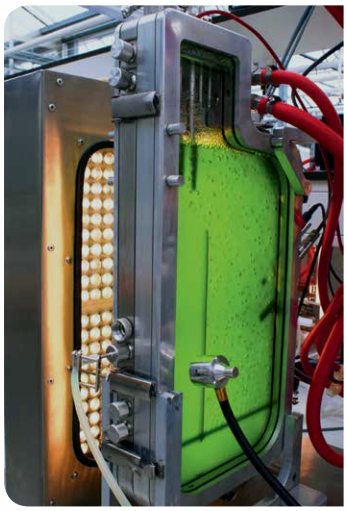
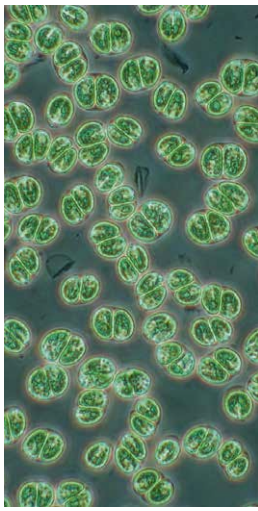
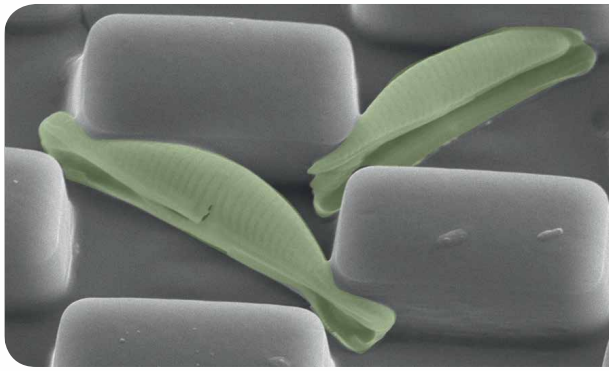
European
MARINE BOARD
Advancing Seas & Oceans Science

3RD EUROPEAN MARINE BOARD FORUM

New Technologies for a Blue Future

18 April 2012, Brussels, Belgium



PROCEEDINGS

" We are entering a new era of engineering – imagineering... Rapid advancements in areas like fibre optic cables are offering the reality of unlimited power and constant telepresence in the oceans...these technologies and the knowledge they produce are going to vastly enhance the planet we live on and the future planets we will explore."

John Delaney, University of Washington, USA

www.marineboard.eu

European Marine Board profile

European Marine Board provides a pan-European platform for its member organizations to develop common priorities, to advance marine research and to bridge the gap between science and policy, in order to meet future marine science challenges and opportunities.

The European Marine Board (established in 1995) facilitates enhanced cooperation between European organizations involved in marine science (research institutes, research funding bodies and nationally-based consortia of third-level institutes) towards development of a common vision on the research priorities and strategies for marine science in Europe. In 2014, the Marine Board represents 36 member organizations from 19 countries.

The European Marine Board provides the essential components for transferring knowledge from the scientific community to decision makers, promoting Europe's leadership in marine research and technology. Adopting a strategic role, the European Marine Board provides a unique forum within which marine research policy advice to national agencies and to the European institutions is developed, with the objective of promoting the establishment of the European *marine* Research Area.

The European Marine Board operates in association with the European Science Foundation (www.esf.org).

www.marineboard.eu

Message from the 3rd European Marine Board Forum

On 18 April 2012, experts from academia, industry and policy from 71 organizations gathered at the 3rd European Marine Board Forum in Brussels to discuss future and emerging "Blue Technologies". The forum highlighted innovation hotspots for the European marine sector, showcasing emerging technologies for driving growth, novel applications for human well-being and tools for next generation marine knowledge.

Towards a Knowledge Based Society

Kostas Nittis, Marine Board Chair, stated in the opening address that "Blue Technologies drive science and innovation, supporting economic growth and well-being." He highlighted the need for a knowledge-driven society, explaining that "education and knowledge transfer hold the key to unlocking knowledge and ensuring that innovations are relevant and have a high impact."

The Forum highlighted the continuing need for blue skies ocean research to drive the future economy. In a keynote speech, John Delaney called for society to adopt a system approach and to design bold, innovative ways to further understand our 'inner space' – the global ocean.

The call for fundamental research was supported by other Forum participants including speaker Fiona Regan. She explained that "many relevant technology developments actually started as blue skies research ideas and have taken years to progress to the innovations we see today."

Innovation hotspots driving future investments

The event showcased emerging technology that will empower society to manage, protect and sustainably benefit from the ocean's vast resources. Olav Rune Godø spoke about acoustics and explained, "enhancements to acoustic resolution and increasingly abundant data streams are providing new applications that will advance ecosystem-based management such as predictive modeling and species-specific monitoring."

Technology was also highlighted as driving bio-inspired breakthroughs in areas such as advanced textiles. Bert Groenendaal described some of the latest bio-based polymers with multiple applications for marine and maritime sectors from oil booms to bio-platforms for open sea biomass cultivation. "We are entering a new era of sustainable materials." he said.

Unprecedented access to the deep-sea and innovative molecular techniques, such as molecular studies of sponges presented by Werner Müller, were noted as driving new opportunities for bio-prospecting, leading to discoveries and applications of marine biological resources.

Technology innovations for a sustainable future

The event supported technology innovations that support smarter, more efficient marine and maritime activities whilst maintaining responsibility towards nature. Using the case study of AlgaePARC, Ellen Slegers explained how the reality of large-scale algae biofuel production is one step closer thanks to pilot studies integrating natural and social sciences and creating an ideal test-bed for trialing technological innovations.

Hybrid data infrastructure, such as iMarine presented by Pasquale Pagano, was also noted as a key technological advancement for increasing the accessibility to data and impact of knowledge applications for marine safety, resource management and conservation.

Using Nature's own solutions

Taking inspiration from nature, biomimetics was presented by Fiona Regan as an emerging area offering solutions to biofouling – the undesirable attachment and accumulation of organisms on immersed surfaces – which may lead to significant savings for maritime industries. Huib de Vriend highlighted the need to maintain a balance with the natural world and minimize impact on the marine environment.

Advanced technologies underpinning marine knowledge

The 3rd Forum highlighted Europe's position as a world leader in several marine and maritime sectors, from sensor development to off-shore renewable energy, with a clear need to promote multi-stakeholder collaboration to fast-track commercialization and drive new growth. Speaking about advances in environmental micro sensor development, Matt Mowlem showcased new tools for monitoring complex biological and chemical oceanic processes. He noted that the latest 'lab-on-a-chip' solutions are reaching new levels of maturity with far-reaching applications from marine genomics to monitoring contaminants. But, he stressed, academia alone cannot bridge the current funding gap between prototypes and the mass market.

Multi-sector partnerships

Stakeholder collaboration was also presented as vital for driving multi-use of ocean space towards a smarter, more efficient and environmentally sustainable use of European seas and oceans. Harry Kolar presented SmartBay, a multi-sectoral initiative to provide real-time environmental monitoring of water quality, sea conditions, and weather for Galway Bay, Ireland.

The benefit of collaborative initiatives was also clear for other marine and maritime sectors. Bela Buck explained that such an approach was essential for driving growth in industries such as off-shore aquaculture, currently valued at US $200 Million per year worldwide. "Building consortia through integrated multi-trophic aquaculture will help resolve user conflicts and drive a more efficient green economy," he explained. Industry representatives also stressed the importance of a bottom-up approach for technology developments. "Innovations should answer customer needs," stated Philippe Jean when explaining the research and development route to using electro active polymers as novel converters for creating wave energy.

Investing in Knowledge

The Forum also stressed the importance of investing in marine knowledge in order to achieve economic growth in the context of responsible environmental management. Manuela Soares, Director of the Environment Directorate of the European Commission's DG Research & Innovation, described European research and innovation initiatives on marine technologies, calling for "new and innovative technological solutions" to "ensure the protection and use of the sea and waterways and supply of energy, food and materials are economically sound and conducted in an environmentally sustainable way."

When discussing the need for measurable knowledge transfer, David Murphy explained that effective knowledge transfer is set apart from dissemination because it is tailor-made and targeted to specific end-users. "Scientists do not always realize the cross-cutting applications of knowledge," he stated. "Clearly defining the type of knowledge, who owns it, the market readiness and where it's available will really maximize the impact and will transform the value we gain from marine knowledge." In a presentation on 'Commercializing marine science: Process to production', Stephen de Mora noted that whilst there are still significant hurdles moving from research funded technology developments to industry based production, recognizing the motivation and fostering innovation was key to achieving success. "There is a real potential for gaining financial benefits from scientific excellence through horizon scanning such as tracking market trends and identifying emerging markets," he explained.

Summarizing the event, Marine Board delegate Geoffrey O'Sullivan, Marine Institute Ireland, concluded "It is inspiring to note that many innovations that will progress marine science will come from areas outside marine science including robotics, advanced IT solutions and other emerging technologies converging on the oceans." Regarding the need for an integrated approach, Geoffrey O'Sullivan stated that all sectors could contribute on a multidisciplinary level and that there was evidence that collaborative public and private networks accelerate and catalyze the development and utilization of these technologies in the marine environment.

