RESEARCH CONFERENCES

ESF-COST High-Level Research Conference

Marine Biotechnology: Future Challenges

Hotel Villa del Mare, Acquafredda di Maratea • Italy
20-25 June 2010

Chair: **Jan Olafsen**, University of Tromsø, NO
Vice-Chair: **Adrianna Ianora**, Stazione Zoologica Anton Dohrn, IT

Organising Committee:
Jan-Bart Calewaert, Marine Board-ESF, BE
Amos Tandler, Israel Oceanographic and Limnological Research, IL

With support from: The Research Council of Norway

www.esf.org/conferences/10330

Highlights & Scientific Report

© Flora Palumbo

Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

The conference aimed at highlighting the uniqueness of the marine biotechnology sector - and its grand challenges for the coming decade. This theme was addressed in the opening session, and drew attention to the broad potential for marine biotechnology research to contribute to health, energy, food, environment and industry applications. From the outset it was agreed that the conference should interlink closely with the ongoing work of the ESF Work Group on marine biotechnology, and the position Paper in production.

The marine ecosystem remains largely unexplored. By developing and targeting discovery systems towards exploring marine organisms, it may be possible to identify the next generation of bioactive compounds. By further exploiting the systems biology the marine environment, marine biotechnology has the potential to provide an entirely original stream of compounds of natural origin. Thus, the marine ecosystem, with its enormous biodiversity, may provide us with new model systems and entirely new ways of treating infectious and other diseases, particularly as regards host-microbe interactions, defence, symbiosis, signalling and chemical interactions. Marine biotechnology development of bioactives, models, monitoring and production systems has been perceived as risky, costly and complex. Consequently we need to give more focus to developing new discoveries, and be open to totally new approaches.

With the decline in global fisheries the demand for high quality, healthy food has become apparant. Marine Biotechnology can influence food production in many ways from fish health, new aquaculture techniques, and creating new production systems for healthy seafood and traceability of products – either wholly, processed or as functional food ingredients.

The energy issue is of major importance and concern also in marine biotechnology. The allocation of massive research into the potential of marine algae to provide energy was a major point of discussion at the conference. There is a need for focus and clarity on key issues and exploitation of this resource.

A key issue for medical, energy, food and industrial products is biomass production. We need ways to provide consistency of product quality, a steady supply stream and security of supply. Challenges as these have to be addressed in ways that are integrated with the concern for the environment and the concept of sustainable production. New approaches are required on to how and where we grow marine biomass.

It we are to engage in marine biotechnology we need to have to have tools: Access to the oceans, research vessels, collection and monitoring systems. The traditional marine biology approaches and methodologies need to be built upon, and there is a need to explore the marine environment at molecular levels and with a multidisciplinary approach. Moreover, there is a need to improve on education and training of students and young scientists - and to create an identity for marine biotechnology in Europe.

Consequently we need to be competitive in our research, focus on developing new processes that enable discovery, and be open to totally new approaches. Europe needs to develop some

instruments to achieve this:

• Establish a “virtual” European institute for marine biotechnology with high visibility and professional administration.

• Develop a marine biotechnology curriculum/course – attract the best students.

• An easy access information portal to take on a lead role in the dissemination of research information to students, scientists, policy-makers, stakeholders, and the public.

• Establish and maintain a European "marine culture/gene collection and database" and establish a node for biobank activities.

☒ I hereby authorize ESF – and the conference partners to use the information contained in the above section on ‘Conference Highlights’ in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

Notes on reporting
Due to practical events and change of deadlines the session-chair reports (apart from session 1a) was not available when this report was completed. The session chair reporting and final discussion scheduled at the conference closing was cancelled, and replaced by a discussion focused on the ESF-Marine Board strategy and position paper chaired by Niall McDonough and a summary report by the conference rapporteur Dermot Hurst. This report has been compiled by the Conference Chair based on impressions, comments, notes - and to a great degree on the excellent available reports from the conference rapporteurs, Ilaria Nardello and Dermot Hurst (Marine Institute, Ireland), provided in July.

Nardello, Ilaria. Summary of the conference sessions focusing on the scientific highlights. ESF-COST High Level Conference on Marine Biotechnology. Conference Draft Scientific Report (23rd of July 2010). 20 pp.
Hurst, Dermot. ESF-COST High-Level Research Conference. Marine Biotechnology: Future Challenges. Conference Report, Comments and Highlights. (July 2010). 7 pp.

Background and structure
The Conference was initiated by the European Science Foundation (ESF) - COST office. In view of the present international focus on marine biotechnology it was a timely event, particularly in coordination with the ESF Work Group (ESF-WG 2009-10) on marine biotechnology, highlighting the potential of marine biotechnology a decade after the first marine board position paper (PP 4) on marine biotechnology.

During the last decade, the scientific and political landscape of marine biotechnology has been deeply modified. In this context, marine biotechnology is not yet contributing to its full potential in answering the challenges European countries are facing. The conference drew from a broad range of scientific and technological disciplines focusing on identified themes, research tools and approaches of strategic importance for Europe, including aquaculture, bioprospecting, biomass, human and environmental health issues, novel enzymes, marine bionanotechnology and biomaterials, marine model organisms, marine –'omics', pollution and bioremediation, bioinformatics and research infrastructures. The emphasis of the Conference is on innovation and vision for the future of marine biotechnology in Europe, moving from exploitation to sustainability. The Conference was structured to address a range of Marine Biotechnological research challenges:

- Historic perspectives and Grand Challenges
- Marine Biotechnology and Environmental Health
- Impact of Marine Biotechnology on Human Health and Well-being:
  - Bioprospecting for discovery of novel drugs
  - Marine Food and other healthy products
- Marine biotechnology, Processes and Products
- Marine Models and Research Toolkits: new developments and advances
- Perspectives from industry, policy and the science community – a Future Look

The "roadmap" to focus on the potential of marine biotechnology in Europe has included a range of events over more than a decade. The major challenges facing European Marine Biotechnology

were outlined at what is recognised as a landmark meeting of researchers, industry and policy makers: "The Bremen Meeting". Hopefully we are heading towards a more integrated and clear strategy and approach to be published at EurOcean 2010 in Oostende, with input from the updated ESF WG Position Paper on Marine Biotechnology and conclusions from the 2010 ESF-COST Conference in Italy.

