:

- *specifications for algae-based products*
- *quality specifications for biofuel production*
- *specifications for algae processing*
- *quality characterisation of algal products for non-energy applications*
- *specifications for gaseous capture/soluble nutrient compounds for algal products*
- *specifications for solid and liquid residue streams*

The work of the Committee has expanded from renewable energy requirements to now include food/feed and chemicals/materials/cosmetics/pharma. There is a clear need for further specifying definitions and standards to reduce uncertainty in operations and the communication between entrepreneurs and governmental organisations.

Source: *Bert van Asselt, JRC Workshop on Algae Production, 27/2/2019; Commission Implementing Decision M/547 / COM(2016)1582; CEN working plan 2019*

Harmonisation of regulations and licensing policies between EU member states, but even between national regions, seems an obvious step, although the current policies may be the result of (deliberate) choices and different interests. Text box 3 presents the example of mussel farming for reducing excess nutrients and improving water quality, and how different interpretation of EU policies has led to different situations at the national level.

Text box 3 – *Mussel farming to reduce eutrophication.*

The EU framework on water protection, specifically the Water Framework Directive (WFD) and the Marine Strategy Framework Directive, (MSFD) have led to many actions within member states to improve the quality of water and achieve Good Environmental Status.

One such measure includes mussel farming to reduce excess loads of nutrient content (Petersen J. , Holmer, Termansen, & Hasler, 2019). Mussels extract the nutrients in the sea and therefore contribute to the mitigation of eutrophication. However, as each Member State has to interpret such framework directives, this leads to countries and even regions interpreting the Framework(s) differently. For example, in Sweden, shell fish farming has been adopted as a possible mitigation measure in its national strategy. However, it is not being adopted consistently throughout the country - with the west and east coasts enforcing different licensing systems.

Source: *Water Framework Directive (2000/60/EC) and Marine Strategy Framework Directive (2008/56/EC)*

Access to licences is increasingly complicated and time consuming for nascent industries such as the blue bioeconomy, in a context of often overexploited sea space. For example, AtSeaNova, who build farms for seaweed cultivation indicated it may take over a year to get a licence to farm. As Member States are setting up maritime spatial plans, actors of the blue bioeconomy have trouble getting their voice heard as much as other, larger and incumbent sectors such as renewable energy and fisheries. However, the promotion of multi-use (MU) at sea could change this. The European H2020 project MUSES (Multi-Use in European Seas) lists substantial benefits, including:

- Providing economic benefits to marine users from synergetic use, maximising the economic benefit from a certain area;
- Enabling certain uses to develop in maritime areas, where this would otherwise not be possible due to the dominance of other maritime uses;
- Reducing the environmental impact of a given use by merging it with another activity;
- Providing additional benefits to the coastal region, e.g. to their local economy, tourism etc.

The MU concept has been advocated by both EU policy as well as national policies and developments (see text box 4). It represents a radical change from the concept of exclusive resource rights, to the inclusive sharing of resources by one or more uses in close geographic proximity.

The main driver behind MUs is a lack of suitable space in inshore sheltered areas to reach the targets for increase of aquaculture production (60% for fin fish and 25% for shellfish by 2020). The MU may also provide an opportunity to move aquaculture offshore to further exposed sites and create costs saving through joint development and shared operations and maintenance. Moreover, using energy from offshore wind farms for aquaculture operations could potentially ensure green credentials and allow aquaculture products to be marketed at a premium.

Text box 4 –*. Multi-use at sea.*

Several of our respondents indicated that there are national (and temporal) differences regarding the access to offshore wind farms. Whereas from a wider perspective, multi-use of marine space makes sense, for each individual actor it raises several issues.

The MUSES project concluded that regulatory implications differ across different countries. In some countries (e.g. UK), multi-use of sea space is already taking place and discussions are on-going in relation to innovative ways for integration; in other countries (e.g. Germany) regulatory aspects are still a major barrier. In Belgium, early wind concessions excluded all activities around wind farms, but exceptions to regulations have been made to facilitate experimental research projects. In the Netherlands, transversing windmill farms was allowed. Following the Northsea 2050 Agenda, in which multi-use is promoted, commercial wind-weed combinations will be allowed.

Source: *MUSES (Multi-Use in European Seas) project, Deliverable 4.2.1: Multi-Use Analysis, 30 April 2018*

Novel food status and procedures are unclear for companies

The food and food supplements market represents an important opportunity for several blue bioeconomy sectors, but is yet underdeveloped. In order to access this market, producers must ensure that the substances that they use are authorised, but most of them are extracted from biomasses that fall under the Novel Food Regulation (NFR).

The NFR is of particular importance to the micro- and macro-algae sectors, jellyfish, Arctic shrimp and certain types of oysters. Companies entering the novel food market would do so with a high value product that is easy to produce and scalable. This would free up investment for pursuing high-value products based on the same organism.

Before its revision, the regulation had acquired a reputation of being extremely challenging for most blue bio businesses. This is reflected in the responses to our survey: of the 14 businesses that indicated that the NFR was relevant to their activities, only one had actually gone through the procedure. Of those who had not, half of them indicated that the application procedure was a factor in their decision not to apply. While some difficulties have been tackled with the revision of the regulation, our interviewees indicate that others remain.

Firstly, and beyond NFR, marine biomass requires scrutiny over the level of substances that they tend to accumulate and are known to be detrimental to human health. This has led the EC to produce a recommendation on products based on seaweeds[1]. The EC recommends that Member States, in collaboration with food and feed business operators, monitor during the years 2018, 2019 and 2020 the presence of arsenic, cadmium, iodine, lead and mercury in seaweed, halophytes and products based on seaweed. Marine biomass is therefore under particular scrutiny to pass the authorisation process of the Novel Food Regulation. However, as demonstrated in the example below, the benchmarks employed to assess ingredients' innocuity do not always fully reflect the specificities of blue biomass.

Text box 5 - *The PEGASUS project.*

To ensure that all new blue bio-substance represents no danger for human health, producers must provide studies demonstrating their harmlessness, based on a number of established benchmarks. However, it appears that some of these are not well adapted to blue bio-substances, especially in the case of algae. An example of this is heavy metal levels for safe consumption in cosmetics and food. The recently published report from the PEGASUS (Phycomorph European Guidelines for a Sustainable Aquaculture of Seaweeds) project sums up the issue as follows: "Regulations in some countries do not distinguish between organic and inorganic heavy-metal compounds such as arsenic and cadmium, which can be found in some seaweeds. This creates unnecessary health debates over the appropriateness of eating seaweed or using it as feed for animals. The consumption of seaweeds in China, for example, is many times higher than that of the EU, but there are no detectable negative health effects. The reason is that most of the heavy metals in seaweed are organic and therefore harmless for humans – but this understanding is not taken into account in EU regulations today, making their amendment necessary".

In addition to its cost and length, the NFR procedure was also perceived as being unclear with Member States implementing different requirements leading to unfair approval applications and confusing guidelines. This notably led to a strategic approach to choosing where to apply, with the United Kingdom receiving applications from non-UK companies, and some applicants from Spain or Germany applying elsewhere than in their respective country. (Calderón Pascual, Capón García-Caro, Teruel Muñoz, & López Rodríguez, 2018)

As a result, only a handful of blue biomass products have been successfully added to the list of authorised novel foods. This has also contributed to a number of food products (beyond blue bio-based ones) being marketed without authorisation. As an illustration, when the EC conducted an investigation in 2017 with their Member States on food products marketed online on 1100 websites, they found that 2/3 of the products were not authorised, including 428 non-authorised novel foods. (European Commission, 2018). While this investigation does not detail whether illegal blue bioproducts where discovered in this case, products such as *Nannochloropsis gaditana* microalgae species (van Loveren & Unamunzaga, 2018) can be found - leading not only to a detrimental effect on public health but also on the reputation of the blue bioeconomy.

[1] (EU) 2018/464 https://eur-lex.europa.eu/legal-content/GA/TXT/?uri=CELEX:32018H0464

In January 2018, the revised NFR (EU) 2015/2283 introduced a number of changes:

- A centralised online system to submit applications dossiers managed by EFSA;
- New time period providing more transparency on the authorisation process;
- New food categories, covering blue biomass;
- Guidelines to assist companies;
- A new communication pathway between EFSA and companies to accompany applicants, especially for SMEs;
- Introduction of a dedicated pathway for traditional foods.

These changes are expected to lead to an increased number of applications, and ensure that more support and clarity is provided to applicants. However, a number of other issues are still outstanding:

- The list of novel foods in the Novel Food catalogue often includes information that is inaccurate or incomplete, from identifying the right substance, to adequately describing the authorised use.
- Information included in the catalogue, as well as what constitutes a novel food, come from Member States. While EFSA now centralises the authorisation process, Member States keep an important, subsidiary role in providing information on what is already allowed, and under what conditions.
- An overview/database of existing studies made in the context of the Novel Food application would be helpful.
- More cooperation at the international level is necessary with other countries, within the UN process with the Food and Agriculture Organisation and with the World Trade Organisation, to both inform European bodies on foods that are not yet authorised on the European market, and to promote harmonisation of rules between countries at a global level. Processes to share this information could be explored.

Text box 6 – *The case of Feed*

The marketing of feed and feed ingredients is regulated through Regulation (EC) 767/2009. On the topic of Feed safety and authorization of products, the broader Regulation (EC) 178/2002 applies. Contrary to food, there is no such thing as a "novel feed" concept in EU regulations. Feed authorisation is differentiated for two categories of product: feed additives and feed materials.

New feed additives must follow an authorisation procedure defined by Regulation (EC) 1831/2003. The procedure is very similar to the one of novel food, and a dedicated portal with information exists on the EFSA website[2].

New feed materials benefit from an easy access to the EU market. The only requirement for a new feed material is to register it on an industry-led registry. However, there is also a Catalogue of feed materials, which is part of EU laws. Most marine biomass is already covered (fish and derivatives, aquatic invertebrates, crustacea, krill, zooplankton, mollusk, algae, etc.). To enter the Catalogue, a specific procedure must be followed. While the inscription on the Registry is sufficient to put feed material on the market, the inscription on the Catalogue has advantages. The main one is to have dedicated labelling requirements. When not on the registry, materials must follow general requirements. For this reason, producers might see an interest in applying to be added on the Catalogue.

To decide to register a feed ingredient as a material or an additive, and then pursue its inscription on the Catalogue of feed material is up to the producer, and will impact their costs of entering the market. As part of our consultation process, it is not clear whether this represents a significant hurdle for companies of the blue bioeconomy and could be further monitored.

Finally, similarly to food matters, some blue biomass are restricted for reasons of health safety. In some cases, the restriction was inappropriate and companies launched procedures to adapt the legislation. Recent cases include the amendment of Regulation (EC) 999/2001 to stop the exclusion of starfish in fishmeal, and the subsequent addition of Asteroidea in the Catalogue of feed material[3].

[2] European Commission website, Feed Additives, accessed on October 2019 https://ec.europa.eu/food/safety/animal-feed/feed-additives_en

[3] Byrne, J. (2016) « EU: Starfish now allowed as fishmeal source for pig and poultry feed », Feed Navigator, accessed on October 2019, https://www.feednavigator.com/Article/2016/10/24/EU-Starfish-now-allowed-as-fishmeal-source-for-pig-and-poultry-feed

Ecosystem services lack recognition and are rarely remunerated

"Marine ecosystem services are the services provided by the processes, functions and structure of the marine environment that directly or indirectly contribute to societal welfare, health and economic activities." (Austen, et al., 2019).

Our definition of ecosystem services also includes:

- Provisioning services (i.e. fish, shellfish, seaweed, etc. for food and feed).
- Regulating services (such as water purification).
- Removing and processing excess biomass from algae blooms or invasive species.
- Providing nursery space for local species.
- Preserving and restoring habitats such as salt marshes.

Text box 7 – *Example of the valuable role of ecosystem services.*

The release of excess nutrients (e.g. nitrogen, phosphorus, carbon) and heavy metals into the sea can have a detrimental effect on the environment and human health. Extractive species (mussels and oysters, micro- and macro-algae, etc.) can be raised to filter the water column of nutrients, but also heavy metals or CO_2, with no need for extra feed (Buck, Nevejan, Wille, Chambers, & Chopin, 2017). While biomass removing nutrients can often be reused in further products such as food or feed, biomass used to capture heavy metals might have limited application due to health and environmental risks linked to the release of the captured substances. It has to be noted that the process, which is an ecosystem service, is also called mitigation, bioremediation, bio-extraction, bio harvesting, agro-aqua recycling, or compensation aquaculture (Petersen, Hasler, & Timmersmann, 2014).

Uncertainties regarding the capacity to support ecosystem services

As there is currently a lack of harmonised definitions, results and frameworks around ecosystem services and their contributions to the marine environment, improving the valuation of services and measuring their impact should be a priority in order to set up a system to support them. There is also a need for life-cycle assessments and ecosystem modelling to ensure that there is actual proof of the benefit of these. Some of the BBF stakeholders also emphasised the need to look at project impact at a large scale (sea basin scale rather than at a farm level), as well as looking at restoration rather than just preventing damage. These two elements add a layer of complexity, as these might be harder to both achieve, and measure.