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European Marine Board Forum Series

European Marine Board Forum brings together European marine research stakeholders, representatives of the marine science community, funding agencies and national and European science institutions, to advance research and to promote marine science in Europe and globally. In line with this objective, the Marine Board Forum provides a platform for Marine Board members, partner organizations, individual scientists and European and national policymakers to interact on a particular topic or theme of strategic importance for European marine science. For each selected topic or theme, the Marine Board Forum aims to:

- Provide a focal meeting point for discussion among individual scientists, policymakers and other relevant stakeholders;
- Facilitate the exchange of information and ideas and agree a common position;
- Enhance collaboration and reduce fragmentation and/or duplication in the European research effort.

The main messages, discussions and decisions from Marine Board fora are recorded and published as proceedings. Presentations and outputs of the three Marine Board fora are available on the Marine Board website: **www.marineboard.eu/fora**

The 1st Marine Board Forum (May, 2008) brought a large stakeholder community together to discuss the topic *Marine Data Challenges: From Observation to Information*. The Forum's discussions contributed to the development of the European Marine Observation and Data Network (EMODnet) initiative launched by the European Commission. Furthermore, the Forum led to a joint Marine Board – EuroGOOS vision document on EMODnet, published in September 2008.

The 2nd Marine Board Forum (Sept., 2010) emphasized on the need for long-term time series data, which can best be provided by a coherent European network of marine observatories to support monitoring and research. These form a crucial component of the ocean observing system and the original end-to-end EMODnet.

Technology has transformed the way humans interact with the seas and oceans. But what are the next big ideas that will drive growth in marine and maritime sectors into the future? **The 3rd Marine Board Forum**, held on 18 April 2012, Brussels, brought together experts from academia, industry and policy from 71 organizations to discuss future and emerging 'Blue Technologies' on the understanding that technology is the key to unlocking the secrets of the oceans which will allow us to manage, protect and sustainably benefit from their vast resources.

The 3rd Forum highlighted innovation hotspots for the European marine sector, showcasing emerging technologies for driving growth, novel applications for human well-being and tools for next generation marine knowledge.

All documents and materials from the Forum are available online at:
http://www.marineboard.eu/3rdforum

3RD MARINE BOARD FORUM

Programme

08.45 Registration & welcome coffee, setting up of the poster session

09.30 **Opening address - Kostas Nittis,** European Marine Board Chair

9.40-10.20 **Key-note presentation:** ***Understanding the planetary life support system: next generation science in the ocean basins*** **- John Delaney,** University of Washington, USA

Session 1. Innovation Hotspots: Key examples of future and emerging marine technologies Chair: Kostas Nittis, European Marine Board Chair, Hellenic Centre for Marine Research (HCMR), Greece		
10.20-10.40	***Marine Ecosystem Acoustics: A cost-efficient approach to ecosystem information***	**Olav Rune Godø**, Institute of Marine Research (IMR), Norway
10.40-10.55	***Molecular Marine Biotechnology: From genes to bioactive products***	**Werner Müller**, J. Gutenberg University Mainz, Germany
11.00-11.30 Networking & coffee		
11.30-11.50	***Status Quo of Offshore Aquaculture in Germany: A new vision for a "green economy" in the marine realm***	**Bela Buck**, Alfred Wegener Institute for Polar and Marine Research (AWI), Germany
11.50-12.10	***Building with Nature in Coastal and Marine Environments***	**Huib de Vriend**, ECOSHAPE, The Netherlands
12.10-12.30	***Marine Environmental Micro Sensors***	**Matt Mowlem**, National Oceangraphy Centre (NOC), UK
12.30-12.50	***Standing Wave Tube Electro Active Polymer: Wave energy converter***	**Philippe Jean**, SBM Offshore NV
12.50-13.40 Lunch		
Session 2. What's the big idea? Some new and blue technologies in a nutshell Chair: Antoine Dosdat, Marine Board vice-Chair, French Research Institute for Exploration of the Sea (Ifremer), France		
Flash presentations 13.40-14.20	***Advanced textiles for open sea biomass cultivation (AT~SEA)***	**Bert Groenendaal**, SIOEN Industries NV
	AlgaePARC and models for large scale microalgae production	**Ellen Slegers**, Wageningen University, The Netherlands
	iMarine - a Hybrid Data Infrastructure for an ecosystem approach to fisheries management and the conservation of marine living resources	**Pasquale Pagano**, Istituto di Scienza e Tecnologie dell'Informazione "A. Faedo" (ISTI) – National Research Council of Italy (CNR) & iMarine Technical Director
	Bio-inspired marine anti-fouling strategies for reducing the cost of ownership of marine deployed structures	**Fiona Regan**, MESTECH, National Centre for Sensor Research, Ireland
14.20-14.40	**Multi-sectoral case study:** ***The SmartBay Galway Collaboration: A Marine and Coastal Research and Development Platform***	**Harry Kolar**, Chief Architect for Sensor-based solutions, IBM
14.40-15.30 Networking & Coffee		
Session 3. Investing in Knowledge Chair: Geoffrey O'Sullivan, Marine Institute, Ireland		
15.10-15.30	**Key-note address:** ***Marine Technologies: EU research and innovation initiatives***	**Manuela Soares**, Director of Environment Directorate, EC DG Research & Innovation
15.30-15.50	***Marine Knowledge Management: From RTD to measurable value creation***	**David Murphy**, Aqua TT, Ireland
15.50-16.10	***Commercializing marine science: Process to production***	**Stephen de Mora**, Plymouth Marine Laboratory (PML), UK
16.10-16.50 ***Open floor discussion***		

16.50-17.00 **Closing address - Kostas Nittis,** European Marine Board Chair

17.00 **End of Forum**

3RD MARINE BOARD FORUM

Welcome address

Kostas Nittis (European Marine Board Chair) opened the Forum by welcoming speakers and participants. He introduced the European Marine Board, explaining its strategic role in advancing marine research and bridging the gap between science and policy through a range of different instruments including the Working Groups, Panels and Fora. Kostas Nittis introduced the topic chosen by the Marine Board members for the 3rd Marine Board Forum: "New Technologies for a Blue Future."

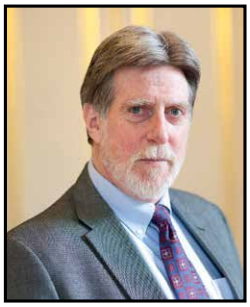
He posed the question "What technologies might we expect in the future?" He also highlighted the need to link technology and scientific research to society to ensure a high impact of future innovations on research and society. He explained the importance for education and knowledge transfer to achieve this goal. He invited participants to be engaged in the Forum to deliver recommendations that could help to bridge the gap between science, society and economy through innovation.

" Blue Technologies drive science and innovation, supporting economic growth and well-being. Education and knowledge transfer hold the key to unlocking knowledge and ensuring that innovations are relevant and have a high impact."

Kostas Nittis, European Marine Board Chair

Keynote presentation

Understanding the planetary life support system: next generation science in the ocean basins



John Delaney (University of Washington, USA) stressed the importance of studying oceans, the life support system for the entire planet. He stated there had already been much investment in outer space exploration and it was time to re-focus and prioritize the need to explore and understand the oceans, which can be called our 'inner space'. He explained that the next huge but crucial challenge was to use a system-based, international approach to study the global ocean, noting this visionary approach was vital to understand marine ecosystems and how the life support systems function.

> *" We are entering a new era of engineering – imagineering... Rapid advancements in areas like fibre optic cables are offering the reality of unlimited power and constant telepresence in the oceans...these technologies and the knowledge they produce are going to vastly enhance the planet we live on and the future planets we will explore."*
>
> John Delaney, University of Washington, USA

He next focused on the idea of the "Perpetual Ocean", and the importance of understanding the age of the seafloor as a direct expression of the feedback between the ocean and dynamics of tectonic plates. He noted that this was fundamental science with direct application to society, such as natural hazards or resource exploitation. John Delaney identified that our knowledge is still limited on processes of underwater volcanic eruptions, the associated release of fluids with high metal concentrations and their roles in supporting life. These could offer clues and further understanding to the origins of life, offer novel applications for medicine and as yet undiscovered metal and biological resources. The temporal scales of the cycles for these processes may be hundreds of years, he stated, and a relevant observation system needs to be designed to capture this.

John Delaney demonstrated that growth of food (vegetation) on the continent is directly tied to the rhythm of the sea surface temperature. He stressed the increasing importance of the ocean as a source of resources and ecosystem services in a world with a rapidly rising human population. In order to tackle global-scale climatic processes, he emphasized the need for a full systems approach, linking terrestrial and ocean processes, promoting interdisciplinary research with a holistic view of the planet.