Planning and Logistics

The Conference Programme Committe consisted of Jan Olafsen, University of Tromsø, Norway (Conference Chair), Adrianna Ianora, Stazione Zoologica Anton Dhorn, Italy (Vice-Chair), with the Organising Committee consisting of Amos Tandler, Israel Oceanographic and Limnological Research, israel, and Jan-Bart Calewaert, Marine Board-ESF, BE and with support from the ESF-COST office and Marine Board Niall McDonough and Zuzana Vercinska, ESF-COST office.

The conference was planned through a number of telephone conferences and contacts and one meeting in Brussels (February 2010), and from the outset it was agreed to interlink with the ongoing work of the ESF-WG on marine biotechnology. ESF acted in a positive way as coordinator in this process. In the first planning stages the conference aimed at a discussion of these broad themes and challenges on an international high-level. Immediately preceding the conference and towards launch of the final programme a number of events resulted in a change of focus which more intimately interlinked the conference with the WG Position Paper. This implied that the scientific focus of the conference was directed towards the "grand challenges" of marine biotechnology in society and particularly in Europe in 2010+. These themes are related to health, high quality and healthy food supply, bioenergy - and environmental issues (bioremediation). As a result the conference, and the reports hitherto produced, must be seen in the perspective of the ongoing work with the upcoming Position Paper. Two full days, the opening and final sessions, were devoted to a discussion of issues related to the position paper.

The science - a summary (adapted from DH)

The increase in antibiotic-resistant infections has increased our awareness of the need for efficient cost effective drug discovery. The marine environment remain largely unexplored. By developing and targeting discovery systems towards exploring marine organisms, it may be possible to identify the next generation of antibiotics and other drugs. Moreover, the marine ecosystem, with its enormous biodiversity, may provide us with entirely new ways of treating infectious and other diseases, particularly as regards host-microbe interactions, defence, symbiosis, signalling and chemical interactions. Marine biotechnology based drug development has been perceived as lengthy, risky and costly. Consequently we need to identify realistic routes to market for marine compounds; be competitive in our research, give more focus to developing new discoveries and be open to new approaches.

With the decline in global fisheries the global demand for high quality, the focus on "healthy food" has become apparant, and is a major focus. Marine Biotechnology can influence food production in many ways from fish health, supporting new aquaculture techniques, the introduction of new disease resistant species or alternative techniques, creating new production systems for healthy seafood and traceability of products – either wholly, processed or as functional food ingredients. However, global and regional issues of food security and access to protein have to be resolved.

It is universally agreed that the energy issue is of major importance and concern. The allocation of massive funds for research into the potential of marine algae to provide energy was a major point of discussion at the conference. Algal energy is a world-wide research theme, but many have asked why - when there remains doubt concerning biomass productivity and yield from mico-algae. We heard a lot about the energy potential of marine algae at the workshop, but there was a need for some focus and clarity on key issues and exploitation of this resource.

A theme across many papers and posters was algae; both macro and micro; and the potential contribution they have as a source of biomass and novel compounds. It is clear from the workshop, given the potential for these species to contribute to commercial activity, that finding ways top expand algal research is of major importance. The environmental importance of the resource; supporting marine biodiversity, in climate change and limiting coastal erosion, and its accassability must be recognised - and if wild sources are used, such use must be sustainable.
A key issue for medical, energy, food and industrial products is biomass production. We need ways to provide consistency of product quality, a steady supply stream and security of supply. Challenges as these have to be addressed in ways that are integrated with the concern for the environment and the concept of sustainable production. New approaches are required on to how and where we grow marine biomass. There are as many engineering challenges as biological ones in building the production systems required. Concepts of integrated systems of algal, finfish and shellfish supply built around “islands” dedicated to tourism, energy generation or living space were proposed. Given the scale of some of the concepts discussed, there are likely to be major challenges to be overcome in establishing such off-shore aquaculture production systems. There is likely to be a major role for new aquaculture production systems; pointing not only to the need for biological research to support such developments – e.g. new species, but also significant engineering inputs to enable them.
In addition to the highlights, a number of cross-cutting themes have also emerged from the workshop. It is worth taking some time to reflect on what these are, since it is likely that these will be important inputs to the Marine Board position paper as well as possibly shape the focus on marine biotechnology priorities.
It we are to engage in discovery, we have to have access to the oceans; we need research vessels, and new collection and monitoring systems. It is quite clear however, that the traditional marine biology approaches and methodologies need to be built upon. There is a need to explore the marine systems at molecular levels, to do so we need greater computing power; demonstration systems, pilot plants and bio-banks. There is clearly a need for increasing the levels of collaboration and cooperation, a concept encouraged by the current Research Framework Programme, and a point made at this workshop.
"The marine" is a diverse environment and there is a strong need for diverse skills to convert a marine resource into a product or service. There is a clear need to draw from expertise in other scientific and disciplines – a multidisciplinary approach. A multidisciplinary approach is a further way of securing success of our research efforts.

Scientific Content of the Conference

(1 page min.)