Challenges in setting up viable business models

While pilot projects set up the activities to be included, ecosystem services are often not accounted for or remunerated within a project.

Some examples include:

- **Public funding**: most pilot projects have been set up with public research funding. Some proved less cost-effective than planned, and many did not have a business plan for continuation beyond the funding period. (Minnhagen, 2017)
- **Commercial reuse of the biomass produced**: in some cases, the product of the activity can be sold to keep financing the activity. This is notably the case of nutrient extracting species such as mussels and algae, which can be sold for feed and sometimes food, providing that toxins levels are below the sanitary norms.
- **Co-use**: multitrophic aquaculture is a common example (e.g. shellfish or seaweed near cage culture of fish to reduce eutrophication resulting from fish production) (Buck, Nevejan, Wille, Chambers, & Chopin, 2017; interview with Hortimare).
- **Scale**: while ecosystem services are expected to play an important role in pollution mitigation, very few projects have managed to become economically viable, and this type of blue bioeconomy activity has still not reached the scale envisaged by stakeholders.

A number of stakeholders have advised that the absence of dedicated remuneration for the ecosystem service itself has proven a major barrier. The European Commission and national governments are therefore advised to explore possibilities for ecosystem service payment in the future.

A number of possible solutions could include:

- The "polluter-pay principle" (used in Denmark)
- Use funding schemes implemented in other sectors such as carbon emission credits. In this case, governments could set up nutrient emission credits, where consumers would pay a tax on high-trophic species to compensate the low-trophic species that can extract the excess nutrient.
- Modelling a solution based on the practice of land decontamination and phytoremediation policies.
- Absence of fishing quota for invasive species (in Latvia).

Future shift to payment of ecosystem services is closely related to the dynamics of costs for nutrient removal (using different species) compared to the marginal costs for nutrient removal of land-based sources. These should be studied in different Member States, in different sea basins and for different species.

In addition, the nitrogen reduction required to achieve good ecological status in different locations should be further explored.

The relatively complex issue of governance models requires the ongoing guidance of the scientific community but also the buy-in of the private sector and the support of the government, the financial sector and the European Commission. In addition, different governance models and arrangements could be investigated for the set-up of the ecosystem payment services and involving public bodies, emitters of nutrients from land and producers of extractive species.

The text boxes below present examples of projects on ecosystem services and what can be learnt from them. As already mentioned in previous examples, mussels can be deployed to reduce eutrophication (Text box 8). The Amalia project (Text box 9) demonstrates how the extraction of invasive species could compensate for their negative effects through exploiting their ecosystem services. The Dutch Climate Agreement in Text box 10 is an example of a large scale ecosystem service (CO_2-capture) measure. The STARPRO example combines combatting invasive species with using them for feed purposes (Text box 11). Limiting coastal nuisance of green algae and use this biomass for biobased products, such as bioplastic, is also aimed by the interviewed SME Eranova.

Text box 8 – *Mussels farming for nutrient extraction in the Baltic Sea.*

The Baltic Blue Growth project has followed 6 mussel farms in the Baltic Sea between 2016-2018. The report includes a comparative analysis of best ways to optimise the production of mussel biomass explicitly for nutrient catch (Minnhahen, et al., 2019). It highlighted that this type of activity is not efficient in all locations, reducing the financial viability beyond public funding.

The Baltic Blue Growth and other projects (EU-life IP Rich Waters, KOMBI-aquaculture) have provided new data on seasonal and geographical variation of mussels nutrient uptake. The function of mussel farms as an environmental measure in the Baltic Sea has been questioned as they can result in nutrient accumulation in the sediments and potentially change important ecosystem functions. There is a need for more ecosystem modelling to really assess where such farms would have an added value (Hedberg, Kautsky, Kumblad, & Wikström, 2018).

Text box 9 – *Removing invasive algae for further exploitation.*

The AMALIA (Algae-to-Market Lab Ideas) project funded by the European Maritime and Fisheries Fund mainly focused on six seaweed and algae species. AMALIA has mapped where these species can be found and has identified what the priorities are in terms of their management. Their collection may become a solution and sustainable management practice contributing to marine ecosystem resilience and even site restoration.

For example, devil's tongue weed could be commercially interesting because of the anticoagulant properties of its extracts. Harpoon weed extracts are already being used in cosmetics and have antioxidant, antibacterial, antiviral, antifungal and anti-parasite properties. Wireweed is able to absorb heavy metal pollutants, and could be used for environmentally-friendly antifouling paint used on ship hulls. Green sea-fingers also have antifouling and antifungal properties, and can absorb ammonia.

Source: *http://www.amaliaproject.eu*

Text box 10 – *Seaweed farming as a way to reach climate goals.*

The Dutch Climate Agreement is a cooperation between industries, academics, civil society organisations, and government with the explicit goal to reduce the Dutch CO_2-emissions to fulfil the requirements of the 2015 Paris Agreement. The draft text that was agreed upon by the Agriculture Table sub-group (2018) mentions as one of the targets the use of water for capturing CO_2: developing blue space for seaweed farms and associated nature development.

Source: *Dutch Ministry of Agriculture, Nature and Food Quality (2019)*

Text box 11 – *STARPRO as an example of a new marine species for feed production.*

Starfish are on the rise in Danish fjords and coasts and they are eating mussels in large quantities. STARPRO is now seeking to establish a sustainable starfish fishery to transform them into feed ingredients which would produce a 100 % organic feed ingredient for livestock production. The project encompasses the entire value chain and aims to develop profitable methods for the production of starfish. The aim is to establish a fishery of 10,000 tonnes of starfish per year corresponding to a production of approx. 2,500 tonnes of starfish flour per year. Activities in STARPRO include inventory of the raw material basis, testing methods for the production of starfish flour from pre-treatment to grinding dried starfish and development of compound feed for poultry and piglets. (Dansk Skaldyrcenter, 2016)

Source: *Dutch Ministry of Agriculture, Nature and Food Quality (2019)*

Finance and business development

Many stakeholders of the Blue Bioeconomy Forum mention difficulties of attracting finance whether this is from private equity, angel investors, investment funds, venture capital, commercial banks or public funding. In a survey launched in 2017, in the context of Bio-Based Industries (BBI) and the Blue Economy (BE) the majority of BBI and BE projects (33 out of 43) mention that they faced access-to-finance issues (InnovFin, 2017).

Funding gaps have been identified in the following phases:

- In upscaling from pilot to demonstration projects and in moving from demonstration to first-of-a-kind (FOAK) and industrial-scale projects (InnovFin, 2017).
- In the commercialisation phase (product development and commercialisation) (Acacia, Metis, Panteia, ICF and CASE, 2018).
- The R&D phase.

Our working groups highlighted that funding is particularly a problem for mid-scale projects (between EUR € 1 million and EUR € 10 million). This is comparable to the funding gap found in the blue economy as a whole, which lies between EUR € 3 million and EUR € 15 million (Acacia, Metis, Panteia, ICF and CASE, 2018). Similarly, the Marine Biotechnology Strategic Research and Innovation Roadmap (Hurst, Børresen, Almesjö, De Raedemaecker, & Bergseth, 2016), found the greatest need for further funding to be in the demonstration plant phase (TRL 6-7), and the upscaling to flagship/first-of-a-kind (TRL 8), when economies of scale have not yet been achieved.

Part of the reason for these challenges is that the financing landscape for the blue bioeconomy is relatively immature. This is the case for most of the blue economy, as 65% of the most important investors for the blue economy were established only in the past 5 years (Acacia, Metis, Panteia, ICF and CASE, 2018). Furthermore, a substantial number of financing platforms are not dedicated to the blue economy. For the blue bioeconomy it is even more difficult to find financing platforms covering this specific area. High risks are often mentioned by companies and investors in the above studies and also in our working groups. These can be market and demand risks (due to a lack of developed markets and insufficient and fluctuating demand for products from the bioeconomy) or regulatory risks (resulting from a lack of effective, stable and supportive EU regulatory framework) (InnovFin, 2017). Furthermore, there are natural risks for the blue bioeconomy, e.g. diseases affecting animals (fish, shrimps, oysters), storms causing physical damage to aquaculture farms or a drop in oxygen level and temperature changes.

From the perspective of emerging fund managers in the blue economy, the problem is not generally a risk-return problem, but a shortage of capital in their funds (Acacia, Metis, Panteia, ICF and CASE, 2018).

However, in the blue bioeconomy, highly characterised by new technologies and innovations, information asymmetry and technology risks are limiting investment. Most Financial Market Participants prefer more mature and technologically advanced projects (InnovFin, 2017).

Three main challenges were identified that need to be addressed in order to close these funding gaps in the blue bioeconomy.

Blue bio projects and businesses lack understanding of investment landscape.

Discussions with investors indicates that blue bioeconomy startups are not generally familiar with the investment landscape. This includes the variety of different forms of finance (debt, equity, etc.) as well as the range of investors. In many cases, their managers or founders lack understanding of the relevant investment options and what is necessary to access them. This is not surprising because most projects and startups are led by researchers and innovators, who are driven by the belief in their technology or product, and its social or market potential. Such managers are not experienced in business finance and this skill needs to be integrated into the business for a successful investment outcome. Investors emphasise the need for companies to present a robust business model for a promising product together with a solid management team.

According to investors, blue bioeconomy projects can present funding difficulties including the risk inherent with new technologies or new products (for which little is known about market acceptance), longer lead times until revenues are generated, and uncertainty concerning possible regulatory issues. Furthermore, expensive license costs, IP hurdles and safety rules for offshore work can be costly (see section on licensing).

A lack of understanding on the part of the investment community is also mentioned as a big challenge in the blue bioeconomy, which aligns with what is also seen in both blue economy and bio-based industries. This challenge was also identified in the blue economy investment platform study (Acacia, Metis, Panteia, ICF and CASE, 2018). In the blue economy, startups and businesses mention for example, a lack of understanding on the part of venture capital funds of the technology risk and market potential.

Most investors may not have a detailed understanding of the risks of blue bio-businesses. Transparency, clarity and effective communication are central for gaining their trust. Businesses need assistance in appreciating what kind of information investors required with some projects and start-ups directly address this challenge by engaging financial expertise in their management structure, as in the case of FP7 project D-FACTORY.

There is a lack of funds and mechanisms to support blue bio projects and start-ups

A second, but related, challenge for financing the blue bioeconomy is the lack of dedicated investment funds and related mechanisms that are available for this sector. This challenge has been identified by a number of recent studies, including the blue economy investment platform study (Acacia, Metis, Panteia, ICF and CASE, 2018) and the study on access to finance in bio-based industries and the blue economy by the EIB (InnovFin, 2017).

There are clear signs of interest among investors, however, there is a lack of dedicated investment funds and mechanisms to bring investors together with projects and businesses. Both of these gaps have been documented in the blue economy investment platform study. The EU's Annual Economic Report on the Blue Economy 2018 highlights that investment capital is available for blue biotechnology but that this is scattered across various sources (EC, 2018). The study on the need for a blue economy investment platform offers several alternative structures for funds that would operate with support from the European Commission (either directly or indirectly), for the blue economy, including the possibility of a dedicated fund focused on the blue bioeconomy sub-theme (Acacia, Metis, Panteia, ICF and CASE, 2018). In several interviews (e.g. with D-Factory, Sea4Us, KeyNatura, Genis, Microsynbiotix) the specific need to include budget for pharmaceutical/clinical trials was indicated.

The blue economy investment platform study already identified the need for associated structures which would address gaps in technical understanding and expertise and provide a matchmaking structure. Technical assistance would help companies seeking financing by supporting them in preparing investment cases. There is also the need for improved understanding among fund managers of technologies, market potential and possible risks, enabling improved assessment of risk-reward opportunities.

The need for such technical support for blue bio companies was highlighted in working group discussions and surveys. Promising proposals for investors need to address the 10+2 timeframe common in private equity and venture capital. This timeframe consists of an investment cost period of 5 years followed by 5 years of monetising the new technology before moving into profit generation. If a company has a longer term horizon, due for example to longer time needed to develop technology, then financing structures are needed that provide investors with possible exit opportunities. The challenge posed by longer-term investment periods was highlighted among companies responding to the surveys. The lack of technical assistance and matchmaking structures restricts many companies from addressing these needs and accessing more finance. Another consequence is that potential investors are obligated to support these activities themselves. While some individuals involved with particular projects have indicated that they are personally willing, they indicate that more investment could be channelled to the sector if these services were being publicly supported.

