Marine Research Sub-Programme
(NDP 2007–'13) Series

SeaChange
Casadh na Taoide

Summary of the 1st Annual Biodiscovery Research Workshop 2008

10th - 11th December 2008, Marine Institute, Galway

NDP
National Development Plan
Transforming Ireland

Marine Institute
Foras na Mara

The Marine Institute is the national agency which has the following functions:
"to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to research and development that, in the opinion of the Institute, will promote economic development and create employment and protect the marine environment" Marine Institute Act 1991

Sea Change:A Marine Knowledge, Research & Innovation Strategy for Ireland

Sea Change—A Marine Knowledge, Research & Innovation Strategy for Ireland 2007-2013—was launched in early 2007 and was the outcome of extensive analysis and consultation with government departments, state agencies, industry and the third-level sector. It outlines a vision for the development of Ireland's marine sector and sets clear objectives aimed at achieving this vision, namely to:

1. Assist existing, and largely indigenous, marine sub-sectors to improve their overall competitiveness and engage in activity that adds value to their outputs by utilising knowledge and technology arising from research.
2. Build new research capacity and capability and utilise fundamental knowledge and technology to create new marine-related commercial opportunities and companies.
3. Inform public policy, governance and regulation by applying the knowledge derived from marine research and monitoring.
4. Increase the marine sector's competitiveness and stimulate the commercialisation of the marine resource in a manner that ensures its sustainability and protects marine biodiversity and ecosystems.
5. Strengthen the economic, social and cultural base of marine dependant regional/rural communities.

The Sea Change strategy was developed as an integral part of the government's Strategy for Science, Technology and Innovation (SSTI) and the Marine Institute as the lead implementation agency is working within SSTI policy and with government departments and agencies to deliver on the Strategy.

The Marine Institute managed Marine Research Sub-Programme, one of eight sub-programmes within the Science, Technology and Innovation (STI) Programme of the National Development Plan 2007—2013, targets funding to meet the objectives of the Sea Change strategy.

Over the lifetime of Sea Change, funding will beprovided for:

- Project-Based Awards
  - o Strategic Research Projects
  - o Applied Research Projects
  - o Demonstration Projects
  - o Desk/Feasibility Studies
- Researcher Awards
  - o Strategic Research Appointments
  - o Research Capacity/Competency Building
  - o Post-Doctoral Fellowships
  - o PhD Scholarships
- Industry-Led Research Awards
  - o Company Awards
  - o Collaborative Awards
- Infrastructure Awards
  - o Infrastructure Acquisition
  - o Access to Infrastructure

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Summary of the 1st Annual Beaufort Marine Biodiscovery Research Workshop

Marine Institute Headquarters, Rinville, Co. Galway

North Atlantic Drift

10-11th December 2008

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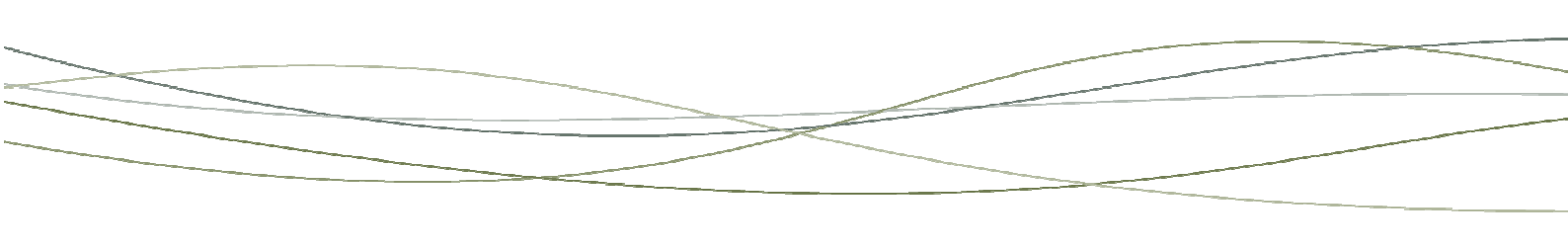


Foreword

Dr Michael O'Toole, Marine Institute, Ireland

This Beaufort Marine Award provided funding to a consortium of institutions to build the initial research capacity to develop a viable National Marine Biodiscovery Programme. Support for this initiative is an important part of the overall objectives of "Sea Change" – A Marine Knowledge, Research and Innovation Strategy for Ireland 2007-2013 with research in the area of marine biodiscovery being a key component of the identified research measure.