- *Summary of the conference sessions focusing on the scientific highlights*
- *Assessment of the results and their potential impact on future research or applications*

(Mainly adapted from I. Nardello, see above)

Opening session
Session Chair: Jan Olafsen - Conference Chair, University of Tromsø, NO

1. Joel Querellou - French Research Institute for Exploitation of the Sea (IFREMER), FR
Towards a strategy for a European marine biotechnology Research Area: the Marine Board Working Group on Marine Biotechnology Position Paper.
The author is the Chair of the Marine Biotechnology Working Group established by the Marine Board in order to provide a strategic assessment of the current scientific understanding of marine biotechnology relevant to European and member states policies, and to identify the priorities for further research needed in this field, and updating the 2001 Position Paper on Marine

Biotechnology. A Position Paper/Report summarising the results of the group's activities is to be published in September 2010 and launched at the EurOCEAN 2010 Conference on 12-13 October 2010 (Oostende, Belgium) – www.eurocean2010.eu. The presentation highlighted the contribution that marine biotechnology products can offer to societal issues, such as food, energy, health, environment, and innovation. Conditions for success: overcoming the fragmentation of funding streams at the policy level; sustainability; shared/distributed infrastructures; development of key techs; strengthening the links between institutions and industry.

- Stimulate research strategies and align programmes at the national, regional, and pan-European level, to work on the grand challenges
- Create a strong identity and communication strategy (i.e. a portal)

2. Marcel Jaspars - Marine Biodiscovery Centre, University of Aberdeen, Scotland, UK
Grand challenges for current and future marine biotech research in Europe
The presentation explored the opportunities for marine biotechnology to contribute to the so called societal 'Grand Challenges', in Europe and globally: i) food; ii) energy; iii) health; iv) environment; v) industry.

- Changes in policy, science funding and its administration, and education are advocated to overcome the currently identified bottlenecks of the marine biotechnology value chain -such as: regulatory issues, quality and supply, cost, technical problems, and an overarching rationale to convince the industry players.

3. Carlo Heip - Royal Netherlands Institute for Sea Research (NIOZ), NL
The Marine Environment: its potential and characteristics as compared to the terrestrial Environment
Seas and Oceans contain 90 % of the planet's biosphere. They harbor life that is nearly 3 billion years older than life on land and a larger number of higher taxonomic groups up to phylum level, implying a greater genetic diversity and a range of natural products and processes.nThe Ocean Biogeographic Information System [1] shows that our knowledge below 100m is very scarce and that the probability to find new species every new record increases with depth. The bulk of the ocean is dark, cold, under high pressure, often hypoxic and oligotrophic. The physiological processes and pathways that marine organism have evolved to adapt to these extreme conditions underpins the potential of the marine environment for biotechnological applications, in diverse domains such as food, medicine, energy and climate.

4. Jan Olafsen - Conference Chair, University of Tromsø, NO
Aim and approach of the Conference and the programme: Future challenges. A road map.
The Conferences Chair stressed the rationale for marine biotechnology, encompassing the responsible management of marine resources and the improved quality of marine products. In a few words, borrowed from Rita Collwell (former "National Science Foundation" Director, USA and credited for first defining "marine biotechnology" 25 years ago): fulfilling the promise of marine biotechnology has in fact been big challenge for all parties involved in this area for the last decades. The challenge now is to realize that we are dealing not only with marine biodiversity - but biocomplexity:

- Biodiversity describes the plant and animal diversity of the planet.
- Biocomplexity speaks of a deeper concept to discover the complex chemical, biological, and social interactions that comprise our planet's systems.

Policy might need to catch up with a few facts: the USA invest three times more than Europe in biotechnology R&D; China is highly competitive; and the profiles of Brazil and India in this sector are rising fast. It was noted that despite the launch of Position Paper n. 4 "A European strategy for marine biotechnology" in 2001, and the organization of the 1996 EU-US Task Force on Biotechnology, Europe did not embrace the opportunity that marine biotechnology was already offering back then. It is hoped that this conference and the new position paper will fuel a EU

response towards a focused marine biotechnology programme of research funding - and realize the "window of opportunity" that we are now facing.
- Use the networks, the stations, the programmes, facilities, but keep it simple! Big is not always beautiful - in science.

Session: Marine Biotechnology, Human Health and Well-being: Biodiscovery of novel marine-derived biomolecules and methodologies
Session Chair: Marcel Jaspars - Marine Biodiscovery Centre, University of Aberdeen, Scotland, UK

1. Bill Fenical - Center for Marine Biotechnology and Biomedicine, Scripps Institution of Oceanography, USA
The deep oceans, developing an unexplored resource for microbial drug discovery (keynote lecture)
- The potential of the terrestrial domain for antibiotic drug discovery has been largely exploited, and the pharma industry has lost interest in this low-yield mining activity. The danger lies in a health crisis generated by bacterial resistance.
- The potential of marine biological resources to produce new antibiotics and molecules of interest for the pharmaceutical industry is large. The exploitation of this potential is an imperative.
- Use of custom built probing instruments in relatively accessible environments
- Target taxonomic groups with high yields.
- “Culture the unculturable”: a matter of techniques and investigating

It was also noted that the pharmaceutical industries today can be interested only to almost-fully developed product. Recommendations on this aspect: try the less demanding solutions when sampling and cultivating; approach the cosmetic industry instead of the pharmaceuticals.

2. Angelo Fontana - Institute of Biomolecular Chemistry (CNR-ICB), IT
The Search of Bioactive Marine Natural Products in the Light of Ecological and Physiological Considerations
Biodiversity is driven by environmental conditions, while chemical diversity is based on the ecological interactions among organisms. Antipredatory chemistry is a good example of this hypothesis: the nudibranchs’s naked bodies are armed with chemicals; diatoms can produce active toxic substance against the copepods, and it is demonstrated that the production peaks just before the population growth collapses. These chemicals have been exploited by industry (e.g. Pharmamar, ES) for their therapeutic properties, such as anticancer agents.
Chemical ecology in the marine domain is the homologue of ethno-botany on the terrestrial domain, in that it can support therapeutic drug discovery.