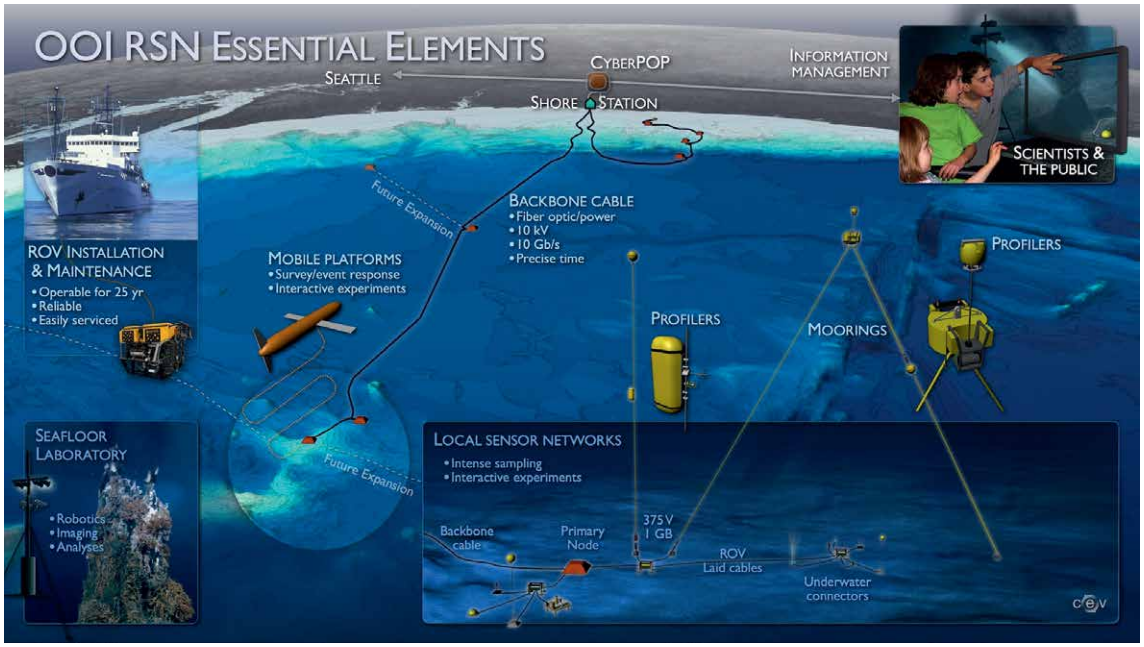
John Delaney used the example of the Ocean Observatories Initiative (OOI)[1] funded by the U.S. National Science Foundation (NSF). This large-scale infrastructure project includes a cabled observatory with sensor-robotic network across the Juan de Fuca tectonic plate. This has turned the seafloor and overlying ocean into an internationally accessible, interactive, real-time natural laboratory capable of reaching millions of users via the internet. Such networks are at the leading edge of ocean and earth science research and education. Simultaneous multidisciplinary science, he stressed, relies on utilizing emergent technologies and a mechanism is needed for bringing all technologies together for the benefit of oceanography.

1 http://www.ooi.washington.edu/

The Global Scale Nodes of OOI consist of four arrays located in four critical, yet under-sampled, high-latitude locations, including two in the southern hemisphere and two in the northern hemisphere in the Irminger Sea and in the Eastern Pacific.

Credit: OOI Regional Scale Nodes and Center for Environmental Visualization, University of Washington

Q&A On the subject of training new engineers, it was stressed the need to train the next generation ready to tackle the integrated-interdisciplinary challenge. John Delaney added it was also time to act now and that academics had to learn how to communicate with society and talk about diverse processes that happen on the planet now.



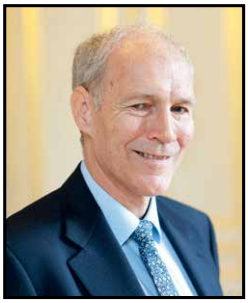
The great advances in fibre optic cable technology have provided unlimited bandwidth and continuous electrical power in the ocean. Sub-sea cables on the Juan De Fuca Plate, a Region Scale Nodes (RSN) system, allows real-time observation of events and *in situ* remote sampling that can be carried back to a laboratory for analysis.

Credit: OOI Regional Scale Nodes and Center for Environmental Visualization, University of Washington

Session 1 – Innovation Hotspots: Key examples of future and emerging marine technologies

Chair: Kostas Nittis (European Marine Board Chair, Hellenic Centre for Marine Research, Greece)

Marine Ecosystem Acoustics: A cost-efficient approach to ecosystem information

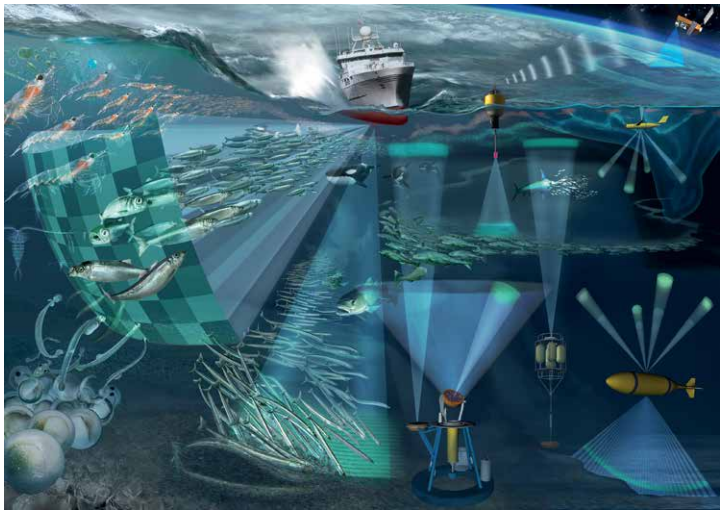


Olav Rune Godø (Institute of Marine Research, Norway) emphasized that recent developments in marine acoustics can allow observers to "see the sea with sound" and to support an ecosystem-based management. He noted that the requirements for ecosystem approach are to understand ecosystem composition and dynamics, the capabilities to assess status, the abilities to adequately predict development of system and components, and the abilities to handle risks.

Acoustics is the only method that can provide information with appropriate resolution at spatial (from mm to km) and temporal (from seconds to seasons) scales across the range of fundamental biophysical processes as well as at the scales needed to resolve trophic interactions from individuals to populations. Exploiting acoustic technology (band and beam widths) and developing platforms for sensors, ecosystem process can be observed on scales at which they occur, an essential requirement for quantitative ecosystem understanding and modelling. Further, the approach also supports the knowledge and information needed to establish a better basis for an ecosystem-based fisheries management.

> *" Enhancements to acoustic resolution and increasingly abundant data streams are providing new applications that will advance ecosystem-based management such as predictive modeling and species-specific monitoring."*
>
> Olav Rune Godø, Institute of Marine Research, Norway

Q&A On using acoustics to distinguish species, **Carlo Heip** (NIOZ, The Netherlands) asked if one can tell the species from the signals from acoustics alone, or is biological sampling still necessary. **Olav Rune Godø** explained that the swim bladders of fish give a different signal and some species, such as mackerel, do not possess a swim bladder. For other species one needs to go into other details of the frequency band, but it is possible to a certain level.



A variety of mobile and stationary acoustics tools enable ocean observations at multiple temporal and spatial scales.

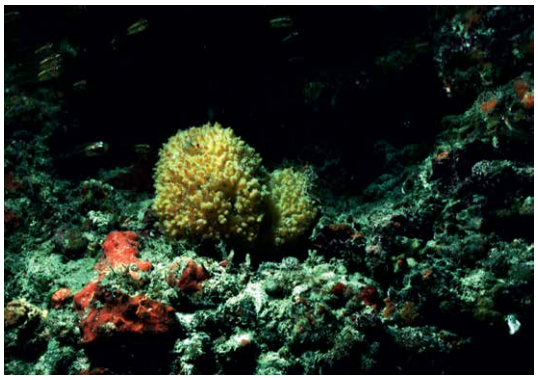
Credit: Olav Rune Godø, Institute of Marine Research, Norway

Molecular Marine Biotechnology: From genes to bioactive products

Werner Müller (J. Gutenberg University Mainz, Germany) presented the emerging area of molecular marine biotechnology, using sponges as a model organism. He noted that sponges, phylum Porifera, are animals that live in symbiosis with microorganisms. Sponges are rich sources of bio-compounds with great potential for bioprospecting and applications ranging from inorganic chemistry to molecular biology, bio-informatics and drug development. For example, AraC (Arabinofuranosyl Cytidine), a potent anti-viral agent found in sponges, was successfully introduced into anti-leukemic studies.

> *" Molecular studies of sponges – the most ancient metazoan taxa – are offering insights into human gene synthesis, control and expression, leading to possibilities for human bone regeneration."*
>
> Werner Müller, Johannes Gutenberg University Mainz, Germany

He explained that sponge can be a model organism for understanding human molecular pathways, noting recent molecular data revealed that molecules with similar characteristics (homologous conserved molecules) exist in sponges and mammals with a role in many molecular functions from tissue formation (e.g. collagens) to transcription. This evidence indicated a common (monophyletic) origin of all Metazoa.



Tethya sponge in the Adriatic Sea. Sponges are one of the most ancient metazoan taxa and studying their genetic blueprint, such as the genomics, proteomics and transcriptomics, offers a deeper understanding of the genetic repertoire of the Urmetazoa (evolutionary precursor of the Metazoa).

Credit: W.E.G. Müller

He noted several potential societal applications of molecular marine biotechnology research focused on sponges:

1. Optical fibres: Large spicules of some sponges use an organic light source (luciferase protein) and inorganic light transducing silica spicules to produce effective light-collecting optical fibres.

2. Mineralization process and human bone formation: The siliceous material in deep-sea glass sponge skeleton is an organic matrix made of quartz glass with low impurities. Much could be learnt from sponges as we can now pinpoint a body plan/ structural element to a few genes and the order from the basal gene required for the synthesis for aggregation and then filament formation. This could potentially revolutionize human bone regeneration, as it is not currently known which gene was responsible for controlling synthesis and bone morphogenesis.