Text box 12 - *BlueInvest platform.*

In 2018, DG MARE commissioned a study to support the development of a blue economy investment platform (Acacia, Metis, Panteia, ICF and CASE, 2018). This resulted in a range of options for investment fund(s), supported by the EC and/or the EIB, to address financing needs in the blue economy, including direct, indirect and co-direct investment structures. This has led to the establishment of the BlueInvest platform (www.blue-invest.eu), which will provide assistance to selected SMEs through coaching packages tailored specifically to each business's readiness levels and business objectives. The platform also supports the European Maritime Fisheries Fund (EMFF) in its calls for proposals from market- and investment-ready SMEs to develop innovative services and technologies. In addition, there are plans to launch a dedicated investment fund.

Human resource needs (skills and qualifications) in the blue bioeconomy sector.

The European labour market is facing a shortage of specialised and technical skills in Science, Technology, Engineering and Maths (STEM) and also challenges due to the changing dynamics brought about by technological change. As a relatively new sector driven by breakthroughs in scientific research, notably marine biology and related innovation, the blue bioeconomy is confronted such challenges. Much activity in the blue bioeconomy is now at the stage of transferring research to commercialisation and gradually to viable businesses that may be upscaled.

The skills required for success become more complex with each phase of product development. Whereas in initial phases, specialised technical skills are needed, latter phases also demand business skills. In a recent (2018) study on the impact of game-changing technologies on work in manufacturing, the essential multidisciplinary skills required for innovation were identified for five different technologies, including industrial biotechnology:[4]

- Management positions requiring more advanced technical skills;
- Technical experts requiring more non-technical skills;
- Specialised positions combining two or more types of technical expertise.

The scarcity of these skills forms a bottleneck for innovation and the development of the blue bioeconomy.

As the blue bioeconomy is not based around one of two technical innovations but rather a wide range of fields, finding the right combination of expertise (marine biology and engineering for example) is a challenge. For example KeyNatura or Swedish Algae Factory who make, respectively, food supplements and ingredients for cosmetics from algal biomass, indicate that they are looking for highly skilled personal in all kind of disciplines, which is hard to find. Within the current market, there appears to be sufficient inflow of students within the relevant fields, however, these cannot be met by current academic offers. Members of the working group indicate that these mismatches are substantial emphasising the need for closer collaboration among different stakeholders. One response to this situation for example has been the creation of a EU-supported Blue Biotechnology Master for a Blue Career (BBMBC)[5].

The need for these specific specialisations does not merely rest at academic level; feedback from the sector also indicates that the combination of skills and expertise required for the maritime sector is not sufficiently available at the level of vocational education.

Technical experts with a successfully developed product require more non-technical entrepreneurial skills to turn the product into a viable business.[6] It is often the technical experts themselves who have to turn the product into a successful business, and therefore require business skills (marketing, sales, management, finance and accounting, etc.) or soft skills required to manage a team (communication, team work, etc.). These profiles are referred to as 'T-shaped professionals' ('depth of technical knowledge' is the vertical stroke of the T and the 'breadth of expertise' using soft skills is the horizontal stroke of the T).[7] Members in the working group have identified this to currently be a major challenge.

[4] https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/fomeef18001en.pdf
[5] https://www.bbmbc.eu
[6] https://www.researchgate.net/publication/305654195_New_Skills_for_Entrepreneurial_Researchers
[7] https://www.digitalsme.eu/digital/uploads/March-2019_Skills-for-SMEs_Interim_Report_final-version.pdf

Text box 13 - *Baltic Blue Biotechnology Alliance – incubator approach.*

The Baltic Blue Biotechnology Alliance of the Submariner Network provides a possible solution to this issue with a biopark function and incubator approach. The network supports technically and financially research groups and start-ups to develop technologies to the next level.

The Alliance has a rolling call for submission of ideas, with deadlines for review and evaluation twice a year (spring & autumn). The most promising applications are invited to pitch their idea to an international expert panel and receive feedback on the feasibility of their idea.

Promising ideas can join its mentoring programme in which mentors and case owners work together to determine and formulate the specific needs of the case:

- *What is currently missing to bring this idea closer to the market?*
- *What are the case owner's specific request: A biomaterial or compound? Access to laboratories? Support and expertise in business planning? Something else?*

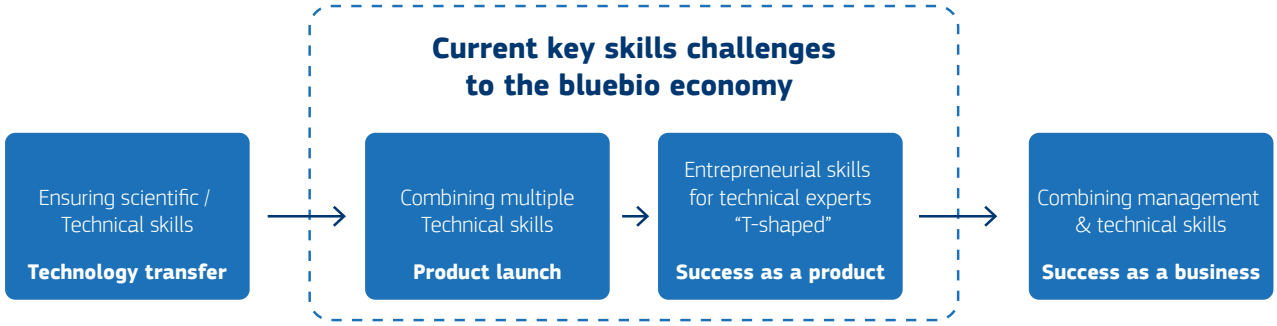
The Alliance is gaining experience and formulating a service offer that will function in a self-sustaining network beyond 2019.

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

Once investors have been attracted and the success of a product has been established, the financing can then allow for a manager to be hired from a business perspective. Multidisciplinary skills are again essential, with managers needing to understand sufficient levels of the technical process to lead the business successfully.

The figure below demonstrates the different needs and skills challenges depending on the phases of the business.

Figure 4 -*Skills challenges for innovation: state of play in the blue bio economy.*



Source: *Technopolis 2019*

Through the New Skills Agenda for Europe (in place as of 2016), the EU acknowledges the need for initiatives to overcome the shortage of appropriately qualified staff in Europe. In addition, national, regional and sector initiatives are in place and aim to boost the labour market across the Member States. These initiatives are aimed at a) retraining and up-skilling the current labour force and b) enabling the system to better prepare the future labour force. These efforts are often aimed at STEM professionals and provide opportunities for the blue bioeconomy to be implicated and ensure that they are developed with the needs of the sector in mind.

Consumers and value chains

The development of the blue bioeconomy sector highly depends on entrepreneurial activities in relation to both existing value chains and consumer acceptance of novel products. Five key challenges that inhibit dynamic development of entrepreneurship in the blue bioeconomy were identified.

Lack of consumer acceptance of 'blue' products.

Consumers' perceptions of non-fish products that originate from aquatic and marine environments are largely unknown. Knowledge about application, use, qualities, benefits and potential of marine bio-based products is still limited. Furthermore, ongoing debates about supposed utility and functionality of bio-based products from aquatic and marine environments are not contributing to favourable consumer perceptions. Some BBF respondents argue that therefore the consumer demand for aquatic bio-based materials and products is lower in Europe than, for example, in Asia.

Entrepreneurs within the blue bioeconomy sector are struggling to position and sell their product on the market and are therefore looking for effective marketing techniques. Large companies are looked at to act as market leaders in promoting blue products. As an example in the blue bioeconomy sector, several large cosmetics companies are developing stories on how 'blue' products are natural, water-based products with exceptional health qualities.

The small companies can either develop products for the same target group as limited editions of large brands or choose an alternative clientele for which the existing key messages will be adjusted. In the latter case, the marketing of novel products requires investment, which for the case of many European SMEs is a significant obstacle.

Text box 14 – *Collective branding in Europe.*

In Ireland, Spain, United Kingdom and France, collective branding by a group of producers is currently the favoured marketing tool for businesses selling to consumers in the case of fresh or little processed fisheries and aquaculture products in Europe, with several hundred labels existing. All collective brands dedicated to aquatic products, promote a higher quality based on a combination of attributes; such as rigorous production practices, particular fishing technique, particular area of production, or even country of production.

Source: *FAO. (2014). Globefish research programme: the European market for mussels. Available at: http://www.fao.org/3/a-bb218e.pdf*

Text box 15 – *How companies try to change the perception of consumers about seaweed.*

Several manufacturers are trying to upgrade seaweed's status as a covetable food ingredient by incorporating the greens into unexpected products like pasta and marinara sauce.

According to CEO of Algaia, Fabrice Bohin: "The main driver for the increasing interest towards seaweeds is linked to consumer pressure for natural products with a healthy nutritional profile but also the mainstream trend towards sustainability.".

In 2017, food company Univar announced a distribution agreement across Europe for the AlgaVia brand of Whole Algae Ingredients. The product lines include Lipid-Rich Whole Algae and Protein-Rich Whole Algae. Lipid-Rich Whole Algae is available in golden and cream varieties, which can replace eggs and dairy fats in a wide range of applications including bakery, beverages and desserts.

Source: *Blumenfeld, J. (2017). Brands find new flavour opportunities with seaweed. Available at: https://www.newhope.com/food-and-beverage/brands-find-new-flavor-opportunities-seaweed ; Selby, G. (2017). Special Report: Seaweed and Microalgae Driving New Product Development. Available at: https://www.foodingredientsfirst.com/news/special-report-seaweed-and-microalgae-driving-new-product-development.html*

There is a lack of agreement on how 'blue' products should be promoted or advertised and whether there is a need to provide public assistance for raising consumer awareness and acceptance of these products. As mentioned in an interview with Swedish Algae Factory "you have to explain to people that your products are good and needed". Among proponents of public intervention, there is an argument that the immature blue bioeconomy sector needs public support in promoting aquatic/marine-based products. Regional governments are considered to offer most effective and justifiable support to local 'blue' producers.

Marketing experts at the EU level argue that a well-defined labelling system for bio-based products could enhance consumers acceptance (KBBPPS, 2018; OpenBio, 2018; SAPEA, 2017). Discussions on the labelling reveal two divergent views. First, there are too many labels that are either disregarded by consumers or create confusion.

The creation of a new label requires the development of standards and mechanisms of quality control. The second view (pro-label) is that a new label or incorporation of blue products into existing labels, such as “organic”, “eco”, “natural”, “sustainable”, “green+blue”, “bio-based”, would be an effective tool in informing consumers about characteristics of a product and thereby raise consumer acceptance. Another frequent suggestion is origin denomination labelling - “Made in …”. This approach is expected to raise acceptance of local/regional consumers and producers.

In contrast to proponents of public intervention, many actors argue that market forces should take care of promotion, marketing and branding of blue products. Each entrepreneur has the freedom to develop and present a unique product in a market. The additional support from the public cannot be easily justified, it may discourage companies to invest in marketing of their product, mis-allocate resources in the market and it can be of little economic value. More importantly, the lack of agreement on utility and benefits of blue products poses a challenge for correct promotion of these products in public initiatives.

At this point the public intervention discussion has not reached a clear point. To help settle arguments about the benefits of ‘blue’ products a research project that focuses on analysis of qualities and impacts of different products could be useful.

Lack of valorisation of rest raw materials from marine origin materials.

Poor management of seafood resources results in considerable waste at the global level. Estimates of waste produced in fisheries and aquaculture include volumes as high as 130Mt and value-lost of up to EUR € 43 billion (EUMOFA, 2018).

The most pronounced problem is that of fishery wastes, which has become a global concern and which is affected by several biological, technical and operational factors as well as socio-economic drivers. The definition of "fish wastes" includes many fish species or by-catch products having no or low commercial value, undersized or damaged commercial species as well as species of commercial value but not caught in sufficient amounts to warrant sale (Caruso, 2015).

Every year discards from the world's fisheries exceed 20 million tons equivalent to 25% of the total production of marine fishery catch and include “non-target” species, fish processing wastes and by-products. More than 50% of fish tissues including fins, heads, skin and viscera are considered "wastes" (EUMOFA, 2018). However, the use of rest raw materials cannot be governed only by fishery market forces. The EU has launched a joint policy to reduce unwanted by-catches and eliminate discards in European fisheries. However, implementation of the EU Regulation for the reduction of fish wastes is still required[8]. The effective implementation of the discarding and the landing obligation will create a huge volume of rest raw materials that can be re-used in the valorisation market.

Only a small fraction of marine biomass is presently used outside the food and feed sectors. Large amounts of sidestream (skin, bones etc) are thrown away, while they can be high value inputs for many products. For example, shells from the aquaculture industry are widely regarded as a nuisance waste product whereas, as indicated in an interview with Musselfeed, they might be applied as fertilizer or even higher value applications. Indeed, with increased awareness of the need for a circular economy many arguments are put forward for considering shells as a valuable biomaterial that can be reused for both environmental and economic benefit (Morris, Backeljau, & Chapelle, 2019). This need for valorisation of all biomass components is also relevant for other blue bioeconomy biomasses such as seaweed as indicated in an interview with Vetik and Danvos and microalgae in D-Factory.

[8] https://ec.europa.eu/fisheries/cfp/fishing_rules/discards_en

Text box 16 – *Shells from aquaculture: a valuable biomaterial, not a nuisance waste product.*

Shell waste can be a big problem for shellfish producers, sellers and consumers, both practically and financially. Depending on the species, shells can account for up to 75 % of the total organismal weight.