The overall aim of the Beaufort Marine Biodiscovery Project is to sample and assess marine biological diversity within the Irish EEZ with a view to extracting, identifying and developing natural products for application in areas such as drug recovery, functional food ingredients and materials of commercial application in the field of bio-medical and nutritional science and devices. A key objective is to create a national interdisciplinary network of researchers working on the taxonomy, systematics and genetics of selected marine organisms and the development of analytical, culture, extraction techniques and screening processes for biochemical compounds with potential application.

The work also included the development of an operational data management system that will facilitate data processing and archival of information at all levels. The project will make major contributions to developing national capacity in marine biodiscovery through strengthening and linking a network of laboratories and collaborative teams based at NUIG, UCC and QUB. It will also support existing research work and capacity being developed in these areas and well as collaboration with other national and international partners.

The project comprise of the following six work packages:

- Establish and implement a management programme for administrative, technical, financial and reporting aspects of the project.
- Establish a programme and protocol for sampling, extraction and identification of biochemical components from selected marine organisms.
- Establish and implement a screening and culturing process for isolation of bioactive compounds from marine microbes.
- Applications of research results into generation of new biomaterials, compounds and agents.
- Establishment of an integrated data management system for tracking and archival of biochemical and microbiological samples and extracts.
- Provide effective educational, outreach and technology transfer activities for the Beaufort Marine Biodiscovery Project.

The Marine Institute plays a central role in the partnership through sourcing and sampling marine species including those from deep sea regions, preliminary processing, storage and distribution of sample extracts and in the assessment, development and management of a dedicated marine biodiscovery data base.

This workshop provides the first opportunity for scientific researchers and team leader of the Beaufort Marine Biodiscovery Project to meet and make presentations on the progress of their work. Participants represented all of the key universities and organisations involved in the project including NUIG, UCC, QUB the Marine Institute as well as associated institutions such as UCD, DCU and Teagasc. This proceedings captures and synthesis the information presented by researchers and affords a record of the event and main issues arising form the research work at a critical start-up phase in the evolution of the project.

An Overview of the Functions and Structures of the Marine Institute and the Sea Change Programme

Yvonne Shields, Marine Institute, Ireland

The mission statement of the Marine institute is to undertake, to coordinate, to promote and to assist in marine rersearch and development and to provide such services related to research and development that in the opinion of the Institute, will promote economic development and create employment and protect the marine environment. The Marine Institute is responsible to the Department of Agriculture, Fisheries and Food and has a number of key areas under it's portfolio namely, clean seas, climate change, sustainable food, sustainable energy and sustainable development. It has seven main service areas which are as follows:- Fisheries Scienec Services, Strategic Planning and Development Services, Marine Environment and Food safety, Irish Maritime Development Office, Ocean Science Corporate Services, Aquaculture and Catchment Management Services and Corporate Services.

The Marine Institute provides scientifc and technical services and supports third level and industrial research in aquaculture, environmental monitoring, fisheries, ocean energy, biodiscovery and functional foods, and advanced technologies amongst others. It has two advanced research vessels, the Celtic Voyager and the Celtic Explorer. The Sea Change Programme is a national strategy for science and technology and innovation to run from 2006 to 2013.

It's 2020 vision is to transform ther marine sector from a traditional sector primarily associated with fishing and shipping to a multi-faceted sector comprising of new, high value knowledge intensive commercial activities which utilise marine resources in a sustainable manner. Sea Change comprises three main research measures i.e. Industry, Discovery and Policy Support. Marine Biodiscovery/Biotechnology is one of the key Discovery research programmes which aims to create capability in the utilisation of marine biodiversity, for the development of drugs, therapies, functional food ingredients and biomaterials.