3. Nano-biotechnology and nano-biomedicine: Further understanding of the synthesis of sponge skeletons and their building blocks could lead to

the development of novel applications of the enzymes/proteins involved in bio-silica formation in various fields of nano-biotechnology and nano-biomedicine. He referred to the latest developments in knowledge of sponge spicule formation, noting that cell types have been identified in the structure-guiding process. He explained that science is currently at the frontiers in the understanding of the different levels of hierarchies, genetic, biological and structural, and this will contribute to the fabrication of new bio-inspired functional materials and bio-reactive compounds for medical purposes.

Status Quo of Offshore Aquaculture in Germany: A new vision for a "green economy" in the marine realm

Bela Buck (Alfred Wegener Institute for Polar and Marine Research, Germany) highlighted the potential for integration of offshore wind farms with open ocean aquaculture beyond the terrestrial limit (12 nautical miles). There is a pressing need to expand aquaculture production as a means of offsetting the global decline in fisheries production as a valuable source of seafood protein, especially with a rapidly growing population. A major limiting factor in Europe is the amount of inshore space suitable and available for mariculture. Moving offshore can overcome this barrier and provide access to higher water quality and less onerous regulation. However, it raises many technical challenges.

He proposed a rationale for integrating offshore aquaculture and offshore wind energy generation. The lack of legislation in EEZs provides a window of opportunity for concerted innovative multiple-use schemes, meeting the need for spatial efficiency and maximizing return per unit area of sea. From a technical perspective, aquaculture systems in offshore environments could benefit from the anchorage provided by solid wind turbine foundations.

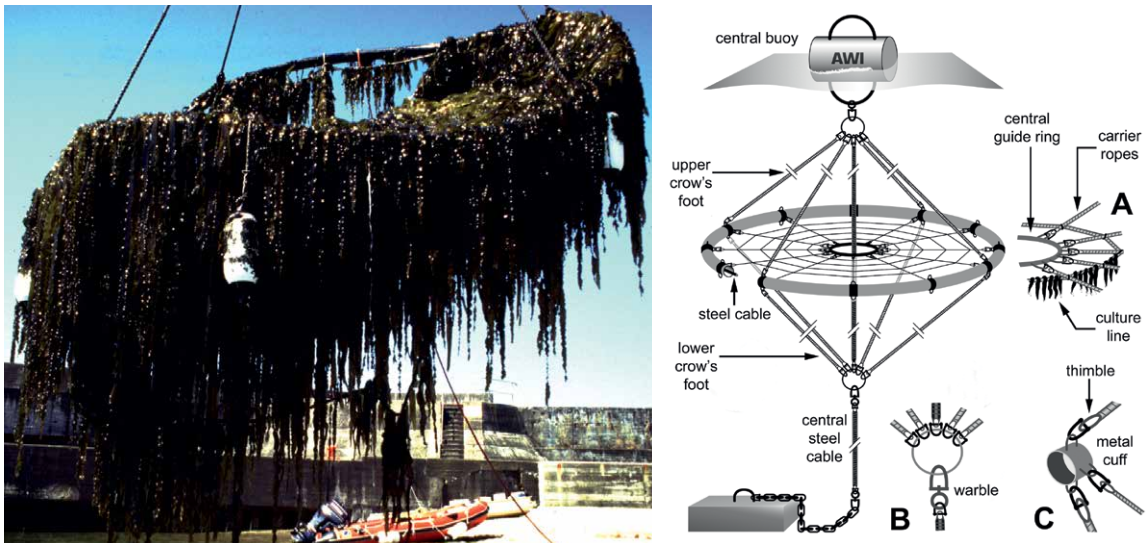
> *" There is an increasing demand for aquatic products and we do not have space on land. So why not produce larger-scale aquaculture offshore?"*
>
> Bela Buck, AWI, Germany

Key principles are being used in that process:

1. *Bioextraction:* an environmental management strategy by which nutrients are removed from an aquatic ecosystem through the harvest of enhanced biological production, including the aquaculture of suspension-feeding shellfish or algae;
2. *Ecological Engineering:* an emerging field that uses ecological processes within natural or constructed systems to achieve environmental goals;
3. *Balanced Ecosystem Approach:* consisting of feeding aquaculture of finfish or shrimp with extractive organic aquaculture of shellfish and extractive inorganic aquaculture of seaweed (Integrated Multi-Trophic Aquaculture or IMTA).

The remaining issues are the following:

- Up-scaling aquaculture requires a move offshore;
- IMTA concepts should form the basis for new enterprises to fulfil criteria of sustainability and environmentally friendly techniques and public acceptance;
- Offshore aquaculture can only be conducted by a consortium and not by a single farmer/fisherman;
- Multi-use concepts will have a better acceptance for both stakeholders (wind / aquaculture) and would save costs.

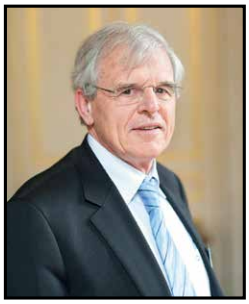


Macroalgae *(Laminaria saccharina)* open sea cultivation and the technical drawing of the 'Offshore Ring' prototype

Credit: B. Buck/ AWI, Germany

Q&A **Andris Andrusaitis** (BONUS EEIG) asked if socio-economic projections existed for intensive fish farming would require daily maintenance. **Bela Buck** answered that such projections exist for seaweed and mussels. Fish farms have not been integrated to wind farms yet, but cages are under development. The possible stress induced by the wind devices would be investigated.

Building with Nature in Coastal and Marine Environments



Huib de Vriend (EcoShape, The Netherlands) presented the idea of "building with nature" to realize hydraulic engineering functionality via natural processes (physical and biological), while at the same time creating new opportunities for nature. He noted that this requires a different way of thinking and working, involving the ecosystem dimension from the early project development stage onwards.

> *" Building with Nature is vital to ensure that natural processes are taken into account…. This is achievable through the Golden Triangle of Innovation – government, private sector, knowledge sector – which together can promote evidence-based approaches to marine management."*
>
> Huib de Vriend, EcoShape, The Netherlands

He presented the "Sand Engine", a pilot project in which 20 million cubic metres of sand were deposited as a super dune on the coastal system of Delfland (The Netherlands). This should result in:

- Better flood protection for the province of South Holland, and also less disruptive for the ecosystem than the standard sand replenishment operations every five years;
- Extra room for nature (rare species have settled), and recreation (the area unexpectedly became a popular windsurfing destination). The area at outset was 128 hectares; ultimately this will result in 35 hectares of new beaches and dunes (juvenile dune formation has already been observed);
- Innovation (acquiring new knowledge about strengthening the coast).

The next steps include:

- An extensive monitoring scheme;
- An additional environmental monitoring programme.

He took the example of offshore sand mining that regulation required seafloor being left horizontal. However, an undulated seabed is richer in biodiversity and biomass, and have been demonstrated by experiments.

A well-functioning triangle of innovation, government, private sector, knowledge sector, is key to the successful initiative such as EcoShape[2], a national programme which ran numerous pilot projects and aims to "broaden up to EU scale."

Q&A **Waddah Saab** (European Commission) asked whether the concept of "Building with Nature" could be applied anywhere or if there were any restriction of its use. **Huib de Vriend** conceded that the concept is not a panacea and indicated that where there is no space, it is very often not possible to implement such a concept and cheaper and flexible solutions would then be favoured. "Building with Nature" concept would most likely be implemented when it can bring cost benefits to practitioners. Huib de Vriend also indicated that one third of the EcoShape programme is dedicated to research related to economic valuation of ecosystem goods and services. He stressed that the Building with Nature concept is nearly impossible in the absence of an appropriate and supportive legal and policy framework. **Paris Sansoglou** (European Dredging Association) stressed the need to create opportunities for practitioners to integrate their projects into the ecosystem and to integrate nature in their projects.

2 http://www.ecoshape.nl/

Delfland Sand Engine, constructed between March and November 2011, uses wind, waves and currents to spread the sand along the coast between the Hook of Holland and Scheveningen. Photos were taken in June 2011 (left) and March 2012 (right). The sand has been gradually redistributed by natural processes over the shore-face beach and dunes. This innovative approach aims to limit the disturbance of local ecosystems, while also providing new areas for nature and recreation.

Source: Rijkswaterstaat Joop van Houdt (https://beeldbank.rws.nl/)

Marine Environmental Micro Sensors

The understanding of ocean biogeochemical systems is limited by a lack of access to environmental data for parameters that are difficult to measure, such as in chemistry (e.g. nutrients) and biology (e.g. types of organisms, their productivity and activity). **Matt Mowlem (National Oceanography Centre, UK)** stressed that sampling structures in space and time are missing, which result in a significant effect on our understanding of the system and capacity to predict future changes. There is a crucial need for numerous and relatively cheap sensing nodes across the ocean. Whereas physical sensors are advanced and mature, biogeochemistry sensors are less well developed and focus was needed to develop more reliable and cost-effective sensors for long-term deployment.

> *" Engaging with industry is essential to fast-track product commercialization and maximize the impact of emerging technologies."*
>
> Matt Mowlem, National Oceanography Centre, UK

Matt Mowlem used the example of the commercially available Environmental Sample Processor (ESP, 1999-present) to illustrate that biogeochemical sensors are often still very large and expensive (>€200k). He noted that it was necessary to develop miniature, robust and cost effective devices to meet the challenges of *in situ* high-throughput sequencing analyses

and capability to achieve large-scale *in situ* observations of the biogeochemical system. Such sensor systems must be versatile and capable of being fitted to multiple platforms from gliders to moorings and ships of opportunity.