There are a number of implemented and unexploited ways of sustainable use of seashells and mollusc shells as an input in new products and processes. Among the exploited valorisations strategies are:

- *Livestock and hen feed supplement in order to improve the health of livestock.*
- *Use of shells as a soil liming agent.*
- *Using shells for construction incorporated into aggregate and mortar mixes.*
- *Use of mollusc shells as biofiltration medium for treating wastewaters.*
- *De-icing of roads.*
- *Use of mollusc shells as the drainage layer in green roofing structures.*
- *Shells returned to the marine environment are a valuable material within the marine environment that provides a variety of ecosystem services.*

Source: *Morris, Backeljau, & Chapelle (2019)*

One of the causes of the problem, according to the Blue Bioeconomy Forum stakeholders is the dominant perception of marine by-products as a waste. Many consumers and entrepreneurs do not recognise the potential of blue by-products and co-products, assuming that they are of low quality and with questionable effects on health. More research should be conducted to show the usability, value and health benefits of side stream products, thereby assisting in changing the perception.

Furthermore, the development of the market of by-products is rarely considered a viable business idea by current traditional business owners that produce those streams, due to a lack of realisation of their business potential. Many business opportunities are neglected, and entrepreneurs are not aware of effective business models that facilitate collaboration within the 'blue' value chain. The Blue Bioeconomy Forum stakeholders concluded that public assistance is needed for training of entrepreneurs and financing marketing efforts for changing the perception of the value of side stream products.

The geographic scattering of blue bio industries also poses logistical difficulties. The storage facilities and delivery of by-products should be adequate to ensure that by-products do not get spoiled before reaching a producer or a consumer. Public incentives are needed to facilitate investment in logistics facilities.

The Blue Bioeconomy Forum stakeholders recognise a mismatch between several regulations related to production and trade of bio-based products, as well as regulatory restrictions on the use of rest raw material and by-products. Researchers, in particular, admitted that they are discouraged from transforming an idea into a product, due to these barriers. Hence, various stakeholders would welcome the creation of a one-stop-shop where they can obtain (free) advice on regulations in blue bioeconomy sector. In addition, enhanced dialogue is needed among regulatory bodies to ensure complementarity and harmony between regulations. The food regulation authorities are expected to be active in discussion of 'blue' regulations.

To complement this discussion, the EC DG RTD 2016 workshop extensively addressed the fishery by-products as part of the conference FOOD 2030 in 2016 (see box below).

Text box 17 - *Recommendations of the DG RTD workshop.*

Direct financial support actions

- *Develop a roadmap (including a feasibility study) on best (food) use of underused fish biomass, including infrastructure needs.*
- *Use research funds to develop regional pilot plants for proof of concept for fish and for algae food products at semi-industrial scale.*
- *Develop large demonstration or smaller regional bio-refineries for underutilised fish biomass and for microalgae as 'lighthouse' projects to encourage further investment – e.g. using PPP.*

Communication actions

- *Foster and facilitate dialogue between fisheries, scientists, food technologists, health officials and end-users.*
- *Involve industry and scientists in societal debate to raise awareness and promote trust.*
- *Ensure industry and societal involvement in research strategies to provide solutions. use of existing networks (e.g. FARNET Fisheries Local Action Groups).*

Governance actions

- *While maintaining food safety requirements, monitor the impact on availability of marine biomass for human consumption.*
- *Ensure long-term stable regulatory framework that provides a stable operating environment and predictability to facilitate investment in technology and know-how.*
- *Ensure that MS promote aquaculture communication actions that have a clear place in structural funds (EMFF Article 68) and may also include the production, processing and marketing activities along the supply chain.*

Source: *Recommendations from the stakeholder workshop "Aquatic food products and new marine value chains", (EC DG RTD, 2016)*

High costs of blue production

One of the greatest challenges for development of a 'blue' business or commercial project is the relatively high cost of production, as was underlined by our highlighted project Phee, who produce a biocomposite material from dead leaves of seagrass. Marine and aquatic-based biomass often requires more complex production processes compared to other industries, leading to storage and transportation challenges. The extraction of salt, carbon and water, the maintenance of light intensity, temperature, pH levels, quantity and quality of nutrients, sterilisation and filtration of the biomass or water treatments are among few processes that need to be considered in production of blue biomass (FAO, 2017).

Processing of biomass typically includes several stages with high production costs: energy-intensive process of drying the biomass, fractioning for extraction of needed components, and the use of photobioreactors. The current lack of biorefineries and costs of other production/research facilities at sea is one of the critical challenges for timely processing of biomass and for decrease of transportation costs. Favourable production locations that have appropriate infrastructure for logistics and transportation of biomass are an essential factor for energy efficiency, cost-effective production and research (Slegers, 2014). Hence, experts suggest building clusters, concentrating production and reducing costs for many entrepreneurs. Among other potential solutions is more cooperation among producers in sharing of facilities and technologies.

Text box 18 - *Costs of spirulina production.*

Spirulina grows well in sunny, warm alkaline waters and can be continuously cultivated outdoors. Photobioreactors, tube, plate and tank systems have been developed to grow algae in closed systems in colder climates, to prevent contamination, or grow higher value algae that require more cultivation control. Photobioreactors and closed systems have been considered too costly, not competitive and are not generally used for commercial spirulina production. To lower costs, future farms need to integrate nutrient resources, refine production systems and produce a variety of end products, from valuable extracts to inexpensive protein.

Many French spirulina micro-farmers try to use low-cost technology. Although micro-farms may not enjoy the same production cost savings as large-scale production, they can make up the difference by selling directly to local clients. A commercial farm producing finished products gets about 35 % of the retail price, 65 % going to distributors, wholesalers and retailers. A micro-farmer, selling directly to the local community can capture up to 100 % of the value chain.

Source: *Henrikson, R. (2011). Development of a Spirulina Industry – Production. Available at: http://www.algaeindustrymagazine.com/special-report-spirulina-part-5-development-of-a-spirulina-industry-production/*

The scale of production is critical for determining the size of fixed and variable costs. Large scale of production leads to smaller costs per unit. This suggests a limited potential for small and medium-size enterprise (SME) with 'blue' profile unless assistance is available to cope with high costs or investment for scaling up the production. Participants in the Blue Bioeconomy Forum suggested non-monetary instruments that could assist 'blue' SMEs, including business advisory support for scaling up production and diversification of portfolio, and assistance in accessing available financial support from the regional, national or EC programmes.

One of the mechanisms to provide a balanced support for organisations that develop products with different levels of added value is to partially cover R&D costs. The unpredictable duration, success and expenses of, for example, clinical trials for pharmaceutical products are major risk factors and disincentives to explore business opportunities. A policy instrument that could decrease costs of clinical trials, assist in critical research areas of the blue sector (e.g. development of compounds for biomass drying or salt extraction) and stimulate research/product development could be effective at these starting stages of the blue sector.

Discussions on coping with high costs of production revealed that producers have to optimise the productivity of the biomass and the cost-effectiveness of the entire cycle of processing. This implies that producers have to monetise all components that were extracted and fractioned from the biomass. To do this, it is necessary to stimulate development of the market of by-products for increase of business-to-business sales.

Difficulty in stable production of aquatic or marine biomass due to seasonality.

Seasonality is an important issue in aquaculture and in fishing, as it often cannot be controlled, except in some cases of shellfish aquaculture where farmers using closed systems can manipulate the temperature and food supply. At the same time some examples of optimisation of technical resources across various activities in various seasons have been demonstrated (see Text box 19 below).

Text box 19 – *Synergies in using offseason fishing boats for seaweed harvesting.*

An example of optimisation of the resources in various seasons comes from the Estonian Fishery and Seaweed Aquaculture company. Estonian seaweed farmers have established cooperation with local fishery companies. They involve fishing boats in harvesting seaweed, which appears to be a good supplementary work for fishermen during the fishing off-season. For example, Tinurek OÜ, whose main activity is fishery, had to install technical adjustment of the equipment used. Such diversification of the fishing boats has been fully economically justified.

Source: *interview with Mariann Nõlvak, Tartu Biotechnology Park*

Seasonality challenges are related to the seaweed aquacultures due to a higher potential for new products and value chains.

Stable value chains based on marine and aquatic biomass require a high and predictable input and biomass productivity combined with a high content of the demanded components, like for instance carbohydrates that can be fermented to biofuel, proteins for fish feed or bioactive compounds that can be used in functional food.

However, the seasonal variation in chemical composition is characteristic for seaweeds and it poses challenges for the manufacturing of product from it. At least one third of the blue bioeconomy stakeholders involved in our survey indicated seasonality as an important challenge in developing their business and research products (BBF survey, 2019).

The comparative analysis of traditional (lignocellulosic) biomass and seaweed biomass shows that variation in composition of seaweed is much more extreme in comparison to the compositions in traditional biomass (ECN, 2013). In general, seawater has the highest nutrients concentrations during the dark season and gets depleted of nutrients during the microalgae blooms in spring. Thus, the seaweeds have developed strategies to fit the seasonal changes in light and nutrients availability (SINTEF, 2014).

While it is difficult to control the quality of the biomass especially in open systems, due to seasonal, as well as other environmental variations, more adaptive approaches in seaweed and algae farming can be promoted. Despite ongoing research projects studying seaweed and algae composition dynamics under various conditions, there are still large knowledge gaps in this area. For instance, a better understanding of seaweed ecophysiology for development of cultivation strategies could ensure predictable yield, composition and quality of biomass.

Another challenge on a more generic level is that the nature of marine and aquaculture assumes specific harvesting seasons which prevents constant input flows for further production. Consultation with experts indicated that seasonality related challenges in seaweed farming can be addressed in ways similar to challenges in

traditional agriculture. Seasonality is addressed by special solutions that allow stabilising, storing, preserving or pre-processing the harvested biomass that allow to maintain the best quality and content and year-through inputs for the further production.

Discussions revealed a strong need to strengthen the scientific knowledge base as the solutions addressing the seasonality challenge will be a result of better understanding of ecophysiology of seaweeds and natural processes, and availability of good quality data. In summary the following action lines have been proposed (by order of importance, according to our respondents):

1. To narrow the existing knowledge gap, to promote and support further scientific research of impact of seasonality on biomass characteristics in various conditions, open sea, open pond and closed aquaculture systems, as well as in multitrophic aquaculture systems, and other conditions;
2. Promotion of research and innovation in monitoring the crops and harvest at the optimum/ the moment on the highest compound;
3. Establish a decision support system e.g. for growing macro algae based on data models. It should be online open platform that can offer e.g. matchmaking and various data. E.g. European Open Data Initiative intends to bring together all R&I produced data;
4. More R&I on qualities of crops and promote cultivation of specific breeds of macro-algae that are less impacted by seasonality;
5. Mobilise and incentivise private and public investment in silos and biorefinery facilities that can stabilise the input into processing industries.

Logistical challenges for biomass processing.

The chain of logistical processes is quite long, as it involves material handling, production, packaging, storage, inventory and transportation. Although logistical challenges can vary for different types of blue product (e.g., seaweed, shellfish), there are some common challenges that are faced by many producers within the blue bioeconomy sector. 35% of Blue Bioeconomy Forum survey respondents face logistical challenges. The technical challenges include complex and expensive operations throughout the entire production cycle, starting from harvesting, processing and ending with transportation and delivery. Most technical challenges are attributed to the specific characteristics of aquatic and marine biomass.

The limited life of some blue biomass and the containment of salt and water are major factors which require fast processing and, consequently, transportation of the biomass. For example, the drying of biomass decreases the weight of the raw material that needs to be handled, thereby affecting the amount of time, human resources, technologies and energy for packaging, storage and transportation (Balan, 2014).

The overall state of the marine ecosystem and climatic conditions in a region have an impact on the amount and quality of biomass. Currently, the lack of access to open data on pollution, quality and temperature of water in seas does not allow 'blue' entrepreneurs to monitor changes in biomass. The seasonality of biomass and its changing characteristics are affecting the scalability of production and the logistical processes. As a result, the logistical costs might vary depending on a harvesting season. Appropriate technologies can optimise the quality of biomass and the logistical operations. However, based on experience of many 'blue' entrepreneurs, such technologies are either not easily available or accessible, due to location and high cost.

The farming, wild harvesting locations and facilities for (pre)processing can be remote or sparsely located. This leads to higher spending on inputs and resources, lower energy efficiency and greater risks of compromise on the quality of biomass (Slegers, 2014). Hence, logistical challenges are not merely related to convenience, but to financial sustainability of companies and to quality of 'blue' products. The co-sharing of bioreactors, biorefineries, silos and other facilities decreases costs on the use of technologies and allows to form clusters of 'blue' companies in those locations.