3. Andrés Francesch - PharmaMar, ES
Development of Yondelis as an anticancer drug
Pharmamar is a Spanish subsidiary company of the Zeltia Group focused on the exclusive use of marine-derived drugs in anti-cancer research. Their business model encompasses all the steps from expeditions to collect organisms, to biodiscovery and clinical trials, up to commercialization. On average Pharmamar discovers a new compound every two years. Yondelis is one of five compounds currently in the chemical pipeline. In the ten years since the initial discovery phase of this product, the compounds have been first harvested from the natural environment, then cultivated –and cultivation techniques improved (up to a yield of 1mg of purified product per Kg of biomass), and now derived from synthesis.

4. Alan Dobson - University College Cork, IE

Omics for bioactives, status and future challenges
In this talk, a summary was given of the investigation techniques for the discovery of active substances in biological systems. Among those techniques: genomics (the process of identification of known gene families); proteomics; transcriptomics; metabolomics; metagenomics and functional metagenomics. Bottlenecks of the various processes were highlighted. For example genomics imply a lengthy process that discourages the private capital investments. Metagenomics on the other hand does not allow experiencing the full potential of genes expression.

- Common solutions to common problems appear to be emerging. Can this represent a risk in the omics research investigation capability?

The short-talk session of Monday afternoon comprehended the talks listed below. In light of the discussions at the end of the talks, and in the following days, one presentation (Archana Chugh - Indian Institute of Technology of Kharagpur, IN) in particular captured the audience, on the use of traditional marine knowledge as source of information for biotechnological application. While the case study was referred to India, general recommendations could be drawn from this presentation, which clearly pointed at regulatory gaps regarding intellectual property rights. In particular patenting issue related to UNCLOS regulations in regions outside EEZ were noted.

5. Marc Schumacher - Fondation Recherche sur le Cancer et les Maladies du Sang, LBMCC, LU
Marine compounds as inhibitors of pro-inflammatory, proliferative and anti-apoptotic mechanisms
6. Elena Averina - Russian Academy of Science, Baikal Institute of Nature Managment, RU
Perspectives of using of Baikal fish oil for delivery nanostructured lipid drugs carriers (short talk)

7. Archana Chugh - Indian Institute of Technology Kharagpur, IN
Marine Traditional Knowledge for bioprospecting for novel drug development in the Pharmaceutical Industry (short talk)
Information on Marine Traditional Knowledge is quite fragmented but still quite abundant in India. On the other hand, little patenting has emerged from the exploitation of marine natural and few marine biotechnology industries have developed. Patenting issues include UNCLOS regulations in regions outside the EEZs.
8. Sigmund Vegard Sperstad - University of Tromsø, NO
Characteristics of antimicrobial peptides isolated from marine invertebrates (short talk)
9. Johannes F. Imhoff - Leibniz-Institute for Marine Sciences IFM-GEOMAR, D
Natural products from bacteria associated with marine sponges and algae (short talk)

Poster session
Chair: Dr. Raffaella Casotti, Stazione Zoologica A. Dohrn, Napoli, IT
An award was offered for the best poster, judged by the poster session Chair -Dr. Raffaella Casotti, Prof. Marcel Jaspars and Dr. Joel Querellou. It was noted that the presenters came from different backgrounds and levels of education, with about 40% students or early-career researchers. Also, all authors appeared very motivated and amenable to discuss their results. The judges gave preference to early career participants, and the award of 200 Euro was granted to Karina Golberg – an Israeli PhD student from Ben-Gurion University of the Negev, presenting a poster on "Natural Quorum Sensing Inhibitors and Inducers from Marine Bacteria". The winner was invited to give a short oral presentation.

Session: Marine Biotechnology and Environmental health
Session Chair: Adrianna Ianora - Stazione Zoologica Anton Dohm, Napoli, IT

1. Victor Smetacek - Alfred Wegener Institute, Bremerhaven, DE - Marine Biotechnology Research

and Environmental Health
The biggest question in the presentation was on the possibility to feed the oceans to feed us, with an explicit reference to the work of John Marra “When will we tame the oceans?” (Nature, 2005) . Iron fertilization has shown to increase the productivity of the oceans at the primary production level, and could also be adopted as a carbon mitigation option, but a number of controversial arguments still exist today as per the fate of the phytoplankton biomass in its travel towards the oceans’ interior, whether this is depth or a food chain.

- Fertilization of the ocean deserts should be investigated as a means to sustain planetary food production.

The main recommendation of this presentation was further debated in the round-table discussion (chaired by the same author) later in the day. Fertilization of the open ocean remaining a starting point in improving marine productivity, important conclusions were drawn regarding the necessity of ameliorating the cultivation techniques and close the ecological loops.

2. Oded Beja - Technion, Israel Institute of Technology, Haifa, IL
Metagenomics as a tool to unveil new genes and functions in the marine environment
There are millions of cells in one ml of seawater and tens of millions viruses. More than 99% of marine microbes are still uncultivated today, and their potential unlocked.
Omics can help the investigation of the molecular characteristics of microbes, identifying protein coding genes and biochemical pathways. While environmental genomics uses long fragments (up to 1/5 of the whole genome) of bacterial extracted DNA or RNA for implant and expression on E.Choli vectors, metagenomics techniques can use smaller fragments inserted in smaller vectors (bacteria) through the adoption of heavy sequencing. The vector can even be avoided when using pyrosequencing techniques.
It was pointed out that the Global Ocean Survey Metagenomics experiment (J. Craig Venter) found naturally engineered genomes in their samples: c.a 600 scaffolds containing Photosystem I traces (psA), and c.a 5 scaffolds also contain viral genes.