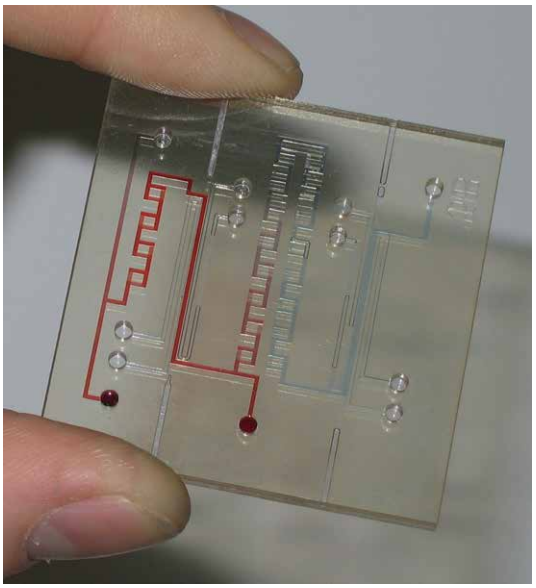
A new generation of biogeochemical miniaturised sensors to measure nutrients and pollutants in the world's oceans. These sensors are capable of operating in harsh environments and are being developed for deployment over months at a time.

Credit: University of Southampton

Matt Mowlem gave an overview of the work of the NOC Sensors Development Group, focusing on marine environmental micro sensors including chip technology. He noted that benefits of miniaturization for making complex reagent-based analysis more cost-effective. He also explained that very highly engineered systems (e.g. pumps, valves, optics, and electronics) were the key to developing sensors that are resistant to high pressures and low temperatures, such as:

- Nutrient sensors, which could be of interest to both science and water industries;
- Carbonate sensors for analysis of CO_2 and pH changes for carbon sequestration, and climate change;
- Bioassays for analysis of microbiology in natural waters, which could have applications in regulatory monitoring and environmental science.

He highlighted the lack of funding available to researchers to support the critical phase of technology development between laboratory prototype and the market. Another key issue to ensure progress is the availability of human resources, including scientists and technologists with the multi-disciplinary expertise essential for sensor research.



Standing Wave Tube Electro Active Polymer: Wave energy converter

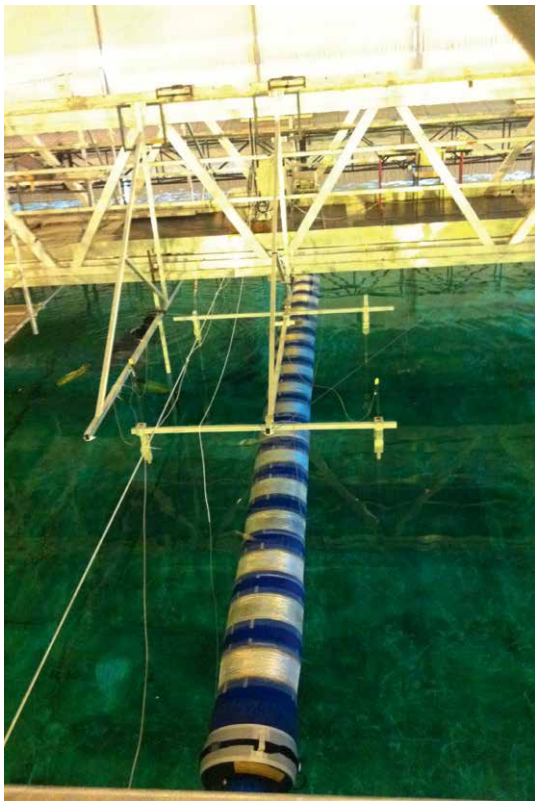
Philippe Jean (SBM Offshore N.V., The Netherlands) stressed the key to innovation success is to answer customer needs. Unlike wind energy technology, he said, conventional heavy and expensive Wave Energy Converter (WEC) technology has no standard that could generate viable energy solutions. He presented the newly developed 'S3' converter by SBM Offshore: the wave tube floats on the ocean surface and efficiently harvests wave energy, activated by pressure, from a wide range of wave periods. Its structure is composed of only elastomers and is extremely flexible, environmentally friendly and silent. By 2015, a 100 to 200m long tube will be installed at the SEMREV test centre in France (Le Croisic). The objective is to increase the diameter of the tube to produce more power.

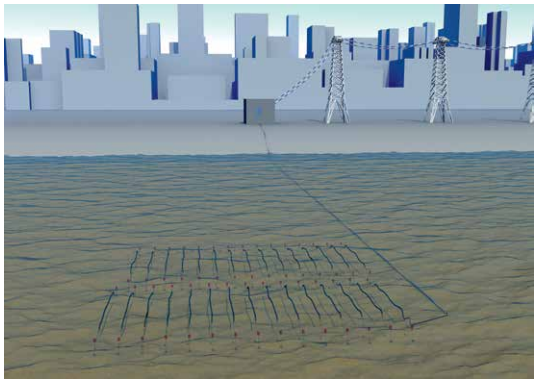
" Innovations should answer customer needs."

Philippe Jean, SBM Offshore NV

In 2010, SBM proved the concept of the Standing Wave Tube wave energy convertor (SWT WEC) with integrated power take off using a small scale model. Due to its entirely deformable structure, the SWT WEC has an infinite number of degrees of freedom. Under excitation of regular and irregular waves, the individual wave harmonics stimulate a particular resonance mode of the tube, resulting in a broadband response of radial deformation and an efficient power take off along its full length.

An 11m proof of concept model is currently being tested in wave tanks. Electro-active polymer ring generators are distributed along an elastomeric tube over several wave lengths, creating a high voltage multiphase DC power source with low ripple, naturally smoothing the irregularities of ocean wave amplitudes and periods.





Artist impression of a 15 MW offshore WEC power plant, comprising 30 flexible Standing Wave Tube WEC units.

Q&A **Stephen de Mora** (PML, UK) queried the potential degradation due to biofouling. Philippe Jean answered that one of the consortium partner, Ifremer, was currently addressing this issue. **Pier Francesco Moretti** (CNR, Italy) queried how the system could match the wave period of resonance and physical length. **Philippe Jean** answered that the system is activated by pressure more than direction of the waves.

Session 2 – What's the big idea? Some new and blue technologies in a nutshell

Chair: Antoine Dosdat (Marine Board vice-Chair, Ifremer, France)

Flash Presentation

Advanced textiles for open sea biomass cultivation (AT~SEA)

Bert Groenendaal (SIOEN Industries NV, Belgium) presented the EU FP7 project, AT~SEA[3], which started in April 2012. The FP7 AT~SEA project is working towards the development of new energy sources (non-oil-based products), in response to the global challenges of the growing population and the need for sustainable energy. The concept is to cultivate aquatic biomass (macroalgae) in the ocean as a source of renewable energy and biomaterials.

> *" We are entering a new era of sustainable materials."*
>
> Bert Groenendaal, SIOEN Industries N.V., Belgium

The project targets the development of novel textile materials for three different components of the aquatic biomass cultivation systems:

- Advanced 3D multilayer textile substrates for seaweed cultivation;
- Advanced textile-based cables and connections for positioning and anchoring of the 3D multilayer textile substrate;
- Advanced coated textiles for flexible and lightweight floatation tubes, as well as for storage and transportation tanks.

The objective of At~Sea project is to develop novel textile materials for the aquatic biomass cultivation farms.

Credit: At~SEA Consortium

Q&A **Cornelia Nauen** (European Commission) asked if deploying these materials in the marine environment could contribute the marine litter problem, particularly at the micro-level? **Bert Groenendaal** replied that it is an issue, mainly in the southern part of the EU where they plan to use nets around the platforms. This is something that they are working to minimize as the technology is further refined.

3 http://www.atsea-project.eu/

Flash Presentation

AlgaePARC and models for large-scale microalgae production

Ellen Slegers (Wageningen University, The Netherlands) presented pilot studies being undertaken at an algae cultivation park which aim to take algae cultivation from a small-scale fundamental research interest to full-scale commercial production. Biofuel extracted from algae could meet the energy demands of European citizens into the future. She outlined the potential of transforming a microalgae strain such as *Tetraselmis suecica* into fuel, food and feed based on a high lipid content and a faster growth rate than terrestrial crops. She specified that one algae species is used to compare various designs and growing conditions in parallel. Models were also being used to predict for ideal growth locations, such as Hawaii or Spain. The AlgaePARC is a versatile combination of experiments and models.

" … the reality of large-scale algae biofuel production is one step closer."

Ellen Slegers, Wageningen University, The Netherlands

Different cultivation conditions are investigated in the AlgaePARC project, such as open pond systems and a tubular photobioreactor. Possibilities of other locations are also investigated on different criteria, such as solar radiation, water supply chain and carbon dioxide.