Based on survey results and discussions with experts, the list of policy-related logistical challenges is dominated by the regulations on waste and the processes for obtaining specific permits. The valorisation of fishing by-catch resources is an important issue for the development of market of such resources and for environmental sustainability. For example, the fishing by-catch can be voluminous and take significant space on the fishing boats. The utilisation and transportation of by-catch creates additional cost for fishers. Such regulation can be considered burdensome, however, in countries where the market of by-products is developed the fisheries are able to reap a profit. In case of Iceland, by-catch finds its market and it is sold for value of 0,5 -1 EUR per kg, depending on the species.

Text box 20 – *The need for a bio-refinery approach for shell waste processing.*

Shrimps and lobsters are among the most popular crustaceans for food consumption. However, the shell waste produced by the seafood industry is a growing problem. The Food and Agriculture Organization estimates that in Europe alone more than 750,000 tons of crustacean shell waste is produced every year.

Besides potentially profiting from selling value-added products, the saving of disposal costs which range from about 60 EUR/t for landfilling to 160 EUR/t for incineration could create an additional boost for the concept, and illegal ocean dumping could be avoided.

The main cost factors identified in the economic process analysis are the stirred tank reactors for the pre-treatment, the Lactobacillus seed, the enzymatic depolymerization, and especially the monomer synthesis. Summarised, the process in not cost-efficient enough.

The pre-treatment of the raw material to yield the chitin is a key step in the process starting from a material with negative to low input price resulting to a significant price of pure chitin/chitosan. This cost structure and the various competing application of chitin/chitosan derivatives require an integrative bio-refinery approach including cost-effective biotechnological pre-treatment as substitute for the harsh conditions and high chemical load in the chemical processing route.

Source: *Rampelotto, P.H. and Trincone, A. (2017). Grand Challenges in marine biotechnology; Gruber, K. (2013). Nylons made from shrimps. Available at: http://www.youris.com/bioeconomy/fisheries/nylons_made_from_shrimps.kl*

Text box 21 – *MODHEAt®, efficient technology for drying of seaweed.*

SFTec is a Finnish startup that aims to generate added value by enabling the efficient reuse of industrial residual resources. It brought to the market MODHEAT®, an industrial drying technology that is efficient, affordable, scalable and mobile and can handle many materials including seaweed. As a partner of the Baltic Blue Biotechnology Alliance network SFTec could test the opportunities offered by the drying technology in the blue bio-economy sector.

Very good results have been obtained from drying seaweed where SFTec managed to convert seaweed into biogas and use this energy to dry other seaweed/ macro-algae on the location closeby the harvesting. This technology can help to avoid the deterioration of the raw material and reduce its weight before it is transported to processing facilities.

Source: *Submariner Network, Baltic Blue Biotechnology Alliance*

Text box 22 – *Geothermal energy for drying seaweed.*

Geothermal energy has been used in Iceland for many purposes including drying seaweed. The seaweed manufacturer Thorverk uses geothermal heat directly in its production. The company harvests seaweed found in the waters of northwest Iceland using specially designed harvester crafts. Once landed, the seaweed is chopped and dried on a band dryer that uses large quantities of clean, dry air heated to 85°C by geothermal water in heat exchangers. The plant has been in operation since 1976, and produces between 2,000 and 4,000 tons of rockweed and kelp meal. The product has been certified as organic. The plant's annual use of geothermal energy is about 150 TJ.

Source: *Orkustofnun - National Energy Authority of Iceland*

Science, technology and innovation

The development of the blue bioeconomy is based on scientific, technological, research and innovation developments. There are four key challenges that need to be addressed in order to unlock the potential of the sector.

Although the research community and industrial players already cooperate in several ways, there is an acute need to improve how these collaborations are established and sustained, as discussed in each of the sub-sections below.

Dialogue and sustainable cooperation between researchers and industry

Significant progress has been made over the past decade in building a community to support research and innovation in marine biotechnology in Europe. Nonetheless, mechanisms are still required to support industry-academic collaboration on business and market development (Hurst, Børresen, Almesjö, De Raedemaecker, & Bergseth, 2016).

Public funding for collaboration between researchers and industries has helped. However, increased research funding requests from industry does not necessarily mean common goals and understanding between researchers and businesses.

The BBF survey shows that most researchers already collaborate with the industry sector, while about half of the surveyed companies collaborate with research organisations. The most common types of collaboration consist of joint research projects and fixed collaboration in a consortium. There are also occasional exchanges of ideas between these two types of stakeholders and some joint uses of facilities. Other forms of collaboration are reflected in activities such as: commercialisation; technical and business support; spin-offs and rendering services coming from the researchers, and; providing services coming from the companies.

The BBF survey further shows that lengthy administrative procedures and difficult access to major funding sources are the main bottlenecks to collaboration between industry and researchers. Start-ups and SME's indicated that access to research grant funding would support collaboration. Publicly funded research should be directed more towards the development of business.

The motivations and constraints are different between among academia and industry. Industry could identify, through careful analysis of the value chain and technology development, where increased collaboration with researchers would help generate new market solutions.

For academia, the Blue Bioeconomy Forum emphasises the importance of shifting the mindset of researchers. This can be promoted by integrating in academic training the skills needed by researchers to turn their discoveries into applicable solutions. This would also help address questions of uncertainty concerning the cost of development of products, and resource availability.

High costs of exploration in the marine environment

The provision of a pipeline of new organisms to screen for novel compounds is an essential support for future innovation. (Hurst, Børresen, Almesjö, De Raedemaecker, & Bergseth, 2016). Researchers expect that many species remain to be discovered in the marine environment, with its high biodiversity and also the effects of seasonality and geography on species composition and morphology. Recent projects and trials have been conducted, for instance within the framework of MBT-ERA NET.[9]

The high cost of exploration activities means that innovations are mostly in the pre-competitive or in a commercial domain. Funding generally focuses on either fundamental research or the potential of functional components with high-end market applications. The ERA-MBT Marine Biotechnology Strategic Research and Innovation Roadmap[10] prioritises exploring targeted environments and hotspots; developing next generation sampling methods; and developing novel methods for the taxonomic, chemical, and biochemical evaluation of marine species as sources of bioactive compounds. This focus would help lower costs of exploration and screening (Hurst, Børresen, Almesjö, De Raedemaecker, & Bergseth, 2016). The activities of Sea4Us, who explore the potential of invertebrates to cure chronic pain, is an example of such a challenge.

More collaboration is also needed. Optimisation of multi-purpose screening on hotspots or sampling programs could lower costs and foster more synchronised utilisation of research activities.

Other challenges include keeping growth in production within sustainability limits. There are considerable coastal areas where production could increase (Gentry, et al., 2017). The EC has suggested that production could increase up to 2-fold of current levels (European Commission, 2017). This will likely be achieved by improvements in efficiency in aquaculture practices. New production areas, including further offshore, have yet to be considered.

[9] http://www.marinebiotech.eu/marine-biotechnology-era-net

[10] http://www.marinebiotech.eu/launch-marine-biotechnology-research-and-innovation-roadmap

New insights and ideas to improve aquaculture are required, for instance on the use of offshore, agriculture, greenhouse cultivation and forestry technologies. Devices such as ROV (remotely operated vehicles) can support expanded exploration in areas of high marine biodiversity. Both the exploration as well as exploitation phases will benefit from techniques such as remote sensing, geoinformatics, remote monitoring tools, high-end food and production tools.

Data-driven technologies are key. Monitoring, automation, and analysis through digitalisation have the potential to transform the aquaculture industry. Clean water is always needed, and improved recirculation technologies will further advance the industry.

The focal point for Ocean Monitoring and Surveillance is developing a framework for "A comprehensive ocean observing system (polar, bio, eco, BGC, eDNA, deep ocean, +)" with the focus on understanding the marine ecosystem. The ambitions may well be combined with the exploration potential for biochemical discovery programmes.

The well-managed and controlled culture of marine biomass needs to be further developed as sustainable sources of biomass in parallel with the development of sustainable harvesting of marine species from the wild. Biomass processing generally involves several intermediary steps from harvesting to end use. Circular agriculture may well provide examples for developing marine value chains (Scholten, 2019).

Priorities for the developing marine biomass production include:

- Reducing the complexity of the supply chain by integrating biomass production and refining, reducing energy demand and waste in processing marine biomass.
- Removing bottlenecks in marine biomass transformation and conversion by identifying novel processes and marine enzymes that can modify biomass, tailor its chemical and biological properties and reduce the energy demand of transformation.
- Engaging in research to support the expansion of cultured biomass production including measures to minimise and mitigate environmental impacts; addressing waste management; enhance biosecurity and the introduction of new production systems and expand the use of molecular methods.
- Harnessing knowledge and expertise from other sectors of the bioeconomy to support the rapid development of pilot scale equipment and scale up of marine biomass refining.

Lack, underuse and geographical distribution of research infrastructure.

Dedicated research tools and facilities to fully exploit marine biological resources are needed, bridging aquaculture, mariculture, marine biotechnology research and areas of fundamental and applied sciences (Hurst, Børresen, Almesjö, De Raedemaecker, & Bergseth, 2016). The most urgent need is to support the demonstration plant phase (TRL 6-7) and the upscaling to flagship/first-of-a-kind (TRL 8) (Hurst, Børresen, Almesjö, De Raedemaecker, & Bergseth, 2016) (Enzing, C., Ploeg, M., Barbosa, M. Sijtsma, L., 2014).

There are four groups of challenges concerning research infrastructure:

(1) **Lack of infrastructure for testing the scalability of technologies.** Start-ups and industry need access to versatile and flexible pilot plants and demo-facilities which can run pilot, pre-market scale-up projects at an acceptable cost. There are examples of companies that decided not to use these facilities for running trials due to high costs. A real constraint is the lack of support for operational expenses. Furthermore, facilities risk being under-used if they are not involved in several projects.

(2) **Underuse of research infrastructures in higher TRL levels.** The costs of using research infrastructure is also a constraint for projects attempting to scale up from lab to pilot, and further from pilot to full scale. As a result, facilities are underused; 30% of surveyed participants indicated that research infrastructure is insufficiently used (for all TRL levels).

(3) **Uneven geographical distribution of research infrastructures.** While some regions generally having sufficient research infrastructure, others lack access. This results in missed opportunities, for example in inland regions with potential for aquatic non-marine production.

Information provision can help tackle these three challenges. Examples include:

- "Pilots4U" set up an easily accessible database of open access pilot and demonstration infrastructure for the European bio-economy[11].
- The European Marine Observation and Data Network (EMODnet) displays to European infrastructure facilities in EU waters[12].
- European Marine Biological Resource Centre (EMBRIC).
- The Marine Research Infrastructure Database, developed by EurOcean.

[11] See: https://www.biopilots4u.eu
[12] See: http://www.emodnet-humanactivities.eu

Text box 23 - *European Centre for Information on Marine Science and Technology (EurOcean).*

The European Centre for Information on Marine Science and Technology (EurOcean) was established in 2002. The members of this independent scientific non-governmental organization comprise leading European marine research, funding and outreach organisations. The aim of EurOcean is to facilitate information exchange and generate value-added products in the field of marine sciences and technologies between a wide range of governmental and non-governmental actors.

The members of EurOcean developed a dedicated platform that provides a comprehensive list of all existing facilities in Europe that are dedicated to marine sciences, covering a broad range of activities.

The information available about the infrastructures includes technical characteristics, services offered by the operator, availability and contact points.

This database is intended for all stakeholders - scientists, engineers, policy makers, private companies, universities -. An iterative map with search criteria allows search of information on discipline, operating areas and related projects.

Source: *eurocean.org*

(4) **Lack of qualified human resources.** The long-term sustainability of research infrastructures is closely linked to the availability of qualified personnel, particularly engineers. Such qualified personnel are typically given project-based short-term contracts. Interviews with companies revealed that engineers have more career opportunities in traditional areas, as compared to the blue bioeconomy.

Lack of access to data and research results

Research results, including basic data are often not freely available, even when publicly funded. Academics tend to publish results, with data available either for free or at a cost. For industry the tendency is to protect and not disclose results and data, as these might yield competitive advantage. Strengthening long term collaboration between academics and industry could help to increase incentives for sharing.

Furthermore, there is no easily accessible database that centralizes available data, meaning that retrieval can be costly and time consuming. Available data sources and portals therefore need to be combined and streamlined. For example, ERA-MBT has created an open access portal to exchange information and data, though so far only limited research results are available[13]. In this regard, the EC also launched the EOSC (European Open Science Cloud) for all scientific content (publications, data, software).