3. Allan Cembella - Alfred Wegener Institute, Bremerhaven, DE
Biotechnological Approaches to Assess Allelochemical Interactions, Toxigenesis, and Gene Regulation for Harmful Algal Blooms.
The author distinguished between two fundamental meanings for Biotechnology: 1) Towards exploitation of marine resources; 2) Enhancing our understanding of marine systems.
In this presentation, marine biotechnology is intended to improve our understanding of the organisms (protists and cyanobacteria) that produce HABS, through a chemical-ecology approach, and with a combination of investigation tools including functional ecology, bioanalytics, and functional genomics and gene expression. This approach will identify, confirm and predict chemical-ecological interactions and elements of secondary metabolite biosynthesis.
The investigation shows that phycotoxin biosynthesis is inconsistent among strains and species, but phylogenetically and biogeographically clustered. Polyether toxins are polyketides produced by distinctive “protist” modular Type 1 PKS. Also, cellular growth rate (μ) and toxin production are usually positively correlated, i.e. toxins are not “stress” metabolites. The pharmacology and mode of action of known phycotoxins are not typically consistent with defensive function (“toxin”) either.

- Determine gene expression profiles (by microarrays) under a variety of alternative cell growth regimes and stress stimuli
- Confirm the biosynthetic and regulatory pathways for phycotoxins by incorporation of genomic information with stable isotope labelling studies
- Identify the chemical nature and mode of action of unknown allelochemicals
- Determine the ecological function of phycotoxins and other bioactive compounds (allelochemicals)

4. Raul Bettencourt - University of the Azores, IMAR-Center, PT
Sequencing the transcriptome of a deep-sea hydrothermal vent mussel: new possibilities for biotechnological development of biological resources

The presentation reports on the detection of a large numbers of novel sequences in the transcriptomes and metatranscriptomes, in vent mussel and its associated microbial communities and discusses new possibilities to find protein-coding genes with potential use in biotechnology. The transcriptome is the part of the genome being transcribed (mRNA) in response to specific stimuli (e.g. environmental conditions changes). The more challenged the organisms, the more gene will be expressed. We are evaluating the expressions of genes in mussels living In extreme oceanic conditions -i.e. the hydrothermal vents.
A new technique has been developed to sequence the transcriptomes and identify all the genes expressed in any given tissue or cells. Results from these analyses point at the presence of an unprecedented number of bacterial phylotypes in the gills of the vent mussel (Bathymodiolus azoricus). The transcriptomes DB from the hydrothemarl vent B. azoricus can also be queried for GENE ONTOLOGY identifiers.

5. Chiara Auritano, Functional and Evolutionary Ecology Laboratory, Stazione Zoologica Anton Dohrn, Naples, Italy.
“Deleterious effects of the oxylipin-producing diatom Skeletonema marinoi on target gene expression in Calanus helgolandicus (Crustacea: Copepoda)”.
6. Louisa Giannoudi - Institute of Oceanography, Hellenic Centre for Marine Research (HCMR), GR
"An amperometric immunosensor tested on Prorocentrum lima cultures".
7. Euan Robert Brown - Stazione Zoologica Anton Dohrn, IT
"Exploring potential biophysical and cellular level assay systems to determine the impact of engineered nanoparticles in aqueous environments".
Nanomaterials are becoming increasingly important in their applications and uses in many industries, including consumer products and healthcare (1). Engineered nanoparticles represent a major part of this growth. However, an understanding of their toxicological properties has not kept pace with the exponential rate of increase of research into their synthesis, characterisation and application. Particularly, research into their behaviour, impact and fate in aquatic environments is at a very early stage.
The FP7 supported project ENNSATOX is an integrated collaborative project on defined engineered nanoparticles to relate their structure to function, at successive levels of molecular, cellular, organism, and ecosystem organisation.
- Biobanking at EU level for small molecules and organisms a major prerequisite.

Tuesday, session IV (applicative sessions)
Session: Marine Biotechnology, Processes and Products
Session Chair: Jan-Bart Calewaert

1. René Wijffels - Wageningen University, NL –
Marine Bioprocess Engineering with Macroalgae
Macroalgae are 3 times more productive in oil than palms; they offer no competition with food for cultural spaces and media. A feasibility study on “Biofuels from algae” (2007) compared the yields from three various techniques over 1 ha and over 100ha. The production costs halved on the larger experiments. If techniques were optimized, it is possible to lower the costs of production to one twentieth of what tried so far.
- The issue is multidisciplinary: it regards the biological and technical aspects of cultivating

macroalgae on a scale that aims to be industrial.
- Business model needs to encompass different end-users, to enable absorption/uptake/use of all the product and by-products of the production pipeline. If this does not happen, the business case is not viable.
- Open or closed systems? The closed systems can be improved beyond any optimization that can be realized with ponds.

2. Tadashi Matsunaga - Tokyo University of Agriculture and Technology, JA – Emerging issues and challenges related to bionanotechnology and biomaterials
"Marine BioNANOtechnology" could introduce completely novel biomaterials. Magnetotactic bacteria synthesize uniform and nano-sized magnetite particles enveloped by lipid membranes. The elucidation of the mechanism of magnetite formation provides a roadmap for the design of novel nano-biomaterials useful in multidisciplinary fields. Diatoms produce diverse shapes and sizes of silica frustules at the nano- and micrometer scale.
- One of the promises of genetic manipulation of marine diatoms is the creation of novel bio-silica materials.

3. Ana Ribeiro - Universidade do Porto, INEB - Instituto de Engenharia Biomédica, PT - Getting inspiration from Nature: sea urchins as models for the development of biomimetic materials for tissue regeneration (short talk)
4. Levent Piker - CRM-Coastal Research & Management, DE-
Sustainable Aquaculture and the Development of Innovative Products from Marine Living Resources in the Baltic Sea (short talk)
5. Assaf Shechter - Ben Gurion University of the Negev, IL -
Biotechnological products based on molt-related calcium deposition in crustaceans (short talk)
The Crayfish species Cherax quadricarinatus is a champion in mineral mobilization and deposition. Molting is required to allow the crayfish to grow. Before the molting, transient calcium carbonate reservoirs called "gastroliths" (up to 4% of body mass) begin absorbing and storing the exoskeleton calcium carbonate. This material will then be released for the new carapace.
The calcium carbonate accumulated in these structures is 65% amorphous. It is a rare finding in nature, given its thermodynamically instable nature, and consequent high solubility. It is found in nanoparticles of 40-80m. These characteristics make it highly bio-available, and commercially interesting as a diet supplement for calcium.
While modeled clinical trials on bio-availability, osteoporosis and others have shown very encouraging results, the pharmaceutical industry will need clinical trials results to translate their interest into practice.
The importance of traditional knowledge was noted, through the citation of T.H. Huxley (1880) who reported on gastroliths and theirs historically-know effects "as sovereign remedies for all sorts of disorders."

Session: Evening round table: Environmental approaches and how marine biotechnology can contribute to global challenges
Moderator: Victor Smetacek - Alfred Wegener Institute, Bremerhaven, DE

The discussion was started by the Moderator with a look forward depicting a future of no fish, pollution, aquaculture, acidification, and stimulating the emergence of ideas around the contribution that marine biotechnology can offer to improve this scenario and face its challenges. Among rather imaginative solutions offered, the participants to the discussion eventually converged on a number of points and themes:

- The need to increase the marine productivity to sustain the increasing world population against the decreasing wild fish stocks
- The need for “closing the loops” during the industrial processes such that involve cultivation of marine organisms (from algae to finfish)
- The necessity to improve biological system models to address the points above
- The evidence of the cross-sectoral relevance of algae

A number of suggestions were deployed by the audience more or less stringently in connection to the above points:

• Development of offshore platforms to create new areas of elevated biological production, across the whole food chain.
• Generation of bio-sensors to detect environmental conditions network of biosensors. Understand how organisms communicate in response to environmental conditions; translate their signals into human readable messages; (BIOTAGUARD.NO)
• Target a specific environmental remediation issue and provide a response through marine biotechnology (oil degrading bacteria; algae and shellfish for the absorption of heavy metals and excessive nutrients from aquaculture sites, etc..)
• Aquaculture sites positioning needs advanced planning. Open-ocean aquaculture should be developed around biologically integrated systems
• Develop system models, and experiment through pilot projects, around the big issues we face.
• Close the loops to limit the dispersion of energy. Do this in a step by step procedure first try on land, and then export to the open ocean

Idea for a large Framework Programme call: OCEANSPHERE I

Session: Marine Biotechnology, Human Health and Well-being: Marine Food and other healthy products
Session Co-chairs:
Yonathan Zohar - Center of Marine Biotechnology, University of Maryland, US;
Edel O. Elvevoll - University of Tromsø, Tromsø, NO

1. Edel O. Elvevoll - UiT, Tromsø, NO
Health aspects of marine food and ingredients
The nutritional quality of seafood is excellent due to the favourable fatty acid profile, the high quality protein. It also serves as a good source for some vitamins, minerals and bioactive components.

• Integration of seafood consumption in human diet
• Need to improve aquaculture techniques, especially regarding the fish feed
• Farmers to produce seafood with added health benefits by incorporating functional components into the feed, and thus raising levels of beneficial components in the fish.

2. Yonathan Zohar - Center of Marine Biotechnology, University of Maryland, US
Aquaculture for the benefit of society: challenges and biotechnology solutions for a sustainable Industry (NOT PRESENTED, AVAILABLE AS PDF)

3. Øyvind Lie - NIFES, Bergen, Norway
Sustainable aquafeeds to maximise the health benefits of farmed fish for consumers - challenges and opportunities
Aquaculture growth is constrained by limited industrial supplies of fish meal and fish oil. Concerns also exist on the presence of pollutants in these products. Alternative feeds have experimented, and results show that substantial replacement of both fish meal and fish oil in feeds with vegetable

meal and vegetable oil is possible without notably affecting the growth performance of any of the four species of fish tested: Atlantic salmon, rainbow trout, gilthead sea bream and carp.

- Establish a methodology for risk-benefit analysis that can be applied to fish consumption.

4. Brian Dixon - University of Waterloo, Ontario, CA

Aquaculture vaccine of the future

Aquaculture production of finfish is becoming increasingly important, with a global market size of over 20 billion US dollars in 2007. Diseases can impact the production and determine a large economic loss. It is estimated that a single vaccine can yield economic returns for 100 million dollars. Difficulties in the production of effective finfish-disease vaccines are found in: i) scarce knowledge of the fish immune system; ii) lack of model organisms; iii) need to investigate the physiological differences down to the fish genera level.

- Increase the knowledge on fish immunity, for the various genera of cultivated fish

5. Ronald Osinga - Wageningen University, NL

The MIRA: CLE concept: mitigating effects of ocean acidification by sustainable production of food and energy through integrated maricultures (short talk)

The MIRA:CLE concept (Marine Integrated Renewable Aquaculture: a Closed-Loop Exploitation) combines sea-based fish aquaculture (cage culture) with the mariculture of filter-feeding invertebrates (e.g. sponges, shellfish) and seaweeds. The seaweeds take up inorganic nutrients produced by the fish, whereas the filter feeders take up the organic (particulate) components in the effluent.

- Common studies to investigate the effect of integrated mariculture systems on: i) the productivity of the organisms in culture; and ii) the environment surrounding the mariculture site.

6. Dagmar Stengel - National University of Ireland, Galway, IE

Pigments as natural products from marine macroalgae: limitations and potential – a case study from Ireland (short talk)

Algal pigments are used as food and industrial dyes but also have applications as cosme-, nutra- and pharma-ceuticals due to their antioxidant, anti-cancer and anti-inflammatory properties. Algal pigments of particular interest, such α-carotene and fucoxanthin can be obtained from sustainably exploited populations of brown seaweeds on north-west European coast (i.e. Ireland). This study focuses on the influence that environmental conditions, geographic distribution, season variations, and storage can have on pigment availability for extraction.

- Informed site selection, harvesting and processing procedures can support the viability and sustainability of industrial exploitation of natural populations of macroalgae.

7. Stéphanie Bordenave-Juchereau - University of La Rochelle, LIENSs MAB/BIEN, FR

Marine cryptides as a tool to fight the metabolic syndrome (short talk)

Several bioactive peptides isolated from fish protein muscle, skin or frame exhibit important health-related properties such as anticoagulant, antioxydative, immunostimulatory characteristics. Effects are important also on lipid metabolism, blood pressure, and insulin production. Traditional drugs often have side effect. The alternative use of dietary bioactive peptides derived from the sea is evaluated in this study.

Session: Marine Models and Research Toolkits: new developments and advances
Session Chair: Manfred Höfle - Helmholtz Center of Infection Research, DE

1. Catherine Boyen - CNRS Station Biologique de Roscoff, FR

Can marine model organisms contribute to marine biotechnology development?

The role of model organisms in biology was explained and its value for biotechnological applications. Marine organisms provide a mostly untapped resources for molecular biology based

approaches in biotechnology due to their enormous phylogenetic diversity and their unique life style in comparison to terrestrial organisms which have been the prime source of raw material which is currently exploited for red and white biotechnology. Based upon broad genomic analyses and in depth biochemical studies of marine enzymes and natural products the following high level recommendations were made and research priorities were identified:
- Study of genomes of lower eukaryota ranging from pico-algae with small genomes (e. g. Ostreococus, 12 Mbp) to complex dinoflagellates and protozoa which have the largest genomes know today (up to 500 Gbp)
- Study a set of genomes from marine invertebrates ranging from mussels to crustaceans with emphasis of deep phylogenetic branches and unique marine phyla
- The genome screening approach has to be complemented by functional studies and chemical analyses to exploit these model organisms to biotechnological products and processes

These research efforts have to be supported by specific infrastructures like collections for marine micro- and macro-organisms and respective cultivation facilities (see presentation 4).

2. Frank Oliver Glöckner - Max Planck Institute for Marine Microbiology, Bremen, DE
The Future of Marine Ecosystems Biology and Biotechnology: Just a Matter of 'Omics' and Bioinformatics?
An overarching bioinformatics approach was presented ranging from genomics and meta-genomics to marine data collection and ecosystem modelling. The combination of state-of- the-art metagenomic analysis of marine planktonic DNA with high-through-put deep pyro-sequencing will allow reverse genetics of marine microorganism. This opens an in-silico approach for the search of novel enzymes and natural products. In addition, whole marine microbial communities can be defined at the genome level. The addition of the specific environmental data sets will allow a better understanding of the ecosystems services such as carbon sequestration and nutrient cycling. In addition, ecosystem specific bioinformatics could be used for the bioremediation of oil spills and other environmental hazards. The following high level recommendations were made and research priorities were identified:
- Standards for data analysis and contextual data should be defined
- Integrative bioinformatic approaches on the level of the ecosystem, on the level (meta)genomics, pure cultures and single cell genomics should be pursued
- Specific efforts should be dedicated the functional assessment of genes with unknown functions which make about 50% of all marine metagenome data sets

These research efforts have to be supported by specialized e-infrastructure for marine bioinformatics that combines physical with biological oceanography (see presentation 4).

3. Joel Querellou - French Research Institute for Exploitation of the Sea (IFREMER), FR
How to improve access to the prokaryotes black box through cultures
The necessity to increase efforts for the cultivation of prokaryotes was demonstrated by the fact that more than 70% of the currently known 104 phyla have not been cultured. All molecular analyses based on DNA extracted directly from marine environments demonstrate that these phyla are representing a huge biosynthetic potential. To make this potential available for biotechnological purposes, the cellar organisms and relevant microbial consortia should be enriched and cultivated. To achieve this goal, a suite of advanced cellar techniques are needed and combined with molecular methods to generate novel cultivation technologies. These technologies should be targeted at marine ecosystems and micro-biomes with a high content of un-cultured phyla. The following high level recommendations were made and research priorities were identified:
- Targeted physical isolation of cells (optical tweezers, micro fluidic chips) should be adapted and

applied to marine communities
- Flow cytometry sorting using fluorescent stains and molecular probes should be explored using High Throughput Systems (HTS)
- Isolation using micro-fluid handling robots or spotters (HTS) could be integrated in open-ocean or deep sea monitoring platforms to enable access to unexplored habitats and provide raw material for novel cultivation approaches
These research efforts have to be supported by specific infrastructures like culture collections for marine Bacteria and Archeae, cultivation facilities and biobanks (see presentation 4).

4. Roberto Di Lauro - President of the Stazione Zoologica Anton Dohrn, Naples, IT
Research infrastructures for marine biology and biotechnology
A major European infrastructure to the benefit of marine biological research was presented. Based on the ESPRI process, an infrastructure plan for a set of marine stations and other large scale national facilities was presented that would lead to the European Marine Biology Research Centre (EMBRC). The preparatory phase should start 2011 and full operation is to be expected by 2016, if funding can be secured. Marine biotechnology in Europe will greatly benefit from the infrastructure, despite its exclusion of major European countries with a high profile in marine biotechnology and research. Recommendation:
- In the second phase of the EMBRC all the European countries with an interest in marine biotechnology should be included with at least one facility.

Closing Session: How to support future Marine Biotechnology: Science, Policy and Industry: Perspectives and Forward Looking Panel Discussion
Session Chair: Niall McDonough - Marine Board-ESF, Belgium

The Session Chair led the discussion with the input of the Conference rapporteur, the Conference and Session Chairs and the Marine Board Working Group Chair. All the remaining Conference Participants were invited to actively participate in this final session discussion.

General Objectives:
The Forward Look Plenary Discussion enabled conference participants to discuss medium to long-term views and future research developments in their field. The discussion focused on future challenges and recommendations, taking into consideration advances in relevant neighbouring disciplines.
The output of the discussions would inform the Marine Board Position Paper Marine Biotechnology: Towards a European Strategy on Marine Biotechnology, and will feed into the paper.

It was agreed that the grand challenges of marine biotechnology are global, but that Europe has specific advantages as well as challenges in the "grand challenges" areas

However, Europe has a need (people and industry) to support education, training and visibility and to attract awareness of the future potential of marine biotechnology.

Forward Look

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

▪ Is there a need for a foresight-type initiative?

The "roadmap" to focus on the potential of marine biotechnology in Europe has included a range of events over more than a decade: The EU-US Task-Force Workshop on Marine Biotechnology, Brussels 1996; The ESF Marine Board Position Paper (4) on Marine Biotechnology (2001); EurOcean 2004, Galway, Ireland; The Bremen Meeting (2007), EurOcean 2007, Aberdeen; Biomarine 2008, France; EUROMARES 2010, Gijón, Spain. The major challenges facing European Marine Biotechnology were outlined at what is recognised as a landmark meeting of researchers, industry and policy makers: "The Bremen Meeting". The recommendations from that meeting in 2007 included:

- Raising the awareness and visibility of marine biotechnology
- Continuing to support excellence in basic sciences
- Providing access to improve and integrate research infrastructure
- Streamlining the management of intellectual property (IP)
- Establishing cross-cutting programmes to support commercialisation
- Develop a marine biotechnology strategy for Europe.

Hopefully we are heading towards a more integrated and clear strategy and approach to be published at EurOcean 2010 in Oostende, with input from the updated ESF WG Position Paper on Marine Biotechnology and conclusions from the 2010 ESF-COST Conference in Italy.

Messages for the future (DH)

- Retain a focus on scientific excellence in all we do and remain ethical in how we work.
- Insure we attract the best talents to marine biotechnology, and increase European involvement in international cooperation.
- Secure a place for Marine Biotechnology in national and EU scientific and industrial policy. Increasing visiblity and acces through a portal and a virtual institute of marine biotechnology to educate students, train young scientists and disseminate information to the public.
- Develop more insights to industry and societal needs and find ways to integrate these communities in our work as researchers in marine biotechnology .
- Adopt a sustainable approach in all we do, and act responsibly to protect the marine environment and its unique biodiversity.

“What we try to do in science is to get ever closer to nature. Both in space and time, we seem to be brought near to that great fact — the mystery of mysteries — the first appearance of new beings on this earth” (Darwin)

"The most beautiful thing we can experience is the mysterious. It is the source of all true art and science” (Einstein)

Atmosphere and Infrastructure

▪ *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

The conference venue at Hotel Villa del del Mare, Acquafredda di Maratea, Italy, provided a friendly and intimate atmosphere for lectures, discussions and networking. The relatively remote location, the absence of effective internet for most participants during the conference added to enthusiastic discussions, and the program infrastructure allowed for informal and intense interactions throughout the entire event. One could speculate whether the absence of internet

connection - and the atmosphere of the location - spurred scientific communications and networking! The atmosphere, location, focus and size was exactly what we need to provide lively and enthusiastic "workshops" to benefit the promotion of marine biotechnology in Europe - and encourage networking between involved scientists. The number of participants (80+) was ideal for this setting, and created a workshop-like atmosphere.
The setup, programme and support was almost ideal to support scientific communication. The age, gender, nationality and experience distribution created a setting which allowed young researchers to participate in the debate, and ask questions, and it could easily be observed that the younger scientists networked easily and took active part in discussions - perhaps (unfortunately) to a lesser degree in the last day conclusive session.

About the location: Ideal for science and social networking, but not an easy travel target from all parts of Europe, and the remote location did add to the "travelling strain" of some participants from remote corners! As a "one time event" it was a very positive experience. However, the remote location and relatively complicated access was made apparent by the onset of a practical event - a "communications strike" that hampered the last days - and conclusive sessions - of the conference, and resulted in a number of participants leaving early in fear of loosing communication. The conference secretariat (Zuzana) was a great help in this situation. It took some participants 20 hours plus to reach their destination in Europe - but we all returned home with good memories from a very special event.

The infrastructure of the conference could be a model for future workshops in marine biotechnology, and it is encouraged to involve a professional organization (such as ESF-COST) to carry this forward. The conference secretariat was friendly, helpful and efficient, and the hotel, its staff and setting was a pleasant experience.

Confidential Issues

▪ *Any other issues, not to be included in the published report.*

Admittedly major changes in the Conference program in the last weeks before the event (speaker cancellation) resulted in some hectic work that also affected the focus of the Conference - and linked it more intimately to the Position Paper. This could have been more effectively uitilized during the final discussion, but the final session was considerably altered due to the travel/communication problems. This was an unfortunate situation that could not be foreseen, but perhaps better post-conference communication during the summer could have helped. It was a pity that we missed most of the session chair reports, but I am greatly indepted to excellent reports provided by the two rapporteurs from the Marine Institute; Ilaria Nardello and Dermot Hurst. This report is based on their efforts.

As Conference Chair I have also argued that the conference, particularly with the change of focus, could have "fed more visibly" into the Position Paper. This is in fact a compliment to the participants and organizers of the Conference.

Date & Author:

Sunday, 29th August 2010 **Jan A. Olafsen**