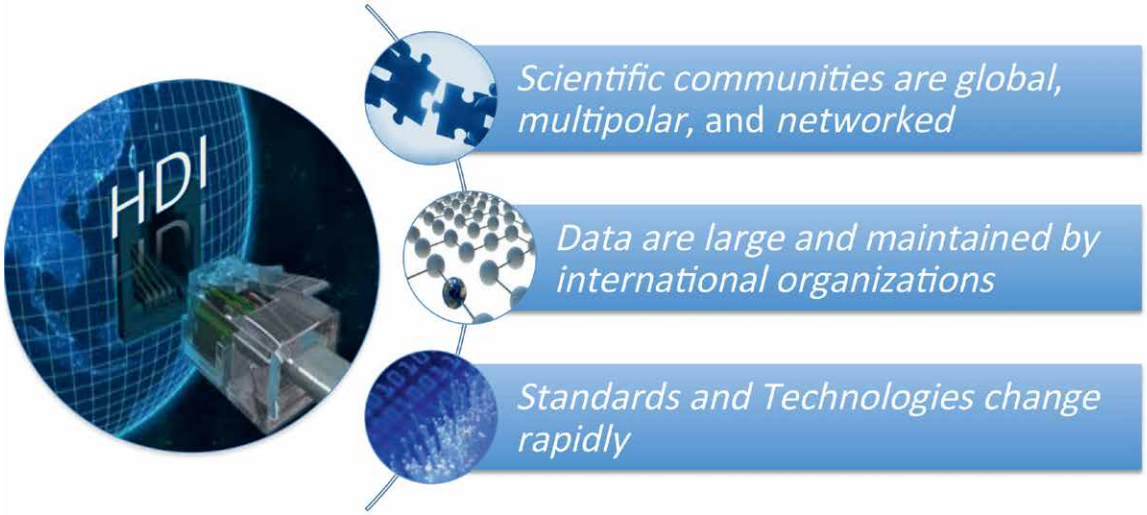
Credit: AlgaePARC, WageningenUR

iMarine - a Hybrid Data Infrastructure for an ecosystem approach to fisheries management and the conservation of marine living resources

Pasquale Pagano (CNR-ISTI, National Research Council of Italy & iMarine Technical Director) presented iMarine[4], an open and collaborative initiative that will establish a data infrastructure for fisheries management and conservation of marine living resources. Rapidly advancing technology in data storage and processing using the "cloud approach" can create an infrastructure for managing high volumes of data. iMarine represents a generic way to reduce the cost of largely distributed electronic infrastructure by integrating a number of data providers. The project applications increase quality of service by 15-45 times compared with existing systems.

Pasquale Pagano gave examples of applications in blue technology, including the generation of probability models for species, performing transformations on environmental data, to perform vessel trajectories analysis and monthly fishing effort calculations, evaluating models, distributions and experiments and performing data quality analyses. Users were invited to join and participate in various initiatives.

> *" The cloud [computing] approach as a service offers the capability to run processes and observing capability up to 45 times faster for data processing, reducing costs of large distributed e-infrastructures."*
>
> Pasquale Pagano, CNR Italy/ iMarine



iMarine operates a hybrid data infrastructure to allow access rich data spaces, reduce operational costs of a given application and increase application quality of service.

Credit: Pasquale Pegano/ iMarine

4 http://www.i-marine.eu/Pages/Home.aspx

Flash Presentation

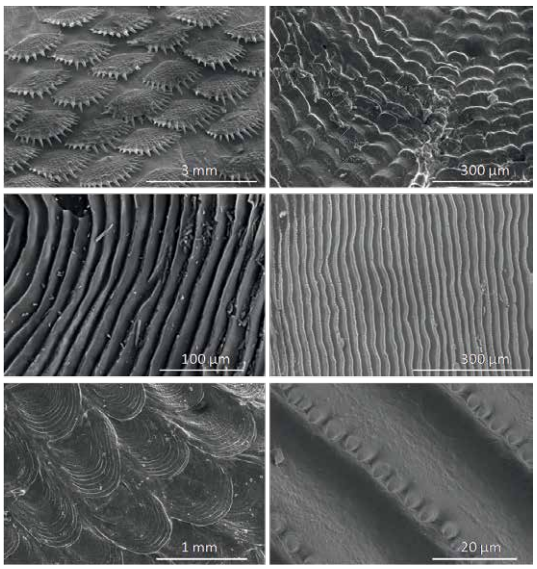
Bio-inspired marine anti-fouling strategies for reducing the cost of ownership of marine deployed structures

Fiona Regan (MESTECH, National Centre for Sensor Research, Ireland) presented anti-fouling strategies that were inspired by biology. Biofouling has been a great challenge in developing environmental sensors to ensure data quality and reduced maintenance costs. Lessons can be learnt from nature. A schematic overview of the process of developing and testing potential biomimetic antifouling materials was presented, using the example of the surface features of the brown crab which have the capacity to resist biofouling.

Bio-inspired design is about taking elements from nature and replicating this for human benefit. The new bio-inspired marine anti-fouling technology will be used on various deployed devices thus both significantly reducing the maintenance costs and increasing data quality.

" Technology is allowing us to replicate nature-inspired design, to create unique structural features to prevent fouling... this will ultimately reduce the cost of ownership and maintenance whilst ensuring better data quality."

Fiona Regan, MESTECH,
National Centre for Sensor Research,
Dublin City University, Ireland

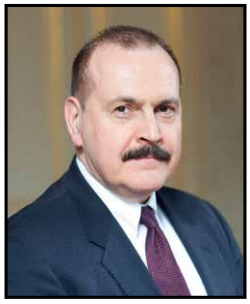


Scanning electron micrographs of surface textures from a range of fish scales, illustrating the diversity of textures and dimensions present on these structures. It has been speculated that the role of surface textures on these structures may be in mucus retention and drag reduction; however such surface features may also act as anti-settlement cues for biofouling organisms.

Credit: Timothy Sullivan, MESTECH, Dublin City University

Multi-sectoral case study

The SmartBay Galway Collaboration: A Marine and Coastal Research and Development Platform

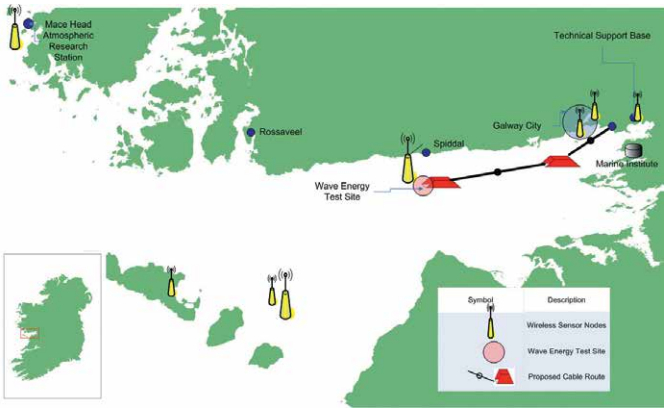


IBM Distinguished Engineer, **Harry Kolar** presented SmartBay, a multi-sectoral initiative to provide real-time aquatic environmental monitoring.

> *" Next generation integrated coastal and marine monitoring and management is essential so we can move from state-funded approach towards beneficial partnerships."*
>
> Harry Kolar, IBM Distinguished Engineer.

The collaboration with the Marine Institute of Ireland allows a wide range of monitoring for research and operational purposes. SmartBay, with IBM technologies, aims to:

- Design, test and implement the next generation marine environmental monitoring R&D platform;
- Establish an "end-to-end" reference architecture with large-scale solution commercialization potential;
- Develop, test and fast-track a number of new technologies appropriate for water management and advanced cyberphysical systems;
- Enhance the partner ecosystem for water management and sensor-based solutions through the collaboration of selected multinationals, SMEs and academic instructions.



The SmartBay Galway infrastructure includes wireless sensor nodes such as monitoring platforms, tide gauges and wave monitoring buoys (Gaughan and Kolar, 2010[5])

Credit: Marine Institute

The idea of SmartBay is to support a wide range of stakeholders, from monitoring of sea conditions, weather, policy, energy, fisheries and safety to education and tourism. The web-based environmental monitoring portal technology, developed by IBM, could present an integrated view of the bay while simultaneously distributing data for specific stakeholders. The portal software is customized to meet the needs of multiple stakeholders and the systems can be accessed via the SmartBay portal, email or by mobile phone text messages.

5 Gaughan and Kolar (2010) A far smarter bay. The Journal of ocean Technology. 5(2) 57-72.

A buoy in Galway Bay uses sensors in the ocean to collect data on water quality and sea conditions.

Credit: Marine Institute

Session 3 – Investing in Knowledge

Chair: Geoffrey O'Sullivan (Marine Institute, Ireland)

Keynote address

Marine Technologies: EU research and innovation initiatives

Manuela Soares (Director of Environment Directorate, EC DG Research & Innovation) acknowledged the success of the European Marine Board Forum series, noting that DG Research representatives had attended all of these events to date. She highlighted the EU efforts dedicated to support blue technologies, to expand knowledge and to develop technological capacities in order to boost innovation and competitiveness in Europe. In order to meet the goals set out in the Europe 2020 strategy, including a sustainable and resource efficient economy, it is necessary to invest in science, as already acknowledged by the science community in the Ostend Declaration (EurOCEAN 2010). More investment will be instrumental in pursuing economic growth whilst preventing any further environmental degradation (e.g. reaching Good Environmental Status in EU waters by 2020). The European Commission is strongly committed to supporting marine and maritime research with dedicated funding.