Text box 24 - *European Open Science Cloud (EOSC).*

The EOSC will allow for universal access to data and a new level playing field for EU researchers. A pan-European federation of data infrastructures will be built around a federating core, providing access to a wide range of publicly funded services supplied at national, regional and institutional levels, and to complementary commercial services. EOSC has 6 lines of action: (1) ***Architecture*** *of the federated infrastructures as the solution to the current fragmentation in research data infrastructures which are insufficiently interoperable. (2) FAIR* ***data*** *management and tools. A common data language to ensure data stewardship across borders/disciplines based on FAIR principles (guiding principles in order to make data* ***f****indable,* ***a****ccessible,* ***i****nteroperable and* ***r****eusable (Wilkinson, et al., 2016)). (3) Available* ***services*** *from a user perspective. A rich environment offering a wide range of services covering the needs of the users. (4) Mechanisms/****interfaces*** *for accessing EOSC. A simple way for dealing with* ***open data*** *obligations or accessing research data across different disciplines.*
(5) ***Rules*** *of participation for different EOSC actors. An opportunity to comply with existing legal and technical frameworks and increase legal certainty & trust. (6)* ***Governance*** *of the EOSC, aiming at ensuring EU leadership in data-driven science but requiring new governance frameworks.*

Source: *EOSC Strategy Implementation Roadmap (2018)*

[13] http://www.marinebiotech.eu/resources

Almost all survey respondents indicated their willingness to share their data and results in an open science cloud. However, some respondents would expect financial compensation for the time needed to prepare and summarise their data. Some also want assurances that they will not be legally responsible for the data, as well as wanting to be acknowledged and informed about use of their data. At the same time, it is important to note that data for patents cannot be published before the patent has been granted. Furthermore, the publication of negative results is an important item to consider.

The principles enshrined in the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation (ABS) to the Convention on Biological Diversity could guide efforts to establish an open science cloud for the blue bioeconomy.[14] The Nagoya Protocol provides a transparent legal framework for the effective implementation of the Convention.

[14] https://www.cbd.int/abs/about

SOLUTIONS

This section provides suggested ways forward in response to the challenges identified during the Roadmap process. The recommendations are examined per challenge, but are also indicated when measures have a cross-cutting effect.

Each way forward gives an indicative timeframe for its implementation. We differentiate:

- Short term actions (2020): These are both actions that have a priority and that realistically can start being implemented "tomorrow".
- Medium term actions (2021-2025): These actions require more time and preparation in order to be launched by the implementing bodies.
- Long-term actions (2025+): These actions are necessary but complex to be achieved, they require that prior actions take place and are fully implemented.

Each way forward also shows which specific actions are required/expected per stakeholder. For the purposes of the Roadmap, we differentiate four main stakeholders:

- European Commission
- National and/or regional bodies
- Industrial players
- Research community

Although not specifically addressed in the ways forward, citizens and civil society organisations should in general be informed and consulted where developments in the blue bioeconomy touch their daily activities.

Simplify license and permit applications

A range of challenges for activities in the blue bioeconomy lies in the legal realm. There are a number of issues here - not only the definitions, rules, governance and activities are currently unclear but there is also a question as which policy field a business could fall in: fishery, aquaculture, marine agronomy, agriculture, bioindustries are all logical candidates but separately do not sufficiently cover the activities.

The Blue Bioeconomy Forum recommends to:

- Harmonise regulatory and legislative requirements, both between member states and within member states.
- Improve clarity about blue bioeconomy business activities through establishing and adopting formal standards as promoted by standardisation bodies, while some issues will remain of a more political nature.
- Provide clarity on the status of underutilised marine biomass, which strongly links to identifying opportunities on the production side.
- For businesses operating in the blue bioeconomy, create or support one-stop-shops as a way of reducing the burden of operating in this new and upcoming sector: these would provide (paid or free) support to businesses.
- In the medium term, multi-use of scarce marine space should be facilitated by member states, who can be helped by European Commission consistent guidelines.

Licences and Permits

2020. Harmonise regulatory and legislative requirements

European Commission
Encourage harmonisation between different levels of governance (EU, national and local) and the various legislative instruments (policy, regulation, plans) on food, feed ingredients, and waste to create a level playing field among member states.

National and local authorities
Set up inter-ministerial / sectoral committees in member states with representatives of all blue sectors to ensure cooperation between regulators, policy makers and administrations at different levels.

Allow for experimentation in legally poorly defined sectors.

2020. Improve clarity about activities through the establishment and adoption of standards

European Commission
Support the further definition of formal standards to allow for clear definition of activities and statistical tractability.

National and local authorities
Support the adoption of newly defined standards by local companies, improve understanding of local authorities.

Industrial players
Lead in definition of formal standards and adopting them.

Research community
Contribute to defining formal standards.

2020. Provide clarity on the status of underutilised marine biomass

European Commission
Facilitate dialogue among EU regulatory bodies and other stakeholders on food, feed ingredients and waste.

Link biomass utilisation to circular economy policy developments.

Clearly define that underutilised marine biomass is NOT waste and is allowed to be used for several applications.

National and local authorities
Update new definitions of waste not including underutilised marine biomass in order to allow for further valorisation.

Industrial players
Demonstrate how value (including nutritional) can be created from underutilised marine biomass.

2020. Create one-stop-shops where businesses can obtain (free) advice on regulations in blue bioeconomy sector and product requirements

European Commission
Monitor and provide information on national/regional one-stop-shop developments.

National and local authorities
Define one-stop-shop service terms of reference and launch a service request. Provide funding.

2021-2025. Work towards the harmonisation of marine spatial planning and multi-use

European Commission
Facilitate the preparation of consistent guidelines for multi-use.

National and local authorities
Identify cases in which wider societal benefits outweigh benefits to single users. Provide space / multi-use options for blue bioeconomy activities in marine spatial planning and promote multi-use.

Research community
Research multi-use benefits and effects.

Offer clarity and support for novel food and new feed applications

Novel food is an opportunity to commercialise high-value products. Some of these opportunities are barred by (perceived) difficulties in the Novel Food Regulation. Offering clarity and support may help the blue bioeconomy to scale up in this particular sector. Effective implementation of the regulation is important to protect EU citizen's health, but also to protect the sector from unfair competition.

The Blue Bioeconomy Forum recommends to:

- Make the Novel Food authorisation more affordable by funding the analytical procedures for providing the safety information for each product. These procedures are the most expensive part of a novel food dossier. They would fall into public domain, and companies would be able to use them to prepare their further dossiers.
- Ensure the accuracy and consistency of the Novel Food list, in order to improve transparency. Notably industry and researchers should be able to inform public authorities when they notice an error or a missing information.
- Further support novel food applicants, especially SMEs, to navigate the procedure. Support would for example take the form of efficient communication pathways, and consistent information at EU and National level.

On feed applications per se, the BBF has not found major unclarities. Producers may follow different strategies for getting new sources approved. In some cases there were inappropriate restrictions, but further investigation is necessary to find out whether this constitutes a significant problem.

2020. Conduct the necessary studies for the authorisation of more types of biomass

European Commission
Fund safety information research for public domain use so that initial costs can be lower.

Industrial players
Share costs for collective action in conducting tests for market approval.

2020. Ensure the accuracy and consistency of the EU novel food list

European Commission
Include all information available on authorised novel foods. Ensure that any error can be reported and corrected to improve accuracy

National and local authorities
Provide information on which foods are authorised at national level and thus can be included in the regular food list (not constituting a novel food).

Industrial players / Research community
Report missing elements on the novel food list.

2021-2025. Provide necessary support to novel food applicants

European Commission
Make sure that EFSA new SME communication pathway is successful to support SME novel food initiatives.

National and local authorities
Member states continue to provide information to applicants in the first stages of the procedure, according to the new regulation.

Valorise ecosystem services

A number of blue bioeconomy activities can provide ecosystem services, that could be valorised as instruments to achieve EU environmental targets.

The Blue Bioeconomy Forum recommends to:

- Take stock of past and current projects in the sector and focus on the innovation of valorising ecosystem services, with the EC providing the role of a knowledge hub.
- Define the interplay between different types of ecosystem services.
- Improve knowledge of the dynamics of costs for nutrient removal (using different species) compared to the marginal costs for nutrient removal of land-based sources. The nitrogen reduction required to achieve good ecological status in different locations should be further explored. Explore the cumulative effect of closely located projects supporting ecosystem services
- Secure high-level support for payments for ecosystem services and create cohesion between the Common Agricultural Policy (CAP) and the Common Fisheries Policy (CFP). The development of payment systems for ecosystem services is the main pre-condition for scaling up of ecosystem services. Despite the complexity of the issue, EU and national policy makers need to consider different financial models. In order for this to happen governments and the European Commission need to begin by acknowledging mussel farming as a legitimate nutrient removal measure, as this is the service which is in the most advanced stage of development.
- Define and implement an EU strategy for an institutional framework for ecosystem services across European sea basins. This strategy should ensure common monitoring of results, involvement of all actors, coherence between sea- and land-based policies (especially at the EU level), long-term funding mechanisms and implementation targets. Payment of ecosystem services is closely related to precise measuring therefore improving the valuation of ecosystem services and measuring their impact on the marine environment should be intensified.
- Ensure that ecosystem valuation studies become an integral part in decision models for specific marine management decisions (e.g. in Marine Spatial Planning, Coastal Zone Management).
- Study and incorporate marine ecosystem services into macro-regional strategies, projects and initiatives. Many of the ecosystem service issues and challenges are specific to different sea basins.

2020. Take stock of ecosystem services pilots and support their deployment

European Commission
Support further funding and deployment of successful pilots. Ensure common indicators and monitoring. Set up knowledge hub.

National and local authorities
Include ESS (ecosystem services) in MSP (marine spatial planning), set up funding system.

Industrial players
Provide information on ecosystem services examples

Research Community
Review results of pilots. Develop monitoring. Improve knowledge of the dynamics of costs for nutrient removal.

2020. Secure high-level support for payments for ecosystem services and create cohesion between Common Agriculture and Common Fisheries Policies

European Commission
Introduce links between funding point source measures within Common Agricultural Policy and mitigation measures within Common Fisheries Policy. Ensure that both policies are coherent.

Integrate valorisation and payment schemes for ecosystem services provided by blue biomass production e.g. mitigation crops in EU agriculture support actions to improve marine water quality.

National and local authorities
Set up funding mechanism at the national level to support the continuation of local projects beyond EU funding. Enhance policy cohesion between land and sea-based programmes

2021-2025. EU strategy for an institutional framework for ecosystem services across European sea basins

European Commission
Supervise the set-up of the strategy and action plan for ecosystem services.

National and local authorities
Define and implement the strategy.

2021-2025. Incorporate marine ecosystem services into macro-regional strategies, projects and initiatives

National and local authorities
Incorporate ecosystem services in local policies. Coordinate with neighbours at sea basin level.

2021-2025. Ensure that ecosystem valuation studies become an integral part in decision models for specific marine management decisions

European Commission
Support the development of guidelines to include ecosystem valuation studies in decision models.

National and local authorities
Incorporate ecosystem valuation studies in decision making process for e.g. Maritime Spatial Planning, Coastal Zone Management.

Increase understanding of investment landscape for projects and businesses

Financing is required for start-ups and small businesses in the blue bioeconomy when moving through the different phases of technology development and commercialisation of the business. Many businesses do not have this expertise in-house, and it is recommended that financial planning & resources are brought in at the appropriate time. The European Commission has established in 2019 a BlueInvest platform to support investment readiness and access to finance for early-stage businesses, SMEs and scale-ups in the blue economy. BlueInvest will offer an exclusive coaching programme for high potential start-ups and SMEs with innovative and sustainable products and solutions for the blue economy. Businesses and projects selected for Investment Readiness Assistance under BlueInvest will receive coaching packages tailored specifically to their readiness levels and business objectives.

The Blue Bioeconomy Forum recommends that the European Commission moves forward with the implementation of BlueInvest. For relevant regions, national and local authorities should support advisory platforms or innovation hubs that are more locally targeted.

2020. Provide blue bioeconomy start-ups with advice on business and financing

European Commission
Continue BlueInvest activities. Support advisory platforms.

National and local authorities
Establish and support advisory platforms at national or regional scale.

Industrial players
Engage financial experts in partnership on advisory role.

Promote uptake of existing funding mechanism and set up new ones to support projects and start-ups

Investments in the blue bioeconomy will require significant amounts of capital from diverse sources and a strong involvement of both private and public stakeholders.

To address the lack of financing for blue bioeconomy start-ups and SMEs, the Blue Bioeconomy Forum recommends to

- Establish dedicated investment funds, including through the new BlueInvest platform, and also through contributions and possibly a matching fund mechanism from national, regional and local authorities.
- Create separate national and regional funds, more tailored to local circumstances and engaging local actors and authorities.
- Promote blended finance models, for example, by providing opportunities for investment management companies to participate as investing partners in such funds and mechanisms.
- Engage with research community to develop better area-specific risk assessment models, which can improve the sophistication and reliability of risk-return analyses for blue bioeconomy investment proposals.
- Develop, over the longer term, policy instruments, such as technology subsidies or partnership initiatives, to partially offset high production costs. This is particularly important for sub-sectors offering social and environmental benefits, including ecosystem services. Other stakeholders should engage with discussions on the design of the most appropriate supporting policy instruments.

2020. Establish investment funds for blue bioeconomy.

European Commission
Focus on creating an accessible market with right framework conditions.

National and local authorities
Consider financial support to BlueInvest, establishing matching fund mechanism, and possibly separate national and regional funds.

Industrial players
Finance companies consider active role and investment in BlueInvest, or national funds.

Research community
Provide area-specific risk assessment models.

2021-2025. Provide additional support to SMEs in the blue bioeconomy sector

European Commission
Design a policy instrument to partially cover high production costs in blue SMEs (e.g., technology subsidy).
Stimulate collaboration between national / regional governments and industrial players.

National and local authorities
Discuss with the European Commission and the industrial players the most effective policy instruments to support SMEs.

Industrial players
Discuss with the European Commission and the national / regional governments the most effective policy instruments to support SMEs.

Ensure availability of skilled and qualified human resources

The skills required for blue bioeconomy business success become more complex with each phase of product development. Whereas in initial phases the needs are for specialised technical skills, in latter phases, these are expanded to include specific types of business skills. Members of the investment community active in the blue bioeconomy have remarked that entrepreneurs and project leaders often lack necessary business skills for growing a small startup or business. The lack of multidisciplinary skills can constitute a bottleneck to innovation. Therefore, the Blue Bioeconomy Forum suggests further supporting the development and training of the next generation of skilled entrepreneurs (including technical and basic business skills) along the lines of the EMFF Blue Careers, BBMBC, and Blue Labs initiatives. In that sense, relevant authorities should be encouraged to implement scholarship schemes and training programmes that address the mix of skills needs that the blue bioeconomy sector requires, in particular: marketing, sales, management, finance, accounting.

2020. Upcoming sectors and start-ups require more flexible skilled people (including basic business skills)

European Commission
Explicitly draw attention to the blue bioeconomy skills needs. Support training programmes on marketing, sales, management, finance and accounting, etc.

National and local authorities
Explicitly draw attention to the blue bioeconomy skills needs. Scholarships to work in the blue bioeconomy.

Industrial players
Identify needs for personnel.

Increase consumer awareness and acceptance

The qualities, health benefits, functionalities and utilities of blue biomass/products are still hotly debated. As a result, the type and amount of public support, as well as consumer acceptance of novel products is limited. To raise consumer acceptance of blue products, the value of these products needs to be more widely understood, and reciprocally, producers should recognise concerns among potential consumers (such as price, sustainability, and health benefits).

The Blue Bioeconomy Forum suggests to:

- Undertake a study on the functionalities and application of different types of blue biomass/products, to stimulate research community to publish/disseminate findings on qualities of bio-based products.
- Define a communication strategy that mobilises the right people (including civil society; consumer associations; "ambassadors" of blue biomass products, such as chefs) and emphasises appeal for consumers (such as sustainability of products; origin and traceability) with positive wording.
- Design supportive regional policies for the blue sector, including both "soft" measures (such as assisting local producers with the organisation of local fairs) and interventionist measures (such as fiscal policies to support production at cheaper prices) to stimulate the development of innovative and sustainable products from blue biomass origin.
- Promote collaboration among business, institutions, and environmental organisations to contribute to growth and development of the blue sector regionally and across the EU.

In studies regarding consumer acceptance it would be advisable to compare the EU with Asian countries such as Japan or China.

2020. Improve understanding on the value of blue products

European Commission
Launch a study on the value, functionalities, environmental footprint, application and health benefits of different types of blue products

National and local authorities
Support a dialogue between organisations that focus on environmental sustainability and other stakeholders in the (blue) bioeconomy

Industrial players
Highlight the qualities of biobased products in description of a blue product.

Research community
Provide research on qualities of bio-based products.

2020. Define a communication strategy to raise consumer awareness of blue products

European Commission
Support consumer awareness campaigns.

National and local authorities
Mobilise: civil society; consumer associations; "ambassadors" of blue biomass product to take part in the communication campaigns and to spread out positive wording and appealing messages to consumers.

Include wider qualities of biobased products in the curriculum of schools

Industrial players
Share good examples and success stories.

2021-2025. Design more supportive regional policies on blue sector

European Commission
Stimulate collaboration between regional governments and local producers of blue products.

National and local authorities
Assist local blue producers: for example, create taste labs, school campaigns and education classes.

Industrial players
Collaborate with regional actors to develop ideas on how to best propel growth of the regional blue sector, to inform consumers on benefits of blue products.

Research community
Engage in collaboration between regional and industrial actors

2021-2025. Support the blue sector advocacy groups in the EU

European Commission
Support the development of advocacy groups for the blue sector

National and local authorities
Increase representation of blue producers on a national / regional level.

Industrial players
Increase collaboration among industrial players at the EU, national and regional levels.

Research community
Increase collaboration with industrial and institutional players on development of the blue bioeconomy nationally and in the EU.

Increase the valorisation of rest raw material from fisheries and other aquatic biomass

Discards of seafood resources, namely fishery "non-target" species count for 25% of total volumes of marine fishery catch, while the discards in the fish processing industry reach up to 75% of the total volume of products. This problem has been raised continuously over the last decade, but technical solutions have not been commercialised (FAO, 2011), (EUMOFA, 2018), (EC DG RTD, 2016). Main barriers are:

- lack of awareness and interest from the business community and investors, including lack of successful examples of tested products and business models based on valorisation of rest raw material.
- unclarity whether rest raw material from fishing should be considered as waste, limiting their use as inputs for new products.

Solutions include reinforcing the need to find solutions to rest raw material valorisation that will cover not only food related sectors, but also other value chains where side products can be utilised. This requires better exchange between researchers, business and investors.

2020. Enforcement of the landing obligations given by the EU fishery policy

European Commission
Ensure that the EU fisheries policy on landing obligation is fully enforced at the EU member states.

National and local authorities
Ensure that the EU fisheries policy on landing obligation is fully enforced at the EU member states.

2020. More research on use of underused fish and other marine biomass

European Commission
Support via EU research funding instruments, link to Circular Economy priorities.
Develop incentives to promote use of underutilised marine biomass.
Promote platforms at EU level for communication between all types of stakeholders.

National and local authorities
Support via national research funding instruments, motivate companies to engage in R&I. Develop fiscal benefits or other market incentives to promote new use of underutilised marine biomass in local industries. Promote platforms at national/regional levels for communication between all types of stakeholders.

Industrial players
Look into joint research opportunities with research institutes. Engage in communication with other groups of stakeholders.

Research community
Explore new research opportunities on use on underused marine product side-streams. Engage in communication with other groups of stakeholders.

2021-2025. Develop regionally:
- pilot plants for proof of concept at semi-industrial scale
- bio-refineries as 'lighthouse' projects to encourage further investment

European Commission
Secure (co)financing, facilitate the launch via funding programme or BBI -JU and novel funding mechanisms.

National and local authorities
Secure (co)financing, facilitate the launch via funding programme.

Industrial players
Develop pilot plants and bio-refineries.

Research community
Engage in development of the concept.

Support the reduction of blue production costs

Entrepreneurs in the blue bioeconomy sector face relatively high production costs, due to a lack of available and accessible production/processing facilities, as well as risks and expenses during the R&D phase.

The Blue Bioeconomy Forum suggests to:

- Build and invest clusters of blue production with biorefineries and other production facilities across the EU. Appropriate infrastructure for timely processing, logistics and transportation of biomass is an essential factor for both energy and cost efficiency in production and research.
- Design and implement a policy instrument to partially decrease R&D costs of clinical trials, to assist in critical research areas of the 'blue' sector (e.g. development of compounds for biomass drying or salt extraction) and to stimulate research/product development.
- Design a funding mechanism for SMEs and create incentives for private investors and companies to invest in facilities like biorefineries and silos. As identified above, business advisory services could support scaling up production and diversification of product portfolio, and accessing available financial support from the regional, national or EC programmes.

Above-listed suggestions are expected to stimulate business activity and research in the blue bioeconomy sector, to increase efficiency of blue production, reduce losses and logistical costs.

2021-2025. Provide partial coverage of R&D costs for entrepreneurs in the blue sector

European Commission
Design a policy instrument for covering R&D costs in new applications (e.g. clinical trials).

National and local authorities
Design policy instruments for coverage of R&D costs in harmony with EC plans.

Industrial players / Research Community
Discuss with the European Commission and the national / regional governments the most effective policy instruments for coverage of R&D costs.

Research community
Propose an effective policy instrument for coverage of R&D costs.

2021-2025. Planning and building of clusters of blue production in the EU with biorefineries and other production / research facilities

European Commission
Start a discussion with national governments and industrial players on building EU clusters of blue production.
Design policy instrument to support financing of these clusters.

National and local authorities
Discuss the location, needed technologies at blue production clusters with industrial players in the blue bioeconomy to decrease production and logistical costs; develop a plan and a policy instrument to support the building of the cluster.

Industrial players
Discuss the location, needed technologies at blue production clusters with industrial players in the blue bioeconomy to decrease production and logistical costs.

Research community
Suggest ideas on best location, technologies, benefits and impacts of building blue production clusters in the EU.

2021-2025. Provide investment in silos and biorefinery facilities that can stabilise the input into processing industries.

European Commission / National and local authorities
Incentives for private investors and businesses, special loan/co-funding schemes.

Industrial players
Engage in building silos and biorefineries.

Support solutions for biomass processing

35 % of consulted Blue Bioeconomy Forum stakeholders face logistical challenges, of which 80 % are technical in nature (and not legal or policy issues). Technical challenges include complex and expensive operations throughout the entire supply chain, including harvesting, storing, processing, transport and delivery. A better understanding is required of the impact of seasonality on the quality of marine resources, especially in the context of ongoing climate change. Research on these challenges should be linked with commercialisation and the involvement of public and private actors.

Lack of access to data on pollution, quality and temperature of water prevents entrepreneurs to optimise their production process. Ensuring open access to such data, as well as integrating various monitoring data sources in one platform, requires joint action by public, research and industry actors.

Costs arising from the remoteness or sparse locations of farming or wild harvesting locations from processing facilities can be addressed by clustering these.

The compliance with regulations on preventing waste of by-catch incurs logistical challenges and costs for companies. However, in countries where the market of by-catch is developed, the fisheries are able to reap a profit.

Dissemination and exchange of existing good practices on distributed harvesting, processing of biomass, optimisation of the logistics of by-catch fishing resources would be helpful.

2021-2025. Support further scientific research and narrow existing knowledge gap on:
- impact of seasonality on biomass characteristics
- crops and harvesting optimisation
- logistical challenges and pre-processing techniques (biomass specific)

European Commission / National and local authorities
Support via research funding instruments, e.g. for mapping existing technologies.

Industrial players
Initiate and co -fund research projects.

Learn from examples of good practices.

Research community
Engage in relevant research.

2021-2025. Set up knowledge exchange on developing system of distributed production of marine biomass

European Commission
Facilitate an EU/international exchange programme.

National and local authorities
Look for other synergies across countries in improving efficiency of seaweed farming.

Industrial players / research community
Engage in exchange programme.

2021-2025. Open data platform with data (e.g. from ongoing monitoring of water quality)

European Commission
Promote an open data initiative at EU level cooperation of data holders, integrate with the ongoing open data support initiatives.

National and local authorities
Support the EU initiative via engagement and/or co-financing.

Industrial players / research community
Support the EU initiative via engagement and/or co-financing

Facilitate dialogue and cooperation between research and industry

Better links and collaboration is needed to develop and deliver successful products to consumers.

The Blue Bioeconomy Forum suggests to:

- Develop measures to incentivise researchers and companies to collaborate. The interests and motivators from one actor to another can be very different. If concrete actions, such as co-design of research with industry, are taken to facilitate cooperation with specific agreements, knowledge transfer is facilitated between the academic and applied research entities and the private sector.
- Launch exchange programmes for students and academics in industry and vice versa. Possible examples include involvement of PhD students in industrial projects and/or seminars. Such activities could enhance alignment of expectations of both sides in all collaborative activities. These activities could also lead to matchmaking of talents in research and industry, as well as increasing awareness among researchers about market needs.

Increased and improved cooperation between researchers and industry can have cross-cutting effects on the other specific challenges that have been identified.

2020. Develop measures to incentivise researchers / companies to collaborate

European Commission
Provide tools and incentives for companies and researchers to collaborate and share information while protecting interests (e.g. data sharing agreements / IP contracts).

National and local authorities
Support in collecting the needs and conditions that would ensure a high participation of the national / regional actors.
Stimulate participation of national/regional actors.

Industrial players / Research Community
Clarify what are the essential motivators / blockers to share data and collaborate.

2021-2025. Launch exchange programmes for students and staff in industry

European Commission
Continue facilitating cooperation between academia and industry with exchange programmes.

National and local authorities
Include in university curricular modules to facilitate turning research into applicable solutions for industry.

Industrial players / research community
Offer placements for student-industry programme.

Support solutions for marine exploration

The high costs and technical challenges of accessing areas outside the shallow coastal zone and the costs of deep-water exploration mean that much remains to be discovered in the oceans' depths.

Activities and financing generally focuses either on fundamental research or the application potential of the functional components with high end market applications. Many approaches require a new methodological and systematic approach.

The Blue Bioeconomy Forum suggests to:

- Explore targeted environments and hotspots
- Develop next generation sampling methods (bioprospecting)
- Develop novel methods for the taxonomic, chemical, and biochemical evaluation of marine species as sources of bioactive compounds.

More collaboration would also help in reducing exploration costs, for example, through optimisation of multi-purpose screening on hotspots or sampling programs.

2025+ Facilitate exploration of marine environment

European Commission / National and local authorities
Support via research funding instruments.

Industrial players
Co-fund research projects.

Research community
Engage in relevant research.

Support a network of research infrastructures

The availability of relevant and accessible research infrastructures is essential to continue and enhance the development and use of outputs from marine biotechnology. The most urgent technological challenges are in the demonstration plant phase, and the upscaling to flagship/first-of-a-kind, when economies of scale have not yet been achieved. Although lack of information about available infrastructure was mentioned in the BBF working groups, there are databases at demonstration or pilot scale that provide an overview of the available infrastructures. To note, however, none are specific for blue bioeconomy.

The Blue Bioeconomy Forum suggests to:

- Build on existing projects to map and optimise the use of specified, available research infrastructures (in particular at TRL 6-8) including personal skills needed to operate these facilities.
- Bring together different scientific disciplines to promote innovation, turning scientific findings into healthy businesses. Such activities relate to the "New Skills Agenda for Europe" as well as national, regional and sector initiatives that should boost the labour market across the Member States. These initiatives are aimed at a) retraining and up-skilling the current labour force and b) enabling the system to better prepare the future labour force.
- Building a European blue bioeconomy ecosystem that will: 1) foster the interaction between the regional players and develop the research and innovation network at local level (e.g. financing new infrastructures; encouraging schools and universities to adapt their training according to the need of the industry; 2) encourage the development of an European network of blue bioeconomy regions, where more advanced blue bioeconomy regions could help and pull "follower regions" on the development of regional ecosystems. Such initiative could build up on the regional smart specialisation strategies and could be easily integrated in the work that is currently carried out by JRC and DG REGIO on the interregional S3 platforms.
- Build, from 2025 additional research infrastructures and generate financial tools that assure sustainable accessibility and operation of the facilities.

2020. Mapping: optimise use of research infrastructures

European Commission
Support measures that seek to map needs and facilitate access to existing research infrastructures in the BB sector.

National and local authorities
Mapping exercise at regional level to support research infrastructure exchange and closing facility gaps (labs to scale -up).

Industrial Players / Research Community
Take part in mapping exercise / inventory of what is needed or what is available.

2021-2025. Reduce gap of qualified people for running and maintaining research infrastructures – especially engineering profiles

European Commission / National and local authorities
Scholarships for engineers to work in the Blue Bioeconomy.

2021-2025. Build a European blue bioeconomy ecosystem

European Commission
Create a BB smart specialisation platform to enhance peer-to-peer learning. Linking Smart Specialisation Strategies with similar focuses.

National and local authorities
Take part in the Smart Specialisation Strategies platform. Highlight Blue Bioeconomy in the Smart Specialisation Strategies. Engage regional stakeholders in the platform.

Industrial Players / Research Community
Articulate needs and expectations for a blue bioeconomy platform.

2025+ Build research infrastructure and financial tools to sustainably use / operate (joint) facilities

European Commission / National and local authorities
Provide projects to build facilities but also the financial tools to use the facility.

Industrial players
Be involved in the building of facilities and aware of the costs to operate.

Research community
Inventory of needs for large research infrastructures.

Promote open data and access to research findings

Access to data, research results (including data from unsuccessful experiments) are considered a challenge that, when tackled, may stimulate the development of the blue bioeconomy. Research and industry need to be incentivised to share data. A big challenge is to unify / streamline the available data sources and portals that we have worldwide. Therefore, it is proposed to link blue bioeconomy projects with European initiatives to share and standardise data according to e.g. EOSC (European Open Science Cloud) and FAIR data management.

The Blue Bioeconomy Forum suggests to:

- Define structures and establish means for blue bioeconomy data and results that can be shared, according to existing data structures. The EMODnet could be a good starting point; the awareness and visibility of this data source should be improved. National databases should be integrated or federated.
- Stimulate and facilitate "delivery" and "use" of information in open access results databases. For commercial data new tools must be developed (e.g. data pods and/or licenses for data sharing).

2020. Define structure of an open access results database for blue bioeconomy projects, making use of existing data structures (e.g. EMODnet, EOSC)

European Commission
Launch an EU-wide study to define structure and priorities of the blue bioeconomy open access results database.

National and local authorities
Stimulate engagement and commitment of national / regional stakeholders to take part in the discussions.

Industrial players / Research Community
Clarify what data can be shared and how it should be acknowledged.

2021-2025. Construct an open access results database

European Commission
Stimulate or/and facilitate an open access results database.

National and local authorities
Stimulate participation of national / regional actors. Harmonise national / regional repositories.

Industrial players / Research community
Add information to the database.

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Process undertaken to reach this Roadmap

The findings presented in the Roadmap rely on:

- A community of over 375 members that are working on or interested in the blue bioeconomy, representing: industry, public agencies, financial organisations, researchers and civil society, of the European Union. These stakeholders receive information about the BBF activities and are invited to actively contribute to the development of the Roadmap (via interviews, participation to events, surveys).
- The strong commitment of the BBF Steering Group members, taking an active role in the development of the Roadmap. The Steering Group members were:
  - Olavur Gregersen, Ocean Rainforest
  - Liina Joller-Vahter, Faculty of Economics and Business Administration, University of Tartu
  - John van Leeuwen, Seaweed Harvest Holland
  - Snejana Moncheva, Institute of Oceanology, Bulgarian Academy of Science
  - Jens Kjerulf Petersen, Institute of Aquatic Resources, Danish Shellfish Center
  - Wilco Schoonderbeek, InvestNL
  - Vitor Verdelho Vieira, European Algae Biomass Association
  - Helena Vieira, Bluebio Alliance and University of Lisbon
  - Maye Walraven, InnovaFeed
- Working Group members, that were actively involved in the BBF Working Group sessions around specific topics and have been consulted bilaterally in tailored interviews. (WG1: Policy, Environment and Regulation; WG2: Finance and business development; WG3: Value Chains, Markets and Consumers; WG4: Science, Technology and Innovation)
- A state-of-play report, bringing the first insights on the main developments of the blue bioeconomy in Europe and presenting a first selection of blue bioeconomy challenges based on desk research.
- Two surveys addressed to the BBF community:

1. A first "short" survey launched in October/November 2018 to determine the prioritisation of challenges for the discussions at the Working Group workshops (N=107).
2. An in-depth survey intended for members of the business and research community who are active in the blue bioeconomy, to help shape the content of the Roadmap based on the results achieved from the Working Group discussions (N=86).

- A BBF launch event organised on 7 December 2018 with over 90 participants. The goal of the event was to discuss the current status of the emerging blue bioeconomy in Europe and to identify strategic developments, market opportunities, financing possibilities and research priorities. The event was also the opportunity to host the first Working Group sessions. The outcomes of the event have been used for the Roadmap on the development of the blue bioeconomy in the EU.

Working Group workshops organised on 11 and 12 March 2019. The objective of the workshops was to identify the key challenges for advancing the blue bioeconomy in the next 2-7 years. The discussions were around the key challenges, the key questions that are related to these challenges, and some of the possible ways forward to be addressed in the Roadmap document. The working group topics were decided following a consultation with the wider BBF community (via a survey). They were held on 7 December 2018 and on 11 and 12 March 2019.

- A selection of projects and companies, whose owners have been invited to the BBF activities and have been consulted in bilateral interviews (31 interviews conducted).
- A second event organised on 25 June 2019 with over 140 participants. The goal of the second event was to discuss the draft Roadmap for the blue bioeconomy. The discussions during the event have been used to sharpen the descriptions and ways forward presented in this document.

Who is the Blue Bioeconomy Forum?

The following organisations have been present at our two events and workshop meetings. Their input was of great value:

A

ABS-int
Acacia Sustainable Business Advisors
AGC98
AITEX
Algae 4 Future
AlgaePARC, WUR
Algaia
Aqua Spark
AquaBioTech Group
Aquaculture Advisory Council
Aqualicense
AquaTT
Aquimer
ART-ER
Aruba
Association for European Life Science Universties
Association of Local Authorities of Ida-Viru County
Atlanpole

B

Barcelona Ocean
Basque Government
BBF news
BBI JU
Bigh Aquaponic Urban Farms
BioCon Valley
BioMarine International Clusters Association
BioplasticsNews.com
Blue Med Islands L.T.D.
Brittany region european office
BROmotion Representative
Buggypower

C

CEA
Cecoforma
C-Feed
Chirico Consulting
Ciimar
Circle of Sustainable Europe (CoSE)
Cleopatra's Sponges
Cluster Factories of the future
COGEA and EMODnet
Conseil régional de Bretagne
CPI
Cpmr

D

Danish Technical University
Délégation Permanente de la Bretagne Europe
DG Research and Innovation
DTU National Food Institute

E

EBA
EBCD
EBN
eCOAST Marine Research
EJVO
Embassy of Argentina
EMBRC-ERIC and University of the Basque Country
EMODnet
EntoGreen
Eranova
ERCEA
European Algae Biomass Association
European Bureau for Conservation and Developement

European Commission, DG GROW
European Commission, DG MARE
European Commission, DG RTD
European Commission, EASME
European Commission, Joint Research Center
European Federation of Food Science & Technology
European Future Innovation System Centre
European Marine Board
European Open Science Cloud
European Regions Research and Innovation Network
Evonik Industries

F

FAO
FARNET Support Unit
Flanders Marine Institute
Forskningsradet
Fórum Oceano - Association of Maritime Economy
Fundació Bosch i Gimpera

G

Galician Innovation Agency
GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
Greater Copenhagen EU Office
Greenovate! Europe
Greensea

H

Hanse Office
Helmholtz Association
Hortimare

I

IFFO The Marine Ingredients Organisation
Ifremer
InnovaFeed
Innovation and Business Development
Institut des professions juridiques et immobilières
Institute for Agricultural and Fisheries Research
Irish Mussel Seed Company
Irish Permanent Representation to the EU
Italian institute for environmental protection and research (ISPRA)

J

JPI Oceans

K

KNCV
KosterAlg

L

Latvian Institute of Aquatic Ecology
Luke, Natural Resources Institute Finland

M

MadeinSea
Marine BioTechnology
Marine Investment for the Blue Economy
Maritime Institute in Gdańsk
Matis Iceland / Icelandic Food and Biotech Company
Mediterranean Sea and Coast Foundation
Meta Group
MicroBio Engineering
Ministry of Agriculture, Nature and Food Quality, Netherlands
Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina
Ministry of Rural Affairs, Estonia
Mission of Argentina to the EU
Mussella

N

National Research Council
National Technical University of Athens
Natural Resources Institute Finland (Luke)
Netherlands Enterprise Agency (RVO.nl)
Netherlands Standardization Institute (NEN)
Nofima
Nutrition Sciences N.V.

O

Occitanie Europe
Ocean Rainforest & Syntesa
Oceano Azul Foundation
OCTA - Overseas Countries and Territories Association
ORCA (Oil Response Cleaning Apparatus)

P

Paragon Europe
Pays de la Loire Europe
Platform4Business
PNO Consultants
Pôle Mer Bretagne Atlantique
Polytechnic Insitute of Leiria
Pomorskie Regional EU office
PortXL
Power Algae Ltd.
Prognos AG
PwC

R

REA
Region Emilia-Romagna
Regione Basilicata
Representation of Nouvelle-Aquitaine

S

Samenwerkingsverband Noord Nederland (SNN)
Saudi Aquaculture Society
Scholten Holding
Scinan
Scinan S.A.S.
Scottish Association for Marine Science
SDM Partners
Sea Going Green
Sea4Us
Seaentia
Seas At Risk
Seaweed Harvest
South Norway European Office
State Water Holding Polish Waters
Stichting Noordzeeboerderij
Submariner network for Blue Growth EEIG
Suez
Submariner network
Swedish Board of Agriculture
Syddansk Universitet
Synergy Cooling Towers

T

Tartu Biotechnology Park
The European House - Ambrosetti
The National University of Ireland
The Research Counicil of Norway/NORCORE
Turku-Southwest Finland European Office

U

UAB Klaipeda Free Economic Zone Management Company
UAB Metal Production
Union Europäischer Industrie- und Handelskammern (UECC)
United Federation of Danish Workers
Universidad Católica de Valencia
University di Roma
University of Akureyri
University of Bologna
University of Ghent
University of Greenwich
University of Nottingham
University of Portucalense
University of Southern Denmark
University of Turku, School of Economics, Pori Unit

V

Valencia EU Region
Vlaams Gemeenschapsonderwijs

W

Wageningen Economic Research
Wageningen Food & Biobased Research
Wageningen Livestock Research
Wageningen Marine Research
Welsh Higher Education Brussels
West Finland European Office
WindEurope

X

Xanthella

Z

Zunibal

Notes

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