One of it's main objectives is to develop interdisciplinary networks of researchers in key disciplines and to build critical mass and enhance research collaboration. The presentation concluded with a summary of the investment made in biotechnology/ biodiscovery by the Marine Institute which in 2007 amounted to over Euro 15 million. Much of these funds were allocated to the Beaufort Biodiscovery Project (NUIG, UCC and QUB – 7.3 million), Marine Functional Foods (Teagasc, NUIG, UCD, UCC, UL and UU – 5.3 million), IRCSET PhD support (DCU and UCD – 335 k) and insfrastructure (MI Biodiscovery Laboratory and Remote Operated Vehicle –ROV)

Overview of Marine Biodiscovery – the Big Picture

Eoin Sweeney, Marine Institute, Ireland

This presentation outlined the history of the development of marine biodiscovery in Ireland over the last five years from the concept stage through to the preparation of the SFI proposal and the evolution of the Beaufort Award to build research capacity that would allow for new industries in the development of drugs, therapies and biomaterials. The Beaufort Award puts in place a new partnership between universities and institutions that will fund major research in biodiscovery ranging from basics of sampling and storage of materials, taxonomy and culture through to chemical extraction, metagenomic cloning and screening for bioactivity.

The processes involved in marine biodiscovery including the skills, expertise, infrastructure and collaboration will play a key role in addressing some of the major requirements of the evolving health, pharmaceutical, aquaculture and food industries. The difficulties of finding bioactive substances that merit commercial development was highlighted but greater possibilities were offered by marine organisms and there were a much greater number of species, genera and phyla in the marine environment compared to land based forms. Sea water contained vast untapped sources of microbes yet to be cultures and over 15,000 strains of actinomycetes and fungi have been identified in marine sediments. Key requirements of the national biodiscovery programme include a) the identification and analysis of biodiversity hotspots, establishing sampling, processing and storage procedures for marine biomaterials and enhancing marine taxonomic capabilities; b) Establishing primary screening activities to identify novel bioactive compounds; c) develop core capabilities and collaborative networks to purify and elucidate the structures of new compounds and d) establish secondary screening tests to examine the safety and toxicology of the novel compounds.

Data bases and bioinformatics capabilities also need to be development. Amongst the successful criteria for a vibrant biodiscovery research industry would be increasing added-value to marine resources, increased publications, patents and licensing deals, more revenue from IP and further research collaboration with industry.

Overview of Beaufort Marine Biodiscovery Project

Dr Michael O'Toole, Marine Institute, Ireland

In this presentation, a short account of the Beaufort Marine Awards was given and a brief outline of the career of the famous Irish hydrographer Francis Beaufort after whose name the awards was given. Five Beaufort projects have been identified and are to be funded through the Sea Change Programme over the period 2007-2013. These are as follows: a) Ecosystem approach to fisheries management (QUB, UCC and MI - €3.9 m): b) Fish population genetics Research (UCC and QUB - €3.7 m). c) Sensor communication systems for the marine environment (DCU - €2.4 m), d) Marine biodiscovery research (NUIG, MI. QUB and UCC - €7.2) and e) Marine socio-economics research (NUIG ands Teagasc - €2.0m). The main aims of the Beaufort awards are to develop research capacity in these areas, funding principal investigators, researchers, PhD and summer students.

The Beaufort Marine Biodiscovery Award will develop core research expertise in the sampling, taxonomy, processing and preservation of marine organisms for biodiscovery research. It will also develop applied research capabilities for the isolation and identification of novel marine bioactive chemical compounds and an integrated management system for data collection, tracking and archival. The awards will also support opportunities for further national and international scientific collaboration and seek to promote Ireland as a leader and respected partner in international marine biodiscovery research. The project consists of the following six work packages: a) Project management and administration b) Sampling, extraction, identification of biochemical components, c) Screening and culturing process for isolation of compounds, d) Application of research results into generation of new biomaterials, compounds and agents e) Integrated data management system and f) Education, outreach and technology transfer.