> *" New and innovative technological solutions [are required] …to ensure the protection and use of the sea and waterways and that the supply of energy, food and materials is economically sound and conducted in an environmentally sustainable way."*
>
> Manuela Soares, Director of Environment Directorate, EC DG Research & Innovation

Manuela Soares noted that the FP7 "Oceans of Tomorrow" initiative had the objective of promoting research and innovation through large multidisciplinary, multi-sector projects, combining basic and applied research to address specific EU policy needs. She noted that for future calls, 15% funding for SMEs will be an eligibility criterion, encouraging scientists and SMEs to work together and foster innovation.

She referred to Horizon 2020 as the key programme in support of the innovation union. One of the novelties of Horizon 2020 is that it will bring together, for the first time, all EU research and innovation funds under a single umbrella: FP (Framework Programme), CIP (Competitiveness and Innovation Framework Programme) and EIT (European Institute of Innovation & Technology). Marine and maritime research, one of the cross-cutting areas, will be present in all pillars including environment, energy, transport, food security, climate and resources. Horizon 2020 will accommodate a new ERA-NET scheme and if and when there is a clear commitment demonstrated through a JPI, an article 185 could be launched. The JPI Oceans will be building on work from SEAS-ERA ERA-NET and BONUS Art 185 and will foster synergy and complementarities with other EU funds (e.g. fisheries funds).

She concluded by stressing that seas and oceans are part of the European identity and represent a great challenge. New solutions must be found to ensure their protection and that the use of marine resources are undertaken in a sustainable way.

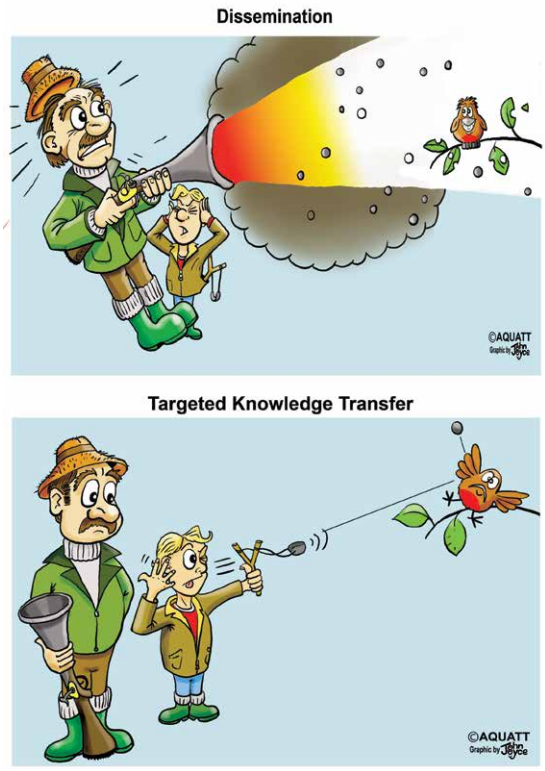
Marine Knowledge Management: From RTD to measurable value creation

David Murphy (AquaTT, Ireland) gave a presentation on the need for measurable knowledge transfer, explaining that effective knowledge transfer is set apart from dissemination because it is tailor-made and targeted to specific end-users. "Scientists do not always realize the cross-cutting applications of knowledge," he stated.

> *" Clearly defining the type of knowledge, who owns it, and its market readiness and availability, will really maximize the impact and transform the value we gain from marine knowledge."*
>
> David Murphy, Aqua TT, Ireland

He explained that several projects were piloting methodologies about marine knowledge including stages of collection, analysis and transfer. However, knowledge is a broad terminology and needs to be further defined in terms of the type of knowledge, who owns it, whether it is market-ready and if available, where, and what are the applications? He also noted the abundance of grey knowledge that is not published in the peer-reviewed literature but has huge potential for fast-tracking economic growth if communicated successfully to an appropriate end user.

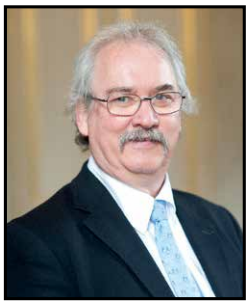
David Murphy then posed the question, how should knowledge be captured and whose job is it to transfer knowledge? He noted that scientists don't always know cross-cutting applications of knowledge and there were social aspects and motivation of the scientists to consider such as who in a team should be responsible for commercialization?



Differences between dissemination and knowledge transfer: knowledge transfer has a specific end-user in mind and is targeted. It is important to tailor knowledge transfer for a particular message/situation. Successful knowledge transfer should follow a value chain where you can achieve the maximum impact.

Credit: John Joyce/ AquaTT

Commercializing marine science: Process to production



In his presentation, **Stephen de Mora (Plymouth Marine Laboratory, UK)** identified the importance of horizon scanning to recognize potential financial benefits, including scientific developments, market trends, internal ideas, rapid recognition of potential winners and fostering innovation.

He noted that whilst there are still significant hurdles moving from research funded technology developments to industry-based production, recognizing the motivation and fostering innovation was key to achieving success. For meeting industry/market needs, there is currently insufficient industrial pull and there is a need to engage and expose industry and academia to solutions and skills outside of the usual industrial sectors. It is necessary for both academia and industry to overcome secrecy issues. He also stressed the fact that it's not the data that is sold but the downstream products generated from data.

He introduced "The PML Model", established in 2002, based on the delivery of products and consultancy from in-house expertise, in order to:

- Broaden the application of PML's research products;
- Drive the process of knowledge transfer;
- Be profitable to feed funds back to science programmes.

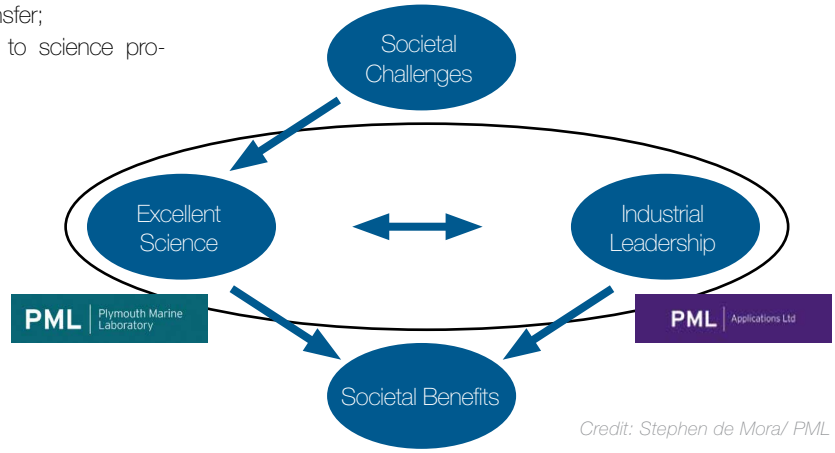
PML Applications employs a Commercial Director with a commercial background to ensure effective commercialization of research. He stressed the importance of managing the process that one has to define mechanisms to recognize potential winning ideas, with the objective to generate money. Fostering innovation requires staff engagement, including additional training for entrepreneurship. Managing expectations are twofold:

- Internally: it takes a long time to generate money out of an idea and the involvement of the scientists throughout the process is important;
- Externally: to understand the needs of the industry and partners and ensure no scope drift.

He also shared the lessons learned through the PML experiences that pitfalls could be avoided with scientific involvement plus a good relationship with the clients and partners. He finally took examples of the PML Applications in blue innovations, such as in unique bacteria culture collection, micro-algae applications in biofuels, and other innovations in biofouling ballast water and satellite remote sensing to meet societal challenges.

> *" There is a real potential for gaining financial benefits from scientific excellence through horizon scanning such as tracking market trends and identifying emerging markets."*

Stephen de Mora, Plymouth Marine Laboratory, UK



Credit: Stephen de Mora/ PML

Discussion: How can marine scientists become better technology developers?

The Forum discussion panel, from left: John Delaney, Manuela Soares, David Murphy, Stephen de Mora, and Harry Kolar. The panel discussion was moderated by Geoffrey O'Sullivan.

The scope of the open floor discussion was to address specific questions concerning the role of the publically-funded marine science community in driving "blue technology" development and innovation in Europe. The need for an integrated approach was stressed to ensure that the marine science and technology community worked more closely and effectively with a range of stakeholders, in particular with industry. The discussion examined both the constraints and drivers for public marine research and technology funding as a future source of new technologies and made concrete proposals for improvements.

John Delaney (Univ. of Washington, USA) stressed that a longer-term vision is required. He noted that the cabling project of the Juan De Fuca plate took 20 years to get the funding. He emphasized that the game changer is for us, as a community, to speak more forcefully and publicly. He stressed the importance and power of engaging with society and the potential opportunity for further utilizing the internet for data collection and communication. He referred to initiatives like Wikipedia which required people to engage in order to make it a success.

Karen Wiltshire (AWI, Germany) agreed with Prof. Delaney's comments on a long-term vision. She had a strong opinion that Europe is very creative but does not have a common vision when it comes to marine science.

Fiona Regan (MESTECH/ National Centre for Sensor Research, Ireland) noted that with the increased support for industry and SME involvement, there was a real concern for blue skies research and she urged policy makers not to lose blue skies research in the blue economy agenda.

Stephen de Mora (Plymouth Marine Laboratory, UK) stressed the need to motivate both scientists and industry, for example to get them together at fora with targeted objectives, with potential shared benefits and with clearly identified outcomes. He emphasized that communication is key as there are too many secrecy barriers.

David Murphy (AquaTT, Ireland) emphasized the importance of creating measures to promote knowledge capture. He used the example of the UK Research Councils, which now require that research outputs are placed in database by the grant holder. Failure to comply with this requirement can lead to subsequent sanctions such as no funding being allocated to that grant holder in the following year.

Daniel Pardo (CNRS, France) remarked on the relations between university and industry. He suggested that one way to bypass this 'valley of death' is to support joint research labs and joint ventures. He took the example of a *"cafeteria effect"* by mixing scientists and developers in same working environment.

Werner Müller (J. Gutenberg University Mainz, Germany) noted that a key objective is also to attract good students, noting that universities compete for students worldwide.

Stephen de Mora noted that blue skies research is fundamental to attract good students and to retain good staff. Scientists are supposed to do science; they are dreamers and should be allowed to remain as such.

Regarding the need for an integrated approach, **Geoffrey O'Sullivan** (Marine Institute, Ireland and Marine Board delegate) stated that all sectors could contribute on a multidisciplinary level and that there was evidence that collaborative public and private networks accelerate and catalyze the development and utilization of these technologies in the marine environment. He noted the application of EU marine science could be enhanced by an integrated approach through synergies and partnership with experts from non-marine fields.

" It is inspiring to note that many innovations that will progress marine science will come from areas outside marine science including robotics, advanced IT solutions and other emerging technologies converging on the oceans."

Geoffrey O'Sullivan, Marine Institute, Ireland

ANNEXES

Annex I: 3rd Marine Board Forum Organization

Forum Programme Committee
Marine Board Executive Committee 2012:
Kostas Nittis (Chair)
Antoine Dosdat (vice-Chair)
Peter Haugan (vice-Chair)
Carlo Heip (vice-Chair)
Beatriz Morales-Nin (vice-Chair)
Çolan Polat-Beken (vice-Chair)
Edward Hill (vice-Chair)
Niall McDonough (Executive Scientific Secretary)

Forum Organization
Marine Board Secretariat:
Niall McDonough (Executive Scientific Secretary)
Jan-Bart Calewaert (Science Officer)
Maud Evrard (Science Officer)
Kate Larkin (Science Officer)
Dina Eparkhina (Administration & Coordination Officer)

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Forum material and presentations
Available at
http://www.marineboard.eu/fora/3rd-marine-board-forum

Proceedings prepared and edited by the Marine Board Secretariat
Nan-Chin Chu (Science Officer) [publication coordinator]
Kate Larkin (Science Officer)
Dina Eparkhina (Administration &Coordination Officer)
Niall McDonough (Executive Scientific Secretary)

Annex II: Glossary of Acronyms

CIP	Competitiveness and Innovation Programme
EMB	European Marine Board
DG ENV	Directorate General for Environment
DG MARE	Directorate General for Maritime Affairs and Fisheries (EU)
DG R&I	Directorate General for Research and Innovation
EC	European Commission
EIT	European Institute of Innovation & Technology
ESP	Environmental Sample Processor
ESF	European Science Foundation
ESMMR	European Strategy for Marine and Maritime Research
ERA	European Research Area
EU	European Union
EurOCEAN	Marine Science Policy Conference series
FP	EU Research Framework Programme
GES	Good Environmental Status
IMTA	Integrated Multi-Trophic Aquaculture
JPI Oceans	Joint Programming Initiative for Healthy and Productive Seas and Oceans
NSF	National Science Foundation (USA)
OOI	Ocean Observatories Initiative
RSN	Region Scale Nodes
SME	Small and Medium Enterprise
WEC	Wave Energy Converter

Annex III: List of Participants

Aas, Kyrre	University of Stavanger, Norway
Almås, Karl Andreas	SINTEF Fisheries and Aquaculture, Norway
Altius, Myriam	Ifremer, France
Andrusaitis, Andris	BONUS
Angell-Hansen, Kathrine	JPI-OCEANS
Ballas, Dionysios	Hellenic Center for Marine Research, Greece
Barbaglio, Alice	University of Milan, Italy
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Bolinius, Damien	Oceans and Lakes, Belgium
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Buonocore, Francesco	Department for Innovation in Biological, Agro-food and Forest systems, University of Tuscia, Viterbo, Italy
Caetano, Ana Teresa	European Commission, DG R&I
Calewaert, Jan-Bart	European Marine Board
Carvalho, Telmo	EurOcean
Chiappetta, Andrea	TorVergata Univeristy, Italy
Combette-Murin, Cécile	Basse-Normandie Brussels office
Connolly, Niamh	Nanyang Technological University, Singapore
Coroner, Florence	Ifremer, France
Costantino, Giulia	IDP European Consultants, Belgium
Costantino, Lorenzo	Institut de Haute Formation aux Politiques Communautaires, Belgium
Cox, David	Belgian Science Policy Office, Belgium
Crawley, Peter	European Commission
Cusumano, Francesco	Europraxis, strategy consultants, Spain
Danoary, Aladin	Vrije Universiteit Brussel, Oceans and Lakes, Belgium
Davide, Vietri	Moverim, Belgium
de Mora, Stephen	Plymouth Marine Laboratory, United Kingdom
De Troch, Marleen	Ghent University, Belgium
de Vriend, Huib	EcoShape, The Netherlands
Dekock, Jan	Flanders Maritime Cluster, Belgium
De Moor, Willem	JPI-OCEANS
Delaney, Ciara	Permanent Representation of Ireland to the EU, Belgium
Delaney, John	Regional Scale Nodes Program, University of Washington, School of Oceanography, USA
De La Paz, Carlos	EC DG MARE
Delory, Eric	Oceanic Platform of the Canary Islands, Spain
Deroo, Rafael	European Commission
D'Hondt, Kathleen	Flemish Governmet Department for Economy, Science and Innovation, Belgium
Dosdat, Antoine	Ifremer, France
Drouillon, Margriet	Ghent University, Belgium
Edvardsen, Torgeir	SINTEF Fisheries and Aquaculture, Norway
Eparkhina, Dina	European Marine Board

Evrard, Maud	European Marine Board
Farcy, Patrick	Ifremer, France
Fiedler-Morotz, Joanna	EMERALD Consultants, Belgium
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Figure captions of the cover images

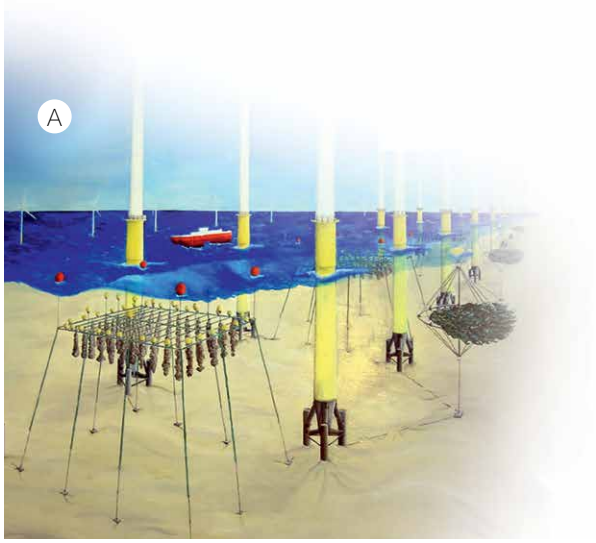
A: Illustration showing different aquaculture setups in wind farms for the future cultivation of mussels, seaweeds and fish. *Credit: B. Buck/ AWI*

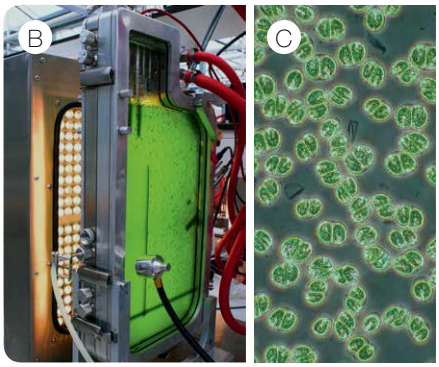
B: Lab-scale flat panel photobioreactor of microalgae cultivation
Credit: AlgaePARC, WageningenUR

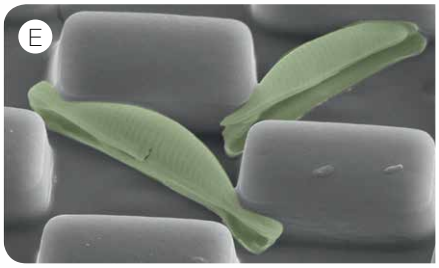
C: The microalga *Tetraselmis suecica*
Credit: AlgaePARC, WageningenUR

D: Clathrina coriacea, a crusty sponge (center – in yellow) contain a battery of potent anti-tumor agents.
Credit: W.E.G. Müller

E: Artificially coloured scanning electron micrograph of diatom cells adhesion on a textured elastomer surface, designed from the antifouling characteristics of the Mytilidae shells. The critical dimensions such as height, spacing and aspect ratio can be maintained, allowing transfer of any antifouling effect between real and artificial materials.
Credit: Timothy Sullivan, MESTECH, Dublin City University







Forum Photos by Vivien Hertz
Back cover: European Marine Board Member Organizations as of March 2014

European Marine Board Member Organizations