Background and recommendations on future actions for integrated marine biotechnology R&D in Europe

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Collaborative Working Group on Marine Biotechnology

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CONTENT

Summary of Recommendations

In this paper the Coordinated Working Group on Marine Biotechnology (CWG-MB) reports the outcome of activities as initiated by the KBBE-net in August 2008. An inventory of ongoing and planned activities and fields of interest revealed substantial overlap in some areas and more scattered interests in others. Four specific areas of activity have been identified as those most likely to benefit from a co-ordinated approach as envisaged in this paper, giving possibilities for development on a fully-transeuropean scale. These are:

- **Marine bioprospecting/biodiscovery** - although different partners fill this with different content, there is a common interest in developing all aspects of this field in co-operations between academic and industrial stakeholders, to accelerate the transition to green chemistry, nutrition and pharmaceuticals based on marine biodiversity.

- Robust, biotechnology-based state of the art **R&D tools** and infrastructures tailored for marine biotechnology are emphasised as necessary factors to achieve the goals set within marine biotechnology, including reference marine organisms and systems, and the application of 'omics' to fields as diverse as disease management, biodiscovery, climate change understanding and mitigation and environmental bioremediation.

- **Molecular aquaculture** – given the need to establish sustainable aquaculture industries with a need for expanded protein and fat production, yet avoid pressures on land-use from conventional agriculture, it is increasingly pressing to accelerate advanced aquaculture using biotechnologies for selection, feeding and management of farmed and wild species. Especially by best practice in applying genomics knowledge and integrating this better with understanding of growth physiology, other biological parameters and management of the wild stocks.

- **Biomass production** for bioenergy and fine chemicals - at the moment in its infancy but the subject of tremendous interest and funding. Technological and efficiency challenges that cannot be met by uncoordinated work and funding in the European context exists, especially in the areas of production and transformation as well as use.

The CWG-MB recommends the development of priority setting that may serve as input for future work programs, common calls and networking in the framework program.

Financial support of future CWG-MB activities is likely to stimulate a continued evolution of a transeuropean community and effort to help develop biotechnology based on marine organisms – marine biotechnology.

This support and the resulting co-ordination activities would assist existing and forthcoming research projects in this area to maximise their value and outputs, allow productive linkage between the relevant activities of existing European platforms that focus on achieving the KBBE targets of the Lisbon agenda and identify and make best use of international cooperation.

1. Definition of Marine Biotechnology

OECD - definition of biotechnology:

"The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" [1].

The provisional single definition of biotechnology is deliberately broad, and the list of biotechnology techniques functions as an interpretative guideline to the single definition.
In the case of marine biotechnology, the living organisms are derived from marine sources.

Marine biotechnology has a horizontal scope encompassing very different applications, for all of which the marine environment is providing the resources.

We will introduce the term *"molecular aquaculture"* to describe aquaculture activities relevant within the scope of marine biotechnology as laid out above.

2. Aims of the CWG-MB

The CWG-MB was set-up in the realm of the KBBE-NET to stimulate the development of marine biotechnology in Europe and to advise the KBBE-NET on Marine Biotechnology related challenges and opportunities.

The main aim of the CWG-MB is to identify priority actions and desired scientific, technological and economic impacts/objectives of common interest, in order to contribute to building a world ranking capability in marine biotechnology research in the European Research Area that could subsequently stimulate and enhance the European biotechnology and bioscience based industries and contribute to the Knowledge Based Bio Economy (KBBE).

To this end, the CWG-MB has considered a range of potential tasks and more specific objectives and deliverables which it could address, depending on the willingness of the participating countries/members, the available funding and time.

For this paper the CWG-MB has focussed on developing an inventory of the participating countries' priorities within marine biotechnology activities, as expressed in strategies and/or research programmes and projects to identify common themes and areas with potential for collaborations (appendix 1). This multi-state study responds to policy requests in identifying specific areas of research, insights to applications for marine biotechnology as well as an overview of the status of marine biotechnology research in Europe.

[1] http://www.oecd.org/document/42/0,3343,en_2649_34537_1933994_1_1_1_37437,00.html

The CWG-MB has built on earlier initiatives in the field of Marine Biotechnology taking into account relevant inputs from different national and international fora and in turn provides its outputs, suggestions and recommendations to all relevant fora. It will among others serve as input to the European Science Foundation's Marine Board Working Group on Marine Biotechnology which is to publish its updated Position Paper on Marine Biotechnology in the fall of 2010.

The CWG-MB has the ambition of establishing a Strategic Research Agenda including recommendations for suitable instruments to implement the SRA, which could be a stepwise operational plan. Such an SRA may in addition serve as input for national programs.

3. Rationale

The marine environment constitutes a major part (71%) of the earth's surface and accounts for more than 90% of the biosphere. Whilst we have a good basic understanding of the food chains in the oceans, marine resources for new applications stay largely uninvestigated. The world's oceans represent diverse environmental niches, and have a large impact on our climate.

Europe has a 70.000 km coastline along two oceans and 4 seas: the Atlantic and Arctic Oceans, the Baltic, the North Sea, the Mediterranean, and the Black Sea. The EU's maritime regions account for some 40% of its GDP and population.

Marine biotechnology utilises biological resources for the production of goods and services or modifies marine organisms for improved properties. These activities can affect the natural environment and sustainable use and social acceptance of this huge and fairly under-exploited pool of resources for biobased production and biotechnology, is high on the policy agenda [2].

While the field of marine biotechnology represents a large potential for European added value, the current level of collaborative research is not sufficient. Collaborative and interdisciplinary cooperation and networking which includes basic research bringing together marine biology, physiology of marine plants and animals, taxonomy, microbiology, biotechnology, nanotechnology, systems biology, bioinformatics, toxicology, -omics technologies and chemistry. This will lead to new application in fields such as drug discovery, novel foods and food ingredients, bio-remediation, biomaterials, aqua- and agriculture, diagnostics, production processes, bioenergy etc. Europe should focus and strengthen its effort in the area of marine biotechnology in order to find competitive niches. Sufficient attention should be given to sustainable exploitation of the uniqueness of Europe's marine biosphere and the understanding of its biodiversity and natural heritages.

Interest in and focus on marine biotechnology has gradually been growing and gaining momentum in Europe. It largely stems from the need to meet growing demands that cannot be satisfied from terrestrial sources alone. A second reason is the unique biodiversity that is found in oceans: not only 21 of the 33 invertebrate phyla are unique to the oceans, but most of the marine microorganisms are still unknown and the corresponding resources remain untapped for biotechnology. Moreover, environmental conditions found in marine environments are radically different from those of terrestrial ones, with unique ranges of ionic concentrations, temperatures, pressures and organism interactions. Not only are such niches likely to yield diverse microbial communities: these organisms are also likely to possess uniquely diverse genetic, biochemical and physiological characteristics.

4. Background

While a number of publications have highlighted the importance of marine biotechnology and its potential to make a significant contribution to sustainable development on all fronts, including social, economic and environmental, it is only now that a concerted effort is being made to develop an initiative that seeks to take action on many of the issues identified, to directly prioritise marine biotechnology, raise its profile, and contribute to the establishment of the Knowledge Based BioEconomy (KBBE). This should in turn influence the EU research agenda. Ongoing FP6 and FP7 research projects in the area of marine biotechnology are shown in appendix 2.

The **ESF Marine Board published a Position paper in 2001**[3] that highlighted the potential of marine biotechnology and the recent advances made in the field, and articulated a vision and strategy for marine

[2] Framework Programme 7, A European Strategy for Marine Research as part of the Action Plan of the Integrated Maritime Policy for the EU

[3] http://www.esf.org/index.php?eID=tx_ccdamdl_file&p[file]=4379&p[dl]=1&p[pid]=3830&p[site]=European%20Science%20Foundation&p[t]=1255870999&hash=91a0083a31bc89d63536760cc23fadb8&l=en

biotechnology in Europe. It identified the key barriers to its development as the absence of a concerted and focused initiative, and the dispersed, disjointed nature of current expertise and infrastructure residing in Europe. It outlined the key requirements for its development as improvement in collaboration amongst this fragmented research community, encouragement of a new generation of scientists, and the inclusion of marine biotechnology topics in future Framework Programmes. The position paper will be revised, updated and republished during the fall 2010.

Subsequent to the ESF report, and informing the **EC green paper on maritime policy (COMM 2006)**, was the **EC background paper No. 10[4] on marine biotechnology**. It identified a range of commercial applications that marine biotechnology would support; including bioprospecting; improving the production of marine organisms, novel products - both food and feedstock and uses in diagnostics and biosensor applications. This paper recognised the potential for marine biotechnology to make contributions to the development of different industry sectors; most of which are far from the marine area, such as agriculture, health, food products, process engineering, environment and energy. Indeed fisheries and aquaculture already benefit from advances in marine biotechnology by way of diagnostics, breeding and feed stock development. **The Background Paper No. 10** identified measures which may be useful to support the development of the marine biotechnology sector:

1. *Measures aimed towards better understanding the marine biotechnology sector*

   Information on marine biotechnology is scarce, and there are many issues that need clarification. As a result, a logical first step is to engage in activities to better understand the sector and its applications, its environment, its specificities its needs and how it differs from other biotechnological sectors. Whereas terrestrial biotechnology is competing with human space on less than one third of our planets surface, marine biotechnology is an under-exploited pool of resources for biobased production and biotechnology. Over 90% of known taxa are represented in the sea which holds an immense biodiversity and several phyla of animal kingdom are exclusively aquatic. The oceans provide different extreme environmental conditions and marine organisms had to adapt their physiology in unique ways, sometimes different to what we know from terrestrial life and therefore posses uniquely diverse genetic, biochemical and physiological characteristics. It should also be noted that this is a young and emerging sector, whose main impacts are likely to be seen in the future.

2. *Measures aimed towards dealing with the location related specificities of marine biotechnology*

   - making coastal regions attractive places to live, work and invest.
   - identifying and supporting the activities having a future.

3. *Measures aimed towards strengthening biotechnology capabilities in these regions*

   - learn from previous work on biotechnology and adapt to specific requirements.
   - support RTD, innovation, and technology transfer; the great promise of marine biotechnology is based on the enormous and unexplored diversity of the oceans; as marine biotechnology is at an early phase of development, support should be stronger for the production of knowledge, on which the production of goods and services will be based. A particular issue with bioprospecting is IPRs and the exploitation of genetic resources in areas beyond national jurisdiction.

In May 2007, the European Commission invited 40 experts from academia, industry and policy to consider marine biotechnology research **(the Bremen meeting[5])**. They pointed to the role of research in generating new knowledge to enable the diverse marine resources to be exploited and its potential realised in a sustainable manner, and noted that such research would benefit not only the marine sector but, as it requires multi-disciplinary input, would also stimulate other sectors such as medicine, food, pharmaceuticals, etc. It urged that basic scientific research should also be maintained to preserve a foundation of basic scientific excellence which underpins the development of marine biotechnology.

The Bremen meeting pinpointed again the Framework Programme as an appropriate vehicle for delivery, particularly in conjunction with national initiatives. However it recognised that research would only have a powerful effect on the long term development of marine biotechnology if co-ordinated and targeted, particularly within a reality of limited resources. It called for the development of a clear strategy for research and the definition of priority research areas along with desired impacts in order to maximise the research effort.

[4] http://ec.europa.eu/maritimeaffairs/pdf/SEC(2006)_689%20_10.pdf
[5] http://ec.europa.eu/research/press/2007/maritime-briefing/pdf/37-bremen-marine-biotechnology-research_en.pdf

The **EC-US Task Force on Biotechnology Research October 2008 workshop in Monaco**[6] focused on marine genomics in relation to microbial species. Microbes play an important role in the marine and indeed global ecosystem and it is suspected that they are responsible for much biological activity. Metagenomics enables microbial species that cannot be cultivated in the laboratory to be studied and has uncovered new information on the bioactivity potential in this biota. Great advances have been made in this and other "omics" technologies that have vast implications for basic scientific research as well as biotechnology research. Whilst highlighting scientific research opportunities, the workshop also stressed the need for research to strengthen Europe's bioinformatics research capability.

The EC delivered a **European Strategy for Marine and Maritime Research**[7] in September 2008, which prioritised marine biodiversity and biotechnology research, and recognised its potential to contribute new knowledge on which to base high value added products and processes through excellent scientific research.

Marine biotechnology is not confined to marine applications and as pointed out in many reports, already contributes to different sectors with notable success. There is now a widespread commercial interest in marine micro-organisms due to the potential of the marine environment to provide unique sources of enzymes and new bioactive molecules with wide application.

Future research priorities should aim to improve the process of biodiscovery and increase the yield of economically important materials from marine organisms. However, the need to expand our research capabilities in these areas is also recognised. There is a strong desire and need to improve the tools that can help with the entire biodiscovery process from the systematic screening of marine organisms for novel proteins, therapeutics, bioactives and other compounds to the eventual production of commercially valuable end products. To achieve this, the use of genomics (including metagenomics) to explore marine resources is increasing.

It is against the background drawn up above that the **Coordinated Working Group on Marine Biotechnology** (**CWG-MB**) was proposed by the KBBE-net and which informs much of the rationale for this paper. In drawing together the multi-state viewpoint, the paper conforms many of the earlier outputs from EC reports and initiatives on marine biotechnology.

There are challenges to be faced in expanding on the research priorities highlighted. This study responds to policy requests in identifying specific areas of research, insights to applications for marine biotechnology as well as an overview of the status of marine biotechnology research in Europe.

5. Identified common themes and areas with potential for collaborations

The CWG-MB made an inventory of the participating countries' priorities within marine biotechnology activities, as expressed in strategies and/or research programmes and projects (appendix 1). From this, four main areas of marine biotechnology applications were identified where trans-European collaborations could give synergies and strengthen European knowledge and development:

- Marine Bioprospecting/Biodiscovery for commercial developments of novel products, including for food and feed.
- Genomics in production and model organisms, including the exploitation of microbial metagenomics.
- Molecular aquaculture, i.e Molecular technologies in aquaculture.
- Biomass production: development and application of new effective systems for biomass production, use and transformation

Below, these areas will be briefly discussed and exemplified. The list is not comprehensive and more work will be needed to extract the full trans-European potential embedded in this information.

[6] http://ec.europa.eu/research/biotechnology/ec-us/workshop_past_en.html

[7] http://ec.europa.eu/research/press/2008/pdf/com_2008_534_en.pdf

5.1 Biodiscovery / Bioprospecting

Biodiscovery is here understood as the systematic search in the marine environment, for new biological activities and biochemical pathways that can be used for the production of goods, knowledge and services. It is to be understood that when we use this term we do not mean the systematic and continuing harvesting of natural living bioresources from the sea, following the discovery of some new use for marine molecules or biomaterials, but rather use new knowledge in controlled and sustainable systems. Themes of active interest differs somewhat among countries, but this theme stands out as the one where all countries have one or more ongoing activities and follow up strategies. Fields of interest are:

- Marine micro-organisms: They include yeasts, protists, bacteria, archaea and viruses. These microorganisms are often sampled from extreme habitats exposed to extreme temperatures, high pressure or high radiation. Marine microbiology is a very active field of research and benefits from the emergence of new culture independent approaches like automated sensing technologies and metagenomics. However, culture dependent approaches are still awaiting innovation to keep pace with more recent technologies.
- In these organisms enzymes with special properties, specialized products, secondary metabolites, molecules with pharmaceutical potentials and materials with new properties are searched for. Biomolecules within this diverse class of molecular properties can be envisaged in applications to produce new biomaterials.

- Food and feed supplements from the marine environment are believed to have interesting properties not found in those from terrestrial organisms. This relates to special lipids for functional food (omega 3 fatty acids, carotenoids), proteins, enzymes and other molecules. In addition, marine organisms do not carry diseases that are likely to be capable of spreading to humans (zoonoses), which in itself is an argument to develop food and feed biotechnology from the marine environment.

  Most partners have activities related to this field.

- Marine macro organisms: This field includes species, mostly invertebrates targeted directly for their active compounds and also byproducts generated from fisheries and aquaculture. Most current marine biotechnology successes are from invertebrates (tunicates, bryozoa, sponges, molluscs, etc.). They are investigated for the identification and characterization of lead compounds in the area of drug discovery and most of the areas mentioned above. Following these investigations, zicotinamide (Prialt), a peptide toxin from cone snails was approved in 2004 for chronic pain treatment and in 2009, 16 compounds derived form marine natural products are under evaluation in anticancer clinical trials with one product in clinical use (Yondelis™). Moreover a comeback of natural products (NP), including marine NP (MNP) is on the agenda of pharmacologists. Other MNP such as fluorescent proteins are also of high interest for functional imagery.

  However, the main obstacles to efficient exploitation of these marine resources for biotechnology are legal access and sustainable supply. The latter emphasis the need for establishing and improving culture conditions, the use of model organisms and development of synthetic biology.

5.2 Reference marine organisms and systems

In order to access the metabolic diversity of marine organisms, the application of genomics and metagenomics is essential. The proportion of known and culturable organisms is very low (<1%), and there is the added complication that symbionts in marine invertebrates, which so far are very difficult to culture on their own, are responsible for many interesting bioactive compounds. Classical molecular technologies also need to be adapted for use in the setting of marine biotechnology, as there is a lack of widely-usable promoters, cloning tools and amenable host organisms for marine bioresearch and biodiscovery purposes.

Moving beyond micro-organisms, there is also a need to understand invertebrate genomic organisation and activity, not only in the context of symbionts relationships. Mass cultivation of invertebrate cells is still an enormous challenge, yet is needed for full utilisation of novel and commercially-interesting bioactives from this source. Whether or not the molecules arise from the symbionts co-existing with the invertebrates such as sponges, sea-fans, sea-cucumbers and squirts, additional work is needed to establish reliable and reproducible methods and engineered systems for pre-commercial and commercial-scale production.

The integration of genetics, genomics, transcriptomics, proteomics, metabolomics, interactomics etc, will allow the development of reference organisms representing the different marine genera and families, that will then allow faster analysis and transfer of knowledge for other useful purposes, much like the role of *E. coli* to study biochemical processes or cell biology, *Saccharomyces cerevisiae as a model for a eukaryote cell, Arabidopsis* for the development of plant biotechnology, *Pichia pastoris* for industrial biotechnology and *Caenorhabditis, Oikopleura, Zebrafish* and *Drosophila* for developmental biology. Crucial for the establishment of reference organisms and molecular toolbox dedicated to marine biotechnology are central repositories which guarantee reproducibility and uniformity of tests across the world.

Metagenomic approaches are necessary to understand to make use of knowledge arising from complex marine biosystems. Examples of which are the role of microorganisms in invertebrate-symbiont relationships and marine biofilms. They are important not only in themselves, but because increased understanding of these complex interactions, which are either unculturable or where culture destroys the inherent complexity, will lead to a better understanding of areas as diverse as biogeochemistry and its impacts on climate change, the role of biodiversity in maintaining or changing ecological balance, the impact and management of pollutants in the sea, cell-cell signalling in mammalian health and disease and management of biofouling in both aquatic and terrestrial conditions. In addition metagenomic approaches also have potential for new biomolecule discoveries. Especially enzymes with new and useful properties in industrial processes, analytical methods and consumer products.

Synthetic genomics is the next frontier of application of biological and genetic knowledge. We already see that Exxon-Mobil and the US company Synthetic Genomics are planning to spend $600M on tailoring organisms for production of biofuels. While not suggesting that Europe should seek to tackle the same goal, we see that funding research into synthetic genomics of marine microbes may illuminate and let us make use of their unique biochemistries. Modifying or de novo designing the genome of a novel species of biotechnological interest is within the range of 10 years. Establishing model marine organisms will assist in this process.

5.3 Molecular Aquaculture

The term molecular aquaculture is used to distinguish marine biotechnology relevant activities within aquaculture from the more production related activities. In practice this means the application of standard molecular biotechnologies, such as -omics technologies when addressing aquaculture challenges.

Despite diverse species interests (fish to shellfish) among the partners, there can be foreseen a trans European potential in this area. The biotechnological aspects can be applied in the understanding of the genomes through sequencing and further building genotype phenotype understanding. This knowledge will subsequently be applied in the health, feed and breeding areas (MAB, Marker Assisted Breeding), as well as to understand ecosystem behaviour when bred species are introduced through escapes. Basic ecosystem understanding will also be developed through the understanding of domesticated marine organisms' genomes giving possibilities to gain knowledge about population behaviour and how to maintain sustainable wild stocks.

The field of molecular aquaculture should be further elaborated in close cooperation with relevant industries and universities.

The probable future development of gene modified production organisms (GMO) can be foreseen, and a concerted European effort in the area of molecular aquaculture will provide a solid knowledge base for the evaluation of food safety and human health effects. Through such activities the social acceptance should also be addressed and discussed openly.

5.4 Biomass production, use and transformation

In order to establish successful industrial production of useful materials and molecules from marine [non-vertebrate] organisms it will be necessary to work out some way of growing sufficient biomass to make production economic. It is absolutely inconceivable that harvesting from the wild will be feasible, not only because of economic reasons of physically obtaining enough biomass, but also not the least because of ecological and ethical reasons that recognise the need not to damage biodiversity. The exception may be the harvesting of macroalgae (seaweeds), but even in this case, industrial economics will probably dictate a need to establish a viable biomass production and harvesting method. An understanding of the biology of marine organisms provides the bedrock to biomass production, but interdisciplinary work is required, with interaction with genetics/genomics, marine biology, industrial biotechnology, chemical and process engineering, micro-technologies and others.

In addition, it is not likely that one, single biomass production system can answer the needs of all possible organisms. Algae can rapidly grow in various aquatic environments, also in some extreme conditions, They fix carbon by photosynthesis (using CO_2 + sunlight) to produce biofuels, foods and fine chemicals. Cultivation of microalgal biomass in open ponds, especially in sunny and temperate region, could be very economic. Such open pond biomass production is not thought feasible in higher latitudes of Europe, or areas with no access to the sea or freshwater. Closed systems involving photobioreactors are considered necessary, with implications of high cost and need for high-value outputs. Innovative photo bioreactors should be developed to overcome the difficulties in conventional fermentation.High current cost of such systems can also drive technological advances. However, due to the CO_2 capture inherent in these processes, the climate change agenda could also be a driver to develop this field.

The algal biorefinery concept is being developed with help of relevant calls in FP7, and the potential of algae (macro and micro) for bioenergy production is being investigated through trans-EU projects (eg Interreg's BioMara) and national funding support (eg the Carbon Trust in the UK and ITI Energy in Scotland). Trans-national programmes are highly-relevant to make biomass production from marine organisms economically viable and to ensure a sustainable production.

In addition to those partners already active in this field, most partners see a potential to develop activities within the area of biomass production technologies for products adapted to local strategies and possibilities.

6. R & D tools

To address the R&D challenges within marine biotechnology, access to and development of generic -omic tools on a similar level as all kinds of biotechnology need to be addressed. Common arenas and generic tools for all biotech exists, but specific knowledge and competence needs to be developed relevant to the marine area. An effort in marine biotechnology must address this and map the needs for specific marine biotech tools (methods, infrastructure, instrumentations, etc.) Such can be:

- Model organisms and cell cultures from the marine environment are important tools to develop further and make available on a broad scale.
- Reference sequences for selected marine species are needed within molecular aquaculture for improved knowledge and sustainable production of marine organisms.
- Bioinformatics infrastructures: The amount of data produced in marine biotechnological activities is becoming computationally intractable with existing resources and pipelines and is already outpacing the ability of scientists to analyse it. In order to meet this challenges of managing, interpreting and using the data at an ever increasing rate, a major effort has to be spent in the construction of bioinformatics infrastructure, integration and standardisations. This needs to be addressed in close synergy with already established and planned structures and networks like ELIXIR and EMBRACE .
- Standardised and commonly available databases, biobanks and culture collections and central repositories of model organisms must be developed to foster trans-European initiatives within bioprospecting.
- High throughput screening technologies: improving the tools that can help the systematic screening of marine organisms for novel proteins, therapeutics, bioactives and other compounds to the eventual production of commercially valuable end products.
- Efficient bench to market chains should be identified to realise the potential e.g. within bioprospecting.
- Legal and intellectual property frameworks relevant for an international environment.

7. Industrial and Marine Biotech

To stimulate industry involvement, the European Technology Platforms (ETPs) may have a crucial role as they may address specific issues related to marine biotechnology in their programs. Especially the European Aquaculture Technology & Innovation Platform (EATIP) may have an important role in the uptake of marine biotechnology in addition to the other ETPs related to KBBE, such as Suschem, Biofuels and Plants for the Future. A coordination activity for marine biotechnology at European level would bring together the relevant aspects of each of these existing platforms and add value to their own activities.

All partner countries have industries applying biotechnology to produce value from marine sources. Such products varies from simple bulk chemicals like e.g. chitosans to high value enzymes and pharmaceuticals. Industrial uptake of marine biotechnology is rather limited although numerous applications may be envisioned to have large potentials and impacts.

8. International

The US and Australia have on several occasions expressed their interest in collaboration with the EU and European countries in the field of marine biotechnology. The most recent meeting of the EC-US Task Force on biotechnology research, in Monaco, was on marine biotechnology and concluded that more cooperation between developed and developing countries needs to be established to accomplish research and development using marine genomic resources. This is partly to build on work done by EU projects such as the 'Marine Genomics Europe' Network of Excellence, and partly to ensure that training, standards, and other aspects of knowledge transfer take place on the international scale.

There are many bilateral Memoranda of Understanding in place between the European Commission, representing the EU, and other nations, which are for the purpose of fostering international research and innovation. Calls in FP7 that contain SICAs (specific international cooperation actions) oblige European partners to bring the EC's International Cooperation Partner Countries (ICPCs) into consortia and ensure that their role is not just cosmetic.

We propose that there should be a strategic approach to international cooperation in marine biotechnology. A first stage would be to collate the list of MoUs and ICPCs, and actively identify opportunities for collaboration, based on research and innovation topics as well as on the strengths of specific institutes, research groups and industrial activities in those countries.

In addition, it is clear that a number of countries already have significant activities in marine biotechnology, and it is important for Europe to be able to take advantage of opportunities to work with these. Europe should at least aim to engage in best-practice knowledge and technology transfer actions with these countries, outward and inward. They include USA, Canada, Brazil, Chile, China, India, Australia, New Zealand and South Africa.

Bringing genomics to optimal development in marine biotechnology and setting up databases of information and knowledge will be a major achievement, the sharing of information and infrastructures will be a very important aspect to stimulate innovation in this field for the benefit of society.

Asia is the world's most important region for aquaculture. Collaboration should therefore also be stimulated with this continent, not only in the field of molecular aquaculture and in utilisation of farmed species for non-food uses, but in marine biotechnology in general.

Common interests may be discovered in workshops bringing together the major stakeholders in marine biotech from the different continents. This may be organised as satellite meetings of planned international meetings or could be a role of a future KBBE-Net Marine Biotechnology networking action group.

9. Future Tasks / Objectives

For future development of the activities of the CWG-MB, participants have expressed the desirability of funding possibilities for the coordination activities as time investment and travel costs are sometimes difficult to justify to the parent organisations. Discussions have been started on ways to continue the CWG-MB activities on how to make priority settings for developing the field.

To establish a transeuropean initiative, future work of the CWG-MB may focus on the following:

- In a stepwise manner, propose priority settings aiming at a Strategic Research Agenda (SRA).

- Providing more detailed inventories in the areas of:
    - mapping of available collections of marine organisms and infrastructure needs, envisioned in collaboration with ESFRI (EMBRC)[8].
    - mapping of database and ICT requirements for -omics applications in marine biotechnology in connection to marine collections, bioprospecting / biodiscovery and molecular aquaculture applications.
    - mapping of national strategies and programs, defining gaps, etc.
- Development of common approaches to research priorities.
- Systematic exchanges and development of complementary programmes.
- Defining industry involvement and interest and ensuring industry participation.
- To ensure uptake of marine biotechnology by the industry, mapping of the marine biotech industry across Europe may be envisioned.
- Addressing issues for regulation and IP.
- Finding funding possibilities for future work of CWG-MB and the development of the fields in the form of a CSA/SA or ERA net. Other funding in the field of marine biotech may be found with INTERREG, capacities program, ESFRI, etc depending on the goal aimed for.

These activities are likely to bring together many other stakeholders and existing activities within Europe, including the Framework Programme, Platforms, international collaborations and relevant learned societies and industry associations.

[8] http://admin.webstar.be/content/Ogilvy/ECCR/eMailing/1402/01_TEN_NEW_PROJECTS.pdf

10. Recommendations

- Agree on a priority setting effort to elaborate on the identified issues.
- Framework program: Four specific themes have been identified where a transeuropean approach will bring benefits and where the outcomes will feed directly into the KBBE and related priorities, specifically biodiscovery / bioprospecting, molecular aquaculture, biomass production and all combined with the identified essential R&D tools. A specific focus may be given to systems and synthetic biology when new genomes or organisation of genomes may become available from marine genomics projects.
- Education and training: Through the framework program collaboration and integration of research institutes to address specific needs in education and training in the field of marine biotechnology. Bring together crosscutting disciplines such as marine biology, biotechnology, bio-informatics, systems biology, synthetic biology, nanobiology, chemistry, biophysics, taxonomy, etc.
- CWG further tasks: Call for contributions from more member and associated states to the work of the CWG to elaborate on the future tasks and objectives, especially on the mapping of infrastructure and collections.
- International collaborations: A strategic approach is indicated to international collaborations in marine biotechnology, in order for Europe to benefit from advances outside Europe.
- Support for infrastructure for:
    - culture collections-bioresources.
    - infrastructure for bio-informatics and databases.
- CWG recommends its activities and future plans to be further elaborated. In order not to lose the momentum. To overcome barriers accompanied with travelling and meeting, a CSA/SA type of collaboration would be beneficial.

Appendix 1 - Matrix of national activities and programs

Common matrix on topics for CWG-MB				2nd meeting 28.11.2008			
					X...: Have activities - no priorities listed		
Presenting country	**Bioprospecting (enzymes, misc. compounds, fouling control, biobanks, analysis, access rights, pharmaceuticals, chemistry)**	**Microbiology (included in the other themes?) (global change is addressed in other calls, to be included are MB related challenges, e.g. environmental, ...)**	**Marine organism diseases (Vaccines, ...)**	**Marine organism genomics (fish, shellfish, shrimp, algae, microalgae, metagenomics, model organisms,)**	**Aquaculture (nutrition, feed, ...)**	**Biomass production (Photobioreactors, sustainable production, biorefineries, biofuels)**	**Functional food ( )**
Belgium	**Metabolomics, pathways**		aquaculture	**Model organisms, metagenomics**	feed prod	**Biofuels, etc...**	omega 3, lipids, chitosan etc
Germany	**Compounds, biobanks, analysis**	Cell biology, stem cells	Infectious diseases, fish banks	**XXX**	**XX (proteins)**	**Biomass algae**	omega 3, lipids, chitosan etc
Denmark	**Bioprospecting**	genomics, ecology, bio-geochemistry	xxx	fish (trout, turbot)	feed prod	XXX	**Omega 3, lipids, chitosan etc**
Spain							
France	**Biodiversity, cultivating the uncultured, biopolymers, secondary metabolites, enzymes**	XXX	**Fish and oyster disease**	**Molluscs, fish, algae**	feed optimiz, QTL/ECL assisted selection	**Biorefineries, biofuels**	Omega 3, lipids, biopolymers, etc
Greece							
Irland	**Bioprospecting (human disease, health & spesific applications)**	XXX	fish and oyster disease	**Metagenomics, marine algae**	Seaweed, cod		XXX
Norway	**Secondary metabolites, enzymes, biopolymers, biobanks**		**Aquaculture, diseases, fish**	**Cod & Salmon genomics, metagenomics**	**XXX**	XX	omega 3, lipids, chitosan etc
Slovenia							
Sweden							
United Kingdom	Bioprospecting	X	?	XXX	XX	XXX	XXX
Turkey	pharmaceuticals, biobanks, chemistry	XX	**Vaccines, aquaculture diseases, 3**	fish, microalgae,	**XXX 1**	**XXX 2**	**Food supplements 4**

Appendix 2 - FP6 and FP7 Research Projects in the area of Marine Biotechnology

The European Union (EU) has been and is supporting the improvement of knowledge, human potential and infrastructure for underpinning the development of marine biotechnology throughout Europe and beyond. The EU's actions in field have a structuring effect and aim at ensuring that Europe remains one of the key players in this rapidly evolving and very promising field of science and technology. New initiatives under the Seventh Framework Programme (FP7) are continuing and deepening the development of the European Research Area (ERA) in the field of Life Sciences, by stimulating in a systematic way the sharing of common 'omic' resources. Below, are displayed some previous and on-going key European initiatives with relevance to marine biotechnology:

RESEARCH PROJECTS IN 6TH FRAMEWORK PROGRAMME

FISH & CHIPS: Towards DNA chip technology as a standard analytical tool for the identification of marine organisms in biodiversity and ecosystem science

Call number: FP6-2002-GLOBAL-1
Contract number: 505491
Contract type: Specific Targeted Research Project
Starting Date: 01/01/2004
Duration (months): 39
Project website: http://www.fish-and-chips.unibremen.de
DG responsible: DG RTD
Total Project Cost: 2.245.159,00
EC Contribution: 1.599.872,00
Actionline: Cost effective, reliable and efficient technologies for enabling progress in biodiversity and ecosystem science

Coordinator Prof. Blohm Dietmar, CENTRE FOR APPLIED GENSENSORIK AT THE UNIVERSITY OF BREMEN

Sustainable development is a fundamental goal of the European Union and loss of biodiversity is emphasised as one of the main threats to it. However, biodiversity and ecosystems of European Seas are under human impact, such as pollution, eutrophication, and overfishing.
Therefore it is necessary to monitor changes in biodiversity and ecosystem functioning. The aim of the project is the development of DNA chips for the identification of marine organisms in European Seas as a cost effective, reliable and efficient technology in biodiversity and ecosystem science. Many marine organisms, such as eggs and larvae of fishes, plankton, and benthic invertebrates, are difficult to identify by morphological characters. The classical methods are extremely time consuming and require a high degree of taxonomie expertise.
Consequently, the basic step of identifying such organisms is a major bottleneck in biodiversity and ecosystem science. Therefore, the project seeks to demonstrate that DNA chips can be a new powerful and innovative tool for the identification of marine organisms. Three DNA chips for the identification of fishes, phytoplankton, and invertebrates of European Seas will be developed. These chips will facilitate research on dispersal of ichthyoplankton, monitoring of phytoplankton, and identification of bioindicators as well as prey in gut contents analysis. To achieve this goal a combined biological and technical approach has been initiated:
The biological material will be sampled by marine biologists. The next step is the sequencing of suitable molecular markers for probe design. The technical part consists mainly in constructing gene probe libraries and determining their specificity. This will be done by biotech research centres in connection with SMEs engaged in bioinformatics and DNA chip technology. Therefore the project has the potential to bring Europe's marine biotechnology to the forefront of this field.

MARBEF: Marine biodiversity and ecosystem functioning

Call number: FP6-2002-GLOBAL-1
Contract number: 505446
Contract type: Network of Excellence
Starting Date: 01/02/2004
Duration (months): 60
Project website: http://www.marbef.org
DG responsible: DG RTD
Total Project Cost: 8.707.000,00
EC Contribution: 8.707.000,00
Actionline: Network to structure and integrate European research on marine biodiversity and ecosystems

Coordinator Mr Heip Carlo, NEDERLANDS INSTITUUT VOOR ECOLOGIE- The Netherlands

Knowledge on marine biodiversity in Europe is fragmented within and between disciplines. The approach to understanding the effects of increased anthropogenic pressure on marine biodiversity has hitherto been ad hoc and local. In particular, to understand how marine ecosystems will adapt to climate change, we need addressing especially the longterm and large-scale changes in marine biodiversity. This requires an entirely new research framework. The creation of the network of excellence MARBEF (Marine Biodiversity and Ecosystem Functioning) aims at integrating research efforts by forming a dedicated group of marine scientists and institutes and creating a virtual European institute with a longterm research programme and dedicated links with industry and the public at large. This involves besides coordination of research the training, exchange and outreach activities in several relevant fields of science, including marine ecology and biogeochemistry, fisheries biology, taxonomy and socioeconomic sciences. Better integration of research is also required to support the legal obligations of the EU and its Member States and associated states for the Convention for Biological Diversity, the OSPAR and Barcelona conventions as well as several EU directives (Bird Directive, Habitat Directive, Water Framework Directive). Society needs this information because a large and growing number of industries depend on the sustainable use and exploitation of marine biodiversity. This includes tourism, fisheries and aquaculture but also new industries that explore and commercialise marine genetic and chemical products.

MARINE GENOMICS: Implementation of high-throughput genomic approaches to investigate the functioning of marine ecosystems and the biology of marine organisms.

Call number: FP6-2002-GLOBAL-1
Contract number: 505403
Contract type: Network of Excellence
Starting Date: 01/03/2004
Duration (months): 48
Project website: http://www.marine-genomics-europe.org
DG responsible: DG RTD
Total Project Cost: 10.000.001,00
EC Contribution: 10.000.000,00
Actionline: Developing genomics approaches

Coordinator Mr Stephan Ronan FIST S.A. — FRANCE INNOVATION SCIENTIFIQUE ET TRANSFERT — France

The overall aim of this project is to set up and develop a European Network of Excellence, referred to as ‘Marine Genomics Europe’, for the implementation of high-throughput genomic approaches in the biology of marine organisms. ‘Marine Genomics Europe’ will promote, develop, and spread throughout the European Union a broad range of genomic approaches, to investigate a wide range of questions related to the functioning of marine ecosystems and to the biology of marine organisms. With this aim in view, we propose to group and network experts in genomics, proteomics, and bioinformatics from several centres of excellence in genomics in Europe with marine biologists who can make use of highthroughput genomics data. This will involve the dedication and the development of common research infrastructures, both in genomics and in marine biology. Joining together these distinct scientific communities will establish Europe’s lead in marine genomics. The J.E.R. of ‘Marine Genomics Europe’ is broken down into comparative, functional and environmental genomics, three sections which structure more traditional streamlines, leading to various microbial, algal, evolution development and diversity, and fish and shellfish nodes. This research can be applied to the management of marine resources (prediction of global changes in marine populations, conservation of biodiversity, fisheries management and improvement of aquacultured species) and to gene mining for health and biotechnology.
The Integration effort of Marine Genomics Europe is based on the following strategies:
(i) jointly develop enabling technologies; (ii) sharing existing technical platforms; (iii) collectively gaining access to major Genomic centres; (iv) regrouping under a common Bioinformatics Centre; and (v), create and develop a Knowledge and Communication System.Spreading activities will include workshops and courses implemented by a Training & Education Council.

HERMES: Hotspot Ecosystem Research on the Margins of European Seas

Call number: FP6-2003-Global-2
Contract number: 511234
Contract type: Integrated Project
Starting Date: 01/04/2005
Duration (months): 48
Project website: http://www.eu-hermes.net/

DG responsible: DG RTD
Total Project Cost: 21.828.715,00
EC Contribution: 14.999.974,00
Actionline: Integrated research on ecosystems lying in the deeper ocean section

Coordinator Prof. Weaver Philip NATIONAL OCEANGRAPHIC CENTRE— United Kingdom

HERMES is designed to gain new insights into the biodiversity, structure, function and dynamics of ecosystems along Europe's deep-ocean margin. It represents the first major attempt to understand European deep-water ecosystems and their environment in an integrated way by bringing together expertise in biodiversity, geology, sedimentology, physical oceanography, microbiology and biogeochemistry, so that the generic relationship between biodiversity and ecosystem functioning can be understood. Study sites will extend from the
Arctic to the Black Sea and include open slopes, where landslides and deep-ocean circulation affect ecosystem development, and biodiversity hotspots, such as cold seeps, cold-water coral mounds, canyons and anoxic environments, where the geosphere and hydrosphere influence the biosphere through escape of fluids, presence of gas hydrates and deep-water currents. These important systems require urgent study because of their possible biological fragility, unique genetic resources, global relevance to carbon cycling and possible susceptibility
to global change and man-made disturbances. Past changes, including catastrophic events, will be assessed using sediment archives. We will make estimates of the flow rates of methane from the geosphere and calculate how much is utilised by benthic communities, leaving the residual contribution to reach the atmosphere as a greenhouse gas. HERMES will enable forecasting of biodiversity change in relation to natural and man-made environmental changes by developing the first comprehensive pan-European margin Geographic Information System. This will provide a framework for integrating science, environmental modelling and socioeconomic indicators in ecosystem management. The results will underpin the development of a comprehensive European Ocean and Seas Integrated Governance Policy enabling risk assessment, management, conservation and rehabilitation options for margine cosystems.

SPONGES: Sustainable production, Physiology, Oceanography, Natural products, Genetics and Economics of Sponges

Call number: FP6-2003-SME-1
Contract number: 17800
Contract type: SMEs-Co-operative research projects
Starting Date: 01/11/2005
Duration (months): 24
Project website: http://www.sponges.nl
DG responsible: DG RTD
Total Project Cost: 1.999.790,00
EC Contribution: 1.441.901,00
Actionline: Co-operative Research (all areas of science and technology)

Coordinator Prof. Müller Werner E.G. INSTITUT FUR PHYSIOLOGISCHE CHEMIE, ABTEILUNG ANGEWANDTE MOLEKULARBIOLOGIE, JOHANNES GUTENBERG UNIVERSITAT — Germany

Many marine sponges contain natural compounds that have potential interest to society. Limited possibilities to supply these compounds from natural resources often delays or even stops further development of a product after its initial discovery. In the SPONGES project, systems and processes for the cultivation of marine sponges and subsequent recovery of their natural products will be developed in order to create a stable and sustainable supply and reduce pressures on natural resources. Sponges are regarded as extremely difficult to culture, most likely as a result of our limited knowledge on the biology of these animals. The SPONGES consortium represents a combination of expertise that is unique in the world and the project is one of the most comprehensive research efforts ever to tackle the persisting challenge of growing sponges in tanks. The main objectives of SPONGES are: 1) sponge culture to obtain sponge natural products. Culture methods to be developed within SPONGES include techniques on three different levels of technological complexity: (i) sea based culture; (ii) land-based culture in tanks using natural seawater; (iii) closed land-based culture systems. These are the most challenging techniques to develop in terms of technological complexity, but also the most desired techniques with respect to control of production processes. Hence, a major part of the research efforts within SPONGES will be dedicated to the establishment of these systems, which include both the cultivation of functional sponges in enclosures and the cultivation of sponge primmorphs
(cellular aggregates obtained from dissociated cells) in bioreactors; 2) understanding sponges physiology, ecology and genetics. An upgrade of our fundamental understanding of sponges is needed to improve our abilities to farm these animals.
In SPONGES, ecological and physiological aspects are studied. The knowledge obtained will be converted into system engineering and process optimization. In addition, the genetic background of growth and secondary metabolism of sponges are studied in order to rationalize strategies to improve culture techniques; 3) process design and economic perspectives. In order to achieve the main goal — commercial sponge cultivation — the optimized basic procedures

need to be up-scaled and validated. Market analyses will be executed and business plans will be presented for each individual technique developed as well as for the integrated sponge culture technology.
The project will strongly improve the competitive position of Europe in marine biotechnology and is expected to generate new products for the market.

AQUABREEDING: Towards enhanced and sustainable use of genetics and breeding in the European aquaculture industry

Call number: FP6-2005-SSP-5A
Contract number: 044424
Contract type: Specific Support Action
Starting Date: 01/12/2006
Duration (months): 24
Project website: http://www.aquabreeding.eu
DG responsible: DG MARE
Total Project Cost: 236.614,00
EC Contribution: 236.614,00
Actionline: The modernisation and sustainability of fisheries policies

Coordinator Mr Chavanne Hervé ISTITUTO SPERIMENTALE ITALIANO 'LAZZARO SPALLANZANI' — Italy

The European aquaculture industry is a dynamic production sector characterized by a large variety of cultivated species and various rearing environments. The industry, although heterogeneous in size and type, is willing to collaborate with research organisations to tackle the problems inherent to any young production system but also to invest in strategic areas. Genetic improvement represents a crucial area for any industry whose activities depend on the trade of improved 'seeds' in both the plant and animal production sectors. When we consider the commitments made by the aquaculture sector in the area of genetic improvement, the industry can be divided into two halves. On one side pioneering companies have developed sophisticated selection programs and are now investing in the application of new technologies to their breeding systems. On the other side are the small producers which have either set up sporadic breeding activities or have not invested at all in breeding and are still using unselected broodstock. The project tackles this imbalance through the following objectives:
1) definition of the research priorities of the industry already involved in aquaculture breeding,
2) promotion of knowledge dissemination to support a major involvement of the entire industry in breeding activities,
3) creation of the conditions for a progressive integration of the European aquaculture industry into the FABRE Technology Platform.
The output of this project will consist of the definition of a strategic research agenda for the aquaculture sector in relation to breeding techniques and the provision of a vision paper defining the needs of the industry within the remit of the Technology Platform on Animal Breeding. The project also intends to increase the awareness within the entire industry of the benefits of implementing breeding activities and the use of genomic tools in the production of aquaculture species and by doing this assist in addressing the imbalance described above.

AQUAFUNC: Integrated knowledge on functional genomics in sustainable aquaculture

Call number: FP6-2004-SSP-4
Contract number: 22685
Contract type: Specific Support Action
Starting Date: 01/11/2005
Duration (months): 24
Project website: http://genomics.aquacultureeurope.org/
DG responsible: DG MARE
Total Project Cost: 177.469,00
EC Contribution: 177.120,00
Actionline: The modernisation and sustainability of fisheries policies

Coordinator Dr Sundell Kristina UNIVERSITY OF GOTEBORG— Sweden

A number of projects, using molecular technologies and a functional genomics approach to improve sustainability of European aquaculture, have been funded within the EU 5th and 6th frame work program. An integration of the outcome of these projects would undoubtedly contribute to build a large common knowledge base in this area. A synthesis of the different data sets can be expected to have a leverage effect, creating a more significant output than he sum of the individual projects. Integration and communication of the different projects outcome would also reduce possible overlap both currently and in the future. Bringing together large number of research groups/projects in a common forum should generate a critical mass and improve European and International visibility in this important area of production. he overall aim of the present project is to integrate the outcome of the projects within Framework Program

5 and 6 that concern genome mapping and functional genomics n aquaculture, in order to generate a common scientific basis of a functional genomics approach o aquaculture. This will be achieved through a series of instruments including work group meetings, analyse and combining of results in joint scientific publications as well as the creation of a common Internet site containing both public and restricted, accessible for registered scientific members, areas.

BIODIVERSA: An ERA-Net in Biodiversity Research

Call number: ERA-NET/1/CA-SSA
Contract number: 517836
Contract type: Coordination action
Starting Date: 01/05/2005
Duration (months): 48
Project website: http://www.eurobiodiversa.org
DG responsible: DG RTD
Total Project Cost: 2.837.440,00
EC Contribution: 2.837.440,00
Actionline: Networking of national or regional programmes or parts of programmes; actors: public authorities, research agencies, open call for proposals (ERA-NETs)

Coordinator Ms Deschamps Anne-Marie INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE — France

BIODIVERSA is an ERA Net involving 15 countries and 19 major research funding agencies in Europe with significant research funding in the field of terrestrial, freshwater and marine biodiversity. Most ERA-Net members are represented on other fora which discuss and recommend requirements for European biodiversity research: including the Convention for Biological Diversity (CBD-SBSTTA), Diversitas, the European Platform for Biodiversity Research Strategy (EPBRS) and the European Science Foundation (ESF). Recommendations from these fora are often made without a formal mechanism to ensure connection with the strategies, priorities and budgets of national research funding agencies. The aim of BIODIVERSA is to contribute to setting up such a mechanism, and its objective for the period 2004- 2008 is to achieve an efficient trans-national research cooperation in the field of biodiversity research funding. With the aim of contributing to the implementation of the EU Biodiversity Strategy, BiodivERsA will allow the funding agencies to collate existing activities, compare future strategies and recommendations of consultative bodies, and systematically explore opportunities for future collaboration. BIODIVERSA will also contribute to better coherence and increased synergies between the national programmes of cooperation with developing countries in the field of biodiversity research funding. In order to achieve this, BIODIVERSA will proceed through seven stages: (i) inventory, description and classification of biodiversity research programmes and research funding programmes of ERA-Net members; (ii) information gathering and linkage of ERA-Net members funding programmes with developing countries; (iii) identification of best practices to be compared, shared and implemented among the participants; (iv) identification of the existing opportunities for cooperation; (v) identification of administrative, legal and technical barriers to cooperation.

ERATS: Ecological risk-assessment of transgenic fish

Call number: FP6-2002-MOBILITY-6
Contract number: 8141
Contract type: Marie Curie
Starting Date: 01/05/2006
Duration (months): 36
Project website: http://vivaldi.zool.gu.se/Ekologi/Projects/Laxfiskgruppen/
Transgenics/riskassr.htm
DG responsible: DG RTD
EC Contribution: 178.683,00
Actionline: Marie Curie Outgoing International Fellowships (OIF)

Coordinator Dr Grevby Cecilila Dr Johnsson Jörgen UNIVERSITY OF GOTEBORG— Canada

Recent advances in gene technology have been applied to create fast-growing transgenic fish, which are of great commercial interest to shorten production cycles and increase food production. However, there is growing concern over the impact escaped growth hormone (GH) transgenic fish may have on the natural environment. To predict these risks it is crucial to obtain data on the relative fitness of transgenic and non-transgenic fish under nature-like conditions. Empirical data on this is, however, lacking at present. Since transgenic fish cannot be released to the wild, studies on these fish must be carried out in specially contained laboratory facilities under simulated natural conditions. The main objective of the current proposal is to carry out such work with the goal to obtain knowledge of the potential ecological risks associated with commercial production of transgenic fish. In addition, these transgenic fish will be used both to increase our understanding of how hormones interact with the organism and its environment to regulate behaviour, and to examine evolutionary questions of why growth in nature often is below that physiologically possible. By comparing the performance of transgenic and nontransgenic fish at different life-stages and under various environmental settings, an assessment of the relative success of transgenic fish under natural conditions can be made.

This information will form the base for policy decisions associated with commercial production of transgenic fish which may pose critical risks to natural populations of fish and other aquatic species in their ecosystems.

RESEARCH PROJECTS IN 7TH FRAMEWORK PROGRAMME

MAMBA: Marine metagenomics for new biotechnological applications (*MAMBA*)

Call number:FP7-COOPERATION- KBBE-2008-3
*Contract number:*226977
Contract type: Small or medium-scale focused research project
Starting Date: 01/07/2009
Duration (months): 48
Project website:
DG responsible: DG RTD
EC Contribution: 2.88 million euro

Coordinator: BANGOR UNIVERSITY COLLEGE ROAD UNITED KINGDOM

The Project aims at the mining of individual enzymes and metabolic pathways from extremophilic marine organisms and the metagenomes from microbial communities from peculiar marine environments and consequent funneling the new enzymatic reactions and processes towards the new biotechnological applications. Project builds up on the scientific and technological excellence of individual academic and industrial partners, and beyond that, on application of the state-of-the-art technologies for archiving, molecular screening for the activities (using a unique Surface Plasmon Resonance screening platform), protein structure elucidation, enzyme engineering and directed evolution and establishing new biotechnological processes (biocatalysis, synthesis of fine chemicals, etc.).

Marine sampling hotspots to produce the metagenomic resources for their further exploration will cover the whole diversity of marine microbial life at its limits (hypersaline, low and high temperature, high pressure and low water activity conditions, etc.). Individual enzymes interacting with the substrates will be identified, and in case they are new, hyper-expressed and crystallized and their structures will be elucidated. Consequently, the most promising candidates will be scored against the chiral substrates of relevance for biocatalysis and their ability to perform in water-free systems will be evaluated, the directed evolution will be implemented to improve the performance, and specificity of the enzymes.

A comprehensive bioinformatic survey throughout the whole tree of cellular life will reveal and suggest the new candidates homologous to the discovered new proteins, from other organisms to be cloned and assayed. The implementation of the set of new enzymes in the biotechnological processes for fine chemical synthesis and drug discovery will be conducted in a strong alliance with competent industrial partners.

MIDTAL: Microarrays for the detection of toxic algae

Call number:FP7- COPERATION - ENV.2007
*Contract number*201724
Contract type: Small or medium-scale focused research project
Starting Date: 01/09/2008
Duration (months): 45
Project website: http://www.midtal.com/
DG responsible: DG RTD
EC Contribution: 2.23 million euro

Coordinator: Parr JON, MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM - UNITED KINGDOM

Microalgae in marine and brackish waters of Europe regularly cause «harmful effects», considered from the human perspective, in that they threaten public health and cause economic damage to fisheries and tourism. Cyanobacteria cause similar problems in freshwaters. These episodes encompass a broad range of phenomena collectively referred to as «harmful algal blooms» (HABs). They include discoloration of waters by mass occurrences of microalgae (true algal blooms that may or may not be «harmful») to toxin-producing species that may be harmful even in low cell concentrations.

A broad classification of HAB distinguishes three groups of toxic organisms. For adequate management of these phenomena, monitoring of microalgae is required. However, the effectiveness of monitoring programmes is limited by the fact that it is time consuming and morphology as determined by light microscopy may be insufficient to give definitive species and toxin attribution. Once cell numbers reach a threshold level, then shellfish are selected to toxin analysis by the mouse bioassay. The mouse bioassay is continued on a daily basis until no more toxin is detected. Molecular and biochemical methods are now available that offer rapid means of both species and toxin detection. In this project we will target rapid species identification using rRNA genes as the target.

We include antibodies to specific toxins because even when cell numbers are very low, the toxins can be present and can be accumulated in the shellfish. Microarrays are the state of the art technology in molecular biology for the processing of bulk samples for detection of target RNA/DNA sequences.The purpose of MIDTAL is to support the common fisheries policy to aid the national monitoring agencies by providing new rapid tools for the identification of toxic algae and their toxins so that they can comply with ECC directive 91/1491/CEE that can be converted to cell numbers and reduce the need for the mouse bioassay.

ASSEMBLE: Association of European marine biological laboratories

*Call number:*FP7- CAPACITIES -INFRA-2008
*Contract number*227799
Contract type:
Starting Date: 01/03/2009
Duration (months): 48
*Project website:*http://www.assemblemarine.org/
DG responsible: DG RTD
EC Contribution: 8.7 million euro

Coordinator: Margareta AHLQWIST, GOETEBORGS UNIVERSITET - SWEDEN

ASSEMBLE is a research infrastructure initiative, funded within the European Union's 7th framework programme for Research and Technological Development, comprising a network of marine research stations. The joint research activities of ASSEMBLE are designed to improve the quality of provision of marine organisms with an emphasis on models for marine genomics. This includes multi-cellular organisms, unicellular eukaryotic organisms and cell lines as well as genetic and molecular resources. The research projects in ASSEMBLE will focus on:

- Improving the provision of whole, multi-cellular organisms, including such activities as tank development, flow control, filtration and containment, feeding, breeding, and distribution of marine plants and animals;
- Improving the provision of unicellular eukaryotic organisms and cell lines, including such activities as development of new cell lines, development of techniques for cryopreservation.
- Improving the provision of genetic and molecular resources, including such activities as the development of mutant lines, and the curation and arraying of libraries prior to their archiving into a common genomic resource centre (MPI-MG, Berlin).

ELIXIR: European Life-Science Infrastructure for Biological Information

*Call number:*FP7- CAPACITIES -INFRA-2007
*Contract number*211601
Contract type:
Starting Date: 01/11/2007
Duration (months): 38
*Project website:*http://www.elixir-europe.org
DG responsible: DG RTD
EC Contribution: 4.5 million euro

Coordinator: Janet THORNTON, EUROPAISCHES LABORATORIUM FUER MOLEKULARBIOLOGIE – EMBL - GERMANY

ELIXIR is a research infrastructure initiative, funded within the European Union's 7th framework programme for Research and Technological Development with the aim to develop the plan for a sustainable infrastructure for biological information in Europe. This plan focuses on generating stable funding for Europe's most important publicly accessible databases of molecular biological information, and the development of a compute infrastructure that can cope with the biological data deluge. ELIXIR is one of 44 research infrastructures recommended by the European Strategy Forum for Research Infrastructures as being of key strategic importance to Europe's future. ELIXIR holds a special place among these because it will provide infrastructure for the other biological, medical and environmental research infrastructures being developed. ELIXIR will provide: data resources; bio-computer centres; an infrastructure for integration of biological data, software tools and services throughout and beyond Europe; support for other European infrastructures in biomedical and environmental research; and services for the research community, including training and standards development.

EMBRC: European Marine Biological Ressource Centre

Call number: FP7- CAPACITIES -INFRA
Contract number
Contract type:
Starting Date:
Duration (months): 38
Project website: http://www.embrc.eu/
DG responsible: DG RTD
EC Contribution:

The European Strategy Forum for Research Infrastructures selected end 2008 the European Marine Biological Resource Centre (EMBRC), to become the newest large-scale infrastructure for marine science. This infrastructure will enable scientists to use the most up-to-date techniques to study the composition, functioning and diversity of marine organisms, providing important benefits for life sciences and biomedicine and bringing new insights to the way organisms evolve and adapt to a changing environment. This initiative builds on the synergy developed between partner marine institutes during the Sixth Framework Programme of the European Commission, where networks of excellence in marine biology, such as Marine Genomics Europe, have had a major impact on advancing marine research. The action plan to realise the EMBRC infrastructure will begin with practical steps to obtain governmental commitment from member states and initiate the construction of this new European entity. Importantly the partners will collaborate on the legal and practical issues and liaise with their national representatives and research councils to make this proposal a reality. In the longer term, the ambition is to develop EMBRC as a major global player providing European researchers with a world class infrastructure to explore the world's valuable marine biological resources.

Linked projects and networks:

EUROCEANS	http://www.eur-oceans.eu/
LIFEWATCH.	http://www.lifewatch.eu/index.php?id=392
MarinERA network	http://www.marinera.net:

Appendix 3 - Persons who contributed to the CWG-MB

Belgium

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Denmark

Lone Gram (until December 2008)

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