The Beaufort marine biodiscovery consortium will be managed by a principal investigator and each work package coordinated by a leader based at one of the partner institutions. The project will work closed with other research groups in biodiscovery and biotechnology based at DCU and UCD and collaborate with other stakeholders within the framework of the national biodiscovery programme such as research groups at TCD, NCIB and industry. An agreement on materials transfer with the National Cancer Institute, USA has also been put in place. The Marine Institute will provide support to the project in terms of access to research vessel, a fully equipped and dedicated laboratory and the expertise of specialist staff in data management and advanced marine technologies. It is envisaged that successful project indicators would include strong levels of inter-institutional collaboration, quality research, added value to marine resources, increased publications and patents, licensing deals signed, revenue from IP and close research collaboration with industry.

Encouraging European Marine Biotechnology Research

Dr Dermot Hurst, Marine Institute, Ireland

This presentation outlined the current strategy for European marine biotechnology research and the knowledge based bio-economy (KBBE). Some of the key areas of future research include development of functional foods and ingredients, novel marine bioactive compounds and sustainable use of seas and oceans such as biomass from micro- and macro algae for industrial applications. Factors influencing the direction of marine biotechnology research include the Bremen 2007 conference, the EU 7th Framework programme and a number of joint EU –US workshop reports including the Monaco workshop (2008) on marine genomics. The topics of most interest are marine molecular microbiology, functional (meta) genomics of marine micro-organisms, biocatalysis, drug discovery commercialisation and intellectual property rights of marine genomic resources.

The EU has prioritised marine biodiversity and biotechnology research and has called for an initiation of collaborative working groups to clarify opportunities. It has called for a series of deliverables which would include a basic inventory of marine current marine biotechnology research and industry activity in each member country and direct input into FP 7 Theme 2 (2010-2011) work programme in field of marine biotechnology.

The common areas of interest for future research identified in this area are as follows: a) Bio-prospecting; b) Microbiology; c) Marine organism diseases; d) Marine organism genomics; e) Aquaculture; f) Biomass production and g) Functional foods. With regard to current status in Ireland, a marine research inventory has been drafted and a profile on the national biotechnology industry is being compiled.

The next steps are to identify and justify priority areas for Irish research and link to trans-national collaborative efforts. A notification of an important seaweed research symposium was given at the end of the presentation. This event will be held at the Marine Institute on 22nd January 2009. It will be an information day on industry led seaweed research and will be a joint event hosted by the Marine Institute and Enterprise Ireland.

Beaufort Biodiscovery Work Package 2 "Sampling , Extraction and Identification – The Story so Far"

Professor Mike Guiry, National University of Ireland - Galway

The Beaufort Marine Biodiscovery Project is a multidisciplinary collaborative initiative primarily between NUIG, QUB and UCC that requires expert input, coordination and leadership of a Principal Investigator, group leaders and researchers to achieve the outputs required. This presentation summarised the inputs and contributions by NUIG to the project's development so far. The main areas of interest to NUIG are Work Package 2 " Establishing a programme and protocol for sampling, extraction and identification of biochemical components from selected marine organisms", Work Package 4 " Application of research results into generation of new biomaterials, compounds and agents" and Work Package 5 "Data Management".

Recruitment of NUIG PhD's and Post Doc researchers for the project is nearing completion and most of the project staff have commenced biodiscovery and taxonomic work on species of algae, sponges, cnidarians and barnacles. Some of the project work being undertaken at NUIG is to be presented at the workshop.

The Marine Institute and especially Eoin Sweeney were thanked for the coordinating effort in developing this Project and in hosting the Biodiscovery Science Workshop, which is the first of its kind in the country.

Marine Invertebrate Stem Cell Research

Dr Uri Frank, Martin Ryan Institute, National University of Ireland - Galway

This presentation described the stem cell research being undertaken on the coelenterate *Hydractinia echinata*. The interstitial stem cells (I-cells) are mainly located in the stolen. This invertebrate is a good experimental animal demonstrating embryogenesis, no ageing and no malignancy, mutant screen, gene expression analysis, gene knockdown (Ran) and Tran genesis. The talk outlined the double stranded RNA mediated interference (Ran) and transgenic *Hydro actinia* **and** highlighted the importance of Oct4 as a master regulator of stem cells in mammals.

A putative *Hydroactinia* Oct4 orthologue was identified and expressed in stem cells. A time lapsed movie demonstration was given on stem cell tumour rejection in transgenic embryos with Oct4's function seemingly conserved in the animals.

In conclusion, it was pointed out that *Hydractinia* offered the opportunity to study stem cells and cancer in a cheap and easy system, free of ethical issues. New research work would move towards investigation of stem cells and pattern formation in relation to marine glycobiology

Systematics of Irish Marine Sponges

Dr Grace Mc Cormack, National University of Ireland - Galway

This presentation provided a brief summary of the systematics of Irish marine sponges – Phylum Porifera and the main characteristics of sponges including their unique flagellated cells, choanocytes, aquiferous and skeletal systems. Information on sponges as a source of natural products was also outlined with many compounds being associated with anti-bacterial, anti-fungal, HIV inhibitory, anti-fouling, immunosuppressant and anti-tumour activities. External morphology of sponges is varied and diverse with many different structures and colours. Some of the difficulties associated with classification and taxonomy of sponges were highlighted as was the complexities of the skeletal system of spicules and spongin.

The aim of the project is to further the existing knowledge of the Irish sponge fauna combining various approaches and expertise. Viable population of species and biodiversity will be identified and phylogeny established. Some experimental work will also be done on microbial diversity, reproductive biology and larval development of selected taxa as well as culturing sponges in the laboratory. So far 95 specimens representing over 18 species have been collected and identified and 16 large sub-unit ribosomal gene sequences completed. PKS-like genes and microbial 16S ribosomal DNA has been cloned and sequenced from one species.

Exploring Irish Seaweeds - A Source of Pharmaceutically Valuable Compounds

Dr Fabio Rindi, Martin Ryan Institute, National University of Ireland - Galway

This presentation discussed the use of seaweeds for pharmaceutical purposes citing the examples of *Digenea simplex* (China), *Chondria armata* (Japan), *Hypnea musciformis* (Greece, Turkey) and *Chondrus crispus* (Ireland) as species used as popular remedies in folk medicine. Many of the bioactive substances with pharmaceutical properties produced by marine algae have evolved as chemical responses to ecological pressures. An analysis of the research and bibliographic references has shown that the brown algae demonstrate greatest numbers of pharmaceutical usefulnesses and the blue-green algae the least number. The algal genera, *Saragassum, Chlorella, Ecklonia, Laminaria and Ulva* are the algal genera for which the highest numbers of studies documenting pharmaceutical usefulness have been published. Of the brown algae native to Ireland, *Saragassum, (1 species) Laminaria (4 species), Cystoseria (4 species), Fucus (6 species), Dictyota(2 species) and Ascophyllum (1 species)* all show potential as material for extraction of pharmaceutical compounds. Sargassum, which is present in Ireland with one introduced species, appears to be also a very valuable genus. With regards to the red algal genera of potential value that occur in Ireland, the bibliographic research suggest that the following show the best potential: *Gracalaria, Laurencia, Grateloupia, Porphyridium, Gigartina, Schizymenia and Asparagopsis.* Irish green algal species that have potential usefulness to the pharmaceutical industry include *Chlorella, Ulva (13 species), Codium (5 species), and Monostroma.*

The presentation concluded with a review of the strengths and weaknesses of seaweeds as a source of biodiscovery and novel compounds and suggested that small sized seaweeds could offer the most valuable properties but that their large-scale cultivation might involve costs that would make it commercially not sustainable.

Sample Extract and Banking

Dr Margaret Rae, National University of Ireland - Galway

This presentation described the methodology that would be used in order to establish and put in place a sampling and extracting system for marine organisms collected in waters around Ireland for the location of bioactive substances. In summary, the system would assign identification and tracking number to the sample, freeze dry and extract the materials for banking. Some initial pre-screening and chemical characterisation would be done and then retained and distributed to partners for further analysis.

In sampling specimens in the field detailed data would be collected on location, habitat, morphology, photographs, weight, in storage transit and preservations. The extraction of bioactives in the secondary process would involve milling extracts and making fractionates which would be done in four stages: This bioactive extraction strategy would 1) collect information on chemical content, biological activity, nature of compounds and impurity types; 2) prioritize extracts, mew compounds and bioactives 3) remove unwanted materials (fats, salts) and 4) apply high resolution separating steps, isolation, purification and structure elucidation.

In the final analysis, the partners will need to outline their specific preferences with regard to fractionation of extracts, the types and size of samples requires, the volumes, containers, codes and special transport conditions needed.

Biodiscovery Work Package 3 " Screening, Culturing, Isolation and Synthesis of Bioactive Compounds …. The Story so Far"

Professor Alan Dobson, University College Cork

This presentation provided an overview of work done so far on screening, culturing and isolation and synthesis of bioactive compounds at the Environmental Research Institute and Microbiology Department, UCC. It presented information on the human research infrastructure (organogram) detailing the names of the principal investigator, co-project leaders, and researchers in the areas of metagenomics and signalling and their areas of interest. It also highlighted the national linkages with researchers at other institutions e.g. QUB (through HEA PRTLI cycle 4) where work on viral metagenomics in the marine environment and metagenomic approaches to study phosphorous cycling in natural environments was being carried out.

National linkages to other projects through the Beaufort Award were also presented including research on biofilms and anti-biofouling (QUB) and marine sponges – polyketide synthases (NUIG). Linkages with international initiatives such as CAREX (Coordination Action for Research Activities in Extreme Environments) and with research activities in Strathclyde Institute for Biomedical Research (screens for bioactive compounds and Bio-analytical chemistry) and Cardiff University (metagenomic / molecular microbial ecology and natural products chemistry) were also outlined. A description of the process of functional metagenomics was given from the isolation of sponge DNA, screening for genes to the transforming into alternative host and screening for bioactive compounds. The process of inhibition of cell signalling in *P. aeruginosa* biofilms was presented as well as a flow chart demonstrating functional marine metagenomics.

Metagenomic Strategies to Exploit Marine Microbial Diversity

Dr Jonathan Kennedy, University College Cork

This presentation outlined the some of the challenges faced with extracting marine natural products from marine organisms including the supply of sufficient raw materials, low titres and the fact that most of the interesting compounds presently found are limited to invertebrates such as sponges, tunicates and bryozoans.. These include materials such as Discodermolide (from sponge *Discodermia dissolute*), Bryostatin (from bryozoan *Bugula neritina*) and Yondelis ET-734 (from tunicate *Ecteinascidia turbinate*). Marine sponges are a good source of bioactive compounds and have complex microbial communities where the microbes can make up 40% of the biomass. They provide a food source, can act as pathogens and are also mutualists, assisting the sponge with photosynthetic activities, nitrogen fixation, elimination of toxic waste and providing chemical defence.

The isolation of compounds is done through culturing sponge microbes and subsequent fermentation. The aim of the project is to assess microbial (-16S and 18S rRNA gene library) and metabolic diversity (PKS gene library) of the sponge *Haliclona simulans* and develop functional metagenomics. The experimental work found that the sponge had a diverse and unique microbial community which included many known secondary metabolite producing genera. Culturable and uncultured microbial populations were found to be very different and PKS diversity was generally very high. *Haliclona simulans* was chosen for the initial library because of it's diverse microbiota and metabolism. The strategy and methodology for establishing the metagenomic library involved HMW DNA preparation, constructing modified fosmid vector and optimising conjugation to bacterial host. Initial screens were developed and three diverse host strains where chosen for expression of library. Future research plans will explore the diverse microbiology and metabolism of sponge samples (many collected from Lough Hyne) and analyse using culture dependent and independent techniques.

Exploiting the Diverse Microbial Ecology of Marine Sponges

Stephen Jackson, University College Cork

The aims of this project are to: a) identify bioactive compounds from marine sponges and associated microorganisms: b) develop high throughput screening methods to identify bioactivity from environmental samples; c) isolate producing organisms and/or genes and d) develop a system to optimise bioactive compounds production. The presentation provided a useful summary on sponge microbial ecology and the function of the various microbes including bacterial populations. Sponge microorