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NEW CHALLENGES FOR THE MARINE SCIENCE: THE BIOLOGICAL RESOURCE EXPLOITATION

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1.1. European BioEconomy

It is already known that in the next decades competition for limited and finite natural resources will occur. In fact, a growing global population will need a safe and secure food supply. Further the global climate change will have an impact on primary production ecosystems, such as fisheries, aquaculture, agriculture and forestry.

It is emergent and necessary to act toward an optimal use of renewable biological resources. It is urgent to move towards sustainable primary production and processing systems that can produce more food and other bio-products with lesser inputs, lesser environmental impact and greenhouse gas emissions. All world countries have to contribute for satisfactory goods based on raw materials, energy and industrial products under conditions of decreasing fossil carbon resources; it is expected to drastically decrease the production of oil and gas by 60% by 2050 (http://ec.europa.eu/research/bioeconomy). Bio waste represents a high potential resource as feedstock for productive processes (138 millions/year). Food waste is also a serious concern. About 30% of food produced in developed countries is discarded. Therefore, it is necessary to change the direction to a more resource efficient society that relies more on renewable biological resources to satisfy the needs of consumers, industry and block climate change.

The Bio economy replies to these urgent needs by the sustainable production of renewable resources from sea, land, forestry and conversion into food, feed, drugs, bio-energy and goods. The Bio economy provides 20 millions jobs and accounting for 9% of total employment in EU in 2009. EU within the Europe Strategy 2020 indicates continuous investment in research and production. Bio economy research and innovation under Horizon 2020 expected to generate added value to a more competitive and prosperous Europe (http://ec.europa.eu/research/bioeconomy.

The Bio economy sustains the pillars of Safe Food, Bio-based Industries, Aquatic Resources and Biotechnology.

1.2. Biotechnology

The Biotechnology is the driving technology of the bio-economy. It contributes to innovation in all the other Activities under the bio-economy, namely food, agriculture and forestry, and fisheries and aquaculture. Examples of biotechnology applications are in industrial processes as bio-pharmaceuticals, food, and feed production and bio-chemicals. In Europe, the bio-pharmaceuticals sector includes the 20% of current medicines derived from biotechnology. The potential of biotechnology processes and bio-based products could lead to a reduction of CO_2 emissions to be estimated to range between 1 to 2.5 billion tons CO_2 equivalent/year by 2030

(http://ec.europa.eu/research/bioeconomy/h2020/biotechnology). In particular, the *Biotechnology Biotech Areas* include Novel sources of biomass and bio-products, Marine and fresh-water biotechnology (blue biotechnology), Industrial biotechnology: added-value bio-products and bio-processes (white biotechnology), Bio-refinery, Environmental Biotechnology, Emerging trends in biotechnology.

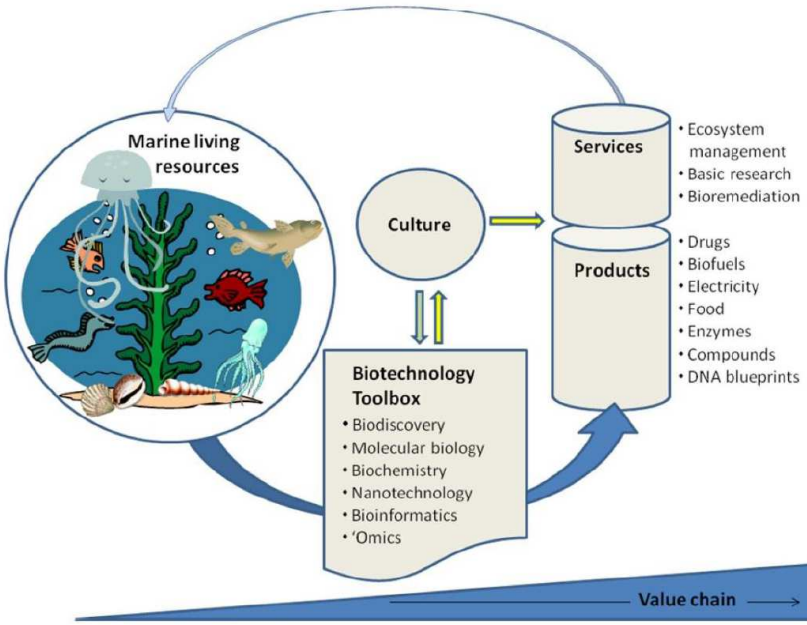

Fig. 1. Marine Biotechnology (source Final report 2014- FWR MARE/2012/06 – SC C1/2013/03 DG Maritime Affairs and Fisheries).

1.3. Blue Biotechnology

Blue biotechnology deals with the exploitation of the sea biodiversity in order to develop new products, as pharmaceuticals or industrial enzymes with high economic value. In the long term, it is expected that the sector will offer high-skilled employment and significant downstream opportunities. In this area, research priorities are strongly driven by Marine and Maritime policies on economical and environmental sustainability.

The high biodiversity contained in the oceans represents a high potential for innovation first as better understanding of marine and maritime resources and biodiversity, second as efficient exploitation of economic and scientific potential. The Blue Biotechnology is able to transform this high potential into real products and acknowledge. Blue biotechnology is one of the key enabling technologies and maritime economic sectors. Further, the Marine Biotechnology contributes to more effectively protect the marine environment across Europe, also specifically about the definition of Good Environmental Status (GES) indicators (see Marine Strategy Framework Directive).

1.4. Marine Bio products: actual and potential markets

A long list of marine bioproducts or linked processes can be done about their exploitation for the generation of industrial products. At the top list of exploitation and market there are the pharmaceuticals, then cosmetics, nutritional supplements, agrichemicals, enzymes, Antifouling and antibiofilm compounds, Bioremediation, biofuels, Nucleotide sequences.

The potential of biotechnology is concentrated on the drug discovery, development and design. The synthesis of antiviral drugs and anticancer drugs includes -AZT (zidovudine, Terovir®): anti HIV; -Acyclovir (Zovirax®): anti herpes; -Ara-A (Vidarabine®): antiviral; - Ara_C (Cystosar-U®): anti leukemias.

The Marine pharmaceutical is a current pipeline: The preclinical pipeline continues to supply several hundred novel marine compounds every year and those continue to feed the clinical pipeline with potentially valuable compounds. From a global perspective the marine pharmaceutical pipeline remains very active, and now has sufficient momentum to deliver several additional compounds to the marketplace in the near future (Mayer et al. 2010). Furthermore, the advent of genetic techniques that permitted the isolation/expression of biosynthetic pathway from microbes may well be the new frontier for natural products lead discovery. It is now apparent that biodiversity may be much greater in those organisms. The numbers of potential species involved in the microbial world are many orders of magnitude greater than those of plants and multi-celled animals. The explosion of genetic information led not only to novel screens, but the genetic techniques permitted the implementation of combinatorial biosynthetic technology and genome mining. The knowledge gained has allowed unknown molecules to be identified. These novel bioactive structures can be optimized by using combinatorial chemistry generating new drug candidates for many diseases (by Gordon et al. 2013).

1.5. Metagenomic and massive sequencing in the oceans: DNA products

EU financed Projects in the framework FP7 started to produce metagenomic multi-sequences of the marine microbial diversity. In particular, the EU 7FP project Micro B3 (Marine Microbial Biodiversity, Bioinformatics, Biotechnology) develops innovative bioinformatic approaches and a legal framework to make large-scale data on marine viral, bacterial, archaeal and protists genomes and metagenomes accessible for marine ecosystems biology and to define new targets for biotechnological applications. Micro B3 builds upon a highly interdisciplinary consortium of 32 academic and industrial partners comprising world-leading experts in bioinformatics, computer science, biology, ecology, oceanography, bioprospecting and biotechnology, as well as legal aspects. Micro B3 takes full advantage of current sequencing technologies to efficiently exploit large-scale sequence data in an environmental context. Micro B3 creates integrated knowledge to inform marine ecosystems biology and modeling. Moreover, it facilitates detecting candidate genes to be explored by targeted laboratory experiments for biotechnology and for assigning potential functions to unknown genes. Micro B3 develops clear IP agreements for the protection and sustainable use of pre-competitive microbial genetic resources and their exploitation in high potential commercial applications. To underline the translational character of Micro B3, outreach and training activities for diverse stakeholders are ongoing as well as an Ocean Sampling Day to transparently make project results accessible and gain valuable user feedback (from

website: http://www.microb3.eu). Within the project the massive sampling for metagenomic activity is carried out. Through a wide network build up by Ocean Sampling Day (OSD) is provided the largest dataset on and function in marine research. The results will mark a baseline for the marine environment accessible for researchers, industry, public and policy makers. The OSD constitutes the Workpackage 2. Meanwhile, another important Workpackage 8 is comprised in the Project MicroB3. The goal are (a) ensure intellectual property protection on downstream commercial applications; (b) while alleviating obstacles to facilitated access to pre-competitive research materials and associated data; (c) adopting appropriate access and benefit sharing rules which can promote R&D activities in resource countries and generate funding for biodiversity conservation through a multilateral approach most appropriate for marine bioprospecting. This last part mentions the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. The sampling of seawater resources is under the Access and Benfit Sharing (ABS) document that settles the legal permits to undertake research in different maritime zones and to transfer research materials to another country. The sampling activity has different rules if the distance from the coast changes. Permit to the National Authority has to asked if the sampling is in internal waters – territorial seas – exclusive economic zones; otherwise, if the sampling is in the areas beyond national jurisdiction the permit is not required; if the sampling is in the Antarctic Treaty Area the activity is subject to prior notification.

1.6. Marine Cosmetics and Nutraceuticals

The greatest applications of Blue Biotechnology products in commercialisation are the cosmetics and food sectors with most products having a large expected societal as well as economic value.

The organisms to be exploited can be microscopic (bacteria and microalgae) or macroscopic (seaweeds, jellyfish); the functionality properties are several as UV-filter, after sun; viscosity control agents; surfactants; preservatives; liposomes, carrier systems for active ingredients; regulation of sebum. The Cosmetic sector is relevant since it is a growing sector demanding marine innovations. Personal care products industry overall is reaching EUR 487 billion by 2017152 with about 713 patents (Final report 2014-FWR MARE/2012/06 – SC C1/2013/03 DG Maritime Affairs and Fisheries - Study in Support of Impact Assessment work on Blue Biotechnology).

The other main sector of large expected societal as well as economic value is the production of nutraceuticals supply of marine origin. The specific applications are antioxidants, anti-inflammatory; fat loss; reducing cholesterol; anti-HIV properties, antibiotic and mitogenic properties anti-tumour; iodine deficiency, goitre and myxoedema; anti-influenza; treatment of gastric ulcers. The Marine organisms can be microorganisms (bacteria, microalgae) and organisms (fungi, sponges, corals, invertebrates, seaweeds). The socio-economic impact of the food sector has experienced a tremendous growth over the past years. The production is based mainly on products from seaweeds. Most of the SME are in north Europe strongly interested in the marine production for food supply even if the largest seaweed production countries are the Philippines and China. The EU is responsible for 21% of world hydrocolloids and for 38% the world production of alginates.

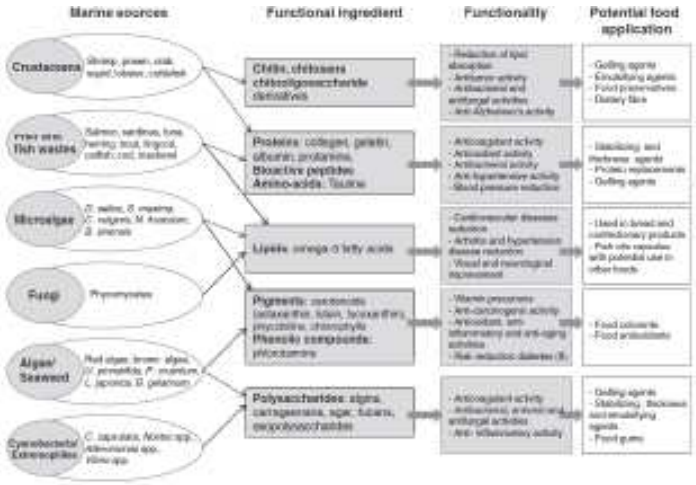

Fig. 2. Marine functional ingredients with food applications, sources and inherent functionality (source Final report 2014- FWR MARE/2012/06 – SC C1/2013/03 DG Maritime Affairs and Fisheries).

1.7. Renovable Energy Production

The Bio refinery research involves the application of biotechnology for the production of bioproducts and biofuels. The Biorefinery can significantly contribute to a green economy supporting the EU's Climate Action. To reduce the dependency on fossil fuels imports and meet the target of renewable energy sources in transport it is highly demand to encourage the production and use of biofuels. The Renewable Energy Directive in 2008, required Members States to meet 10% of transport energy from renewable sources by 2020. By 2012, it was estimated that biofuels consumed in the EU accounted for around 4.5 % of road transport fuels.

The European Renewable Energy Action Plans encourages the sustainable cultivation and use of biomass, bioenergy and biofuels (http://biofuelstp.eu/). The European Biofuels Technology Platform (EBTP) contribute to the development of cost-competitive biofuels and the creation of a healthy biofuels industry, and to accelerate the sustainable deployment of biofuels in the European Union, through a process of guidance, prioritisation and promotion of research, technology and development.

The microalgae and aquatic biomass has the potential to provide a new range of "third generation" biofuels. The microalgae produce high oils and biomass yields of high quality and versatile products, widespread available, not competitive with agricultural land. Further, the algal biomass efficiently capture CO_2 and can be used for wastewater treatments and other industrial plants; algae and aquatic biomass are promising renewable sources for a sustainable and low-carbon economy (http://biofuelstp.eu/algae-aquatic-biomass.html).

Increasing attention is about the rules and policy on the exploitation of algal green and aquatic biomass. The European Policy and Standards for sustainable biomass and biofuels production consists in developing a series of key actions as (1) the Policy and Sustainability, (2) the Deployement of advanced biofuels societal benefits of biofuels, (3) the Biofules markets, (4) the Financing and Investment, (5) the Regulatory Framework, (6) the Policy and legislation, Standards and Certification.

2. Summary: Strategic Research and Needs- Recommendations

- It is necessary to develop regulations and programmes for exploitation and use of sea ecosystem services by human activities (research activity, deep-sea mining, pharmaceuticals).
- It needs to increase the efforts to explore and exploit marine microorganisms for biotechnological applications and products in line with the recommendations of Marine Board Position Paper 15 *Marine Biotechnology : A New Vision and Strategy for Europe* *
- It needs to organise repositories for all samples, cultures and genetic materials collected during a project, and find permanent facilities to host them. Samples, cultures and genetic materials are valuable as reference for future research.
- Funding agencies need to contribute to address the loss of data collected by public funds and specify requirements for each project to permanently archive and publish data generated by the project in public data systems.

<u>Exploitation</u>

- Increase exploitation of marine environment (drugs discovery, food, biofuels).

<u>Technologies</u>

- Develop, improve innovative technologies for the marine exploitment and pipeline analysis processes.

<u>Data network</u>

- Generate a dense network of data on the marine ecosystem by increasing both the number and technological capacities of marine observatories.
- Societal and ethical challenges & Policy arising from these developments needs also to be correctly addressed.

References

Mayer, A. M. S., Glaser, K. B., Cuevas, C., Jacobs, R. S., Kem, W., Little, R. D., et al. (2010). The odyssey of marine pharmaceuticals : a current pipeline perspective, 31, 255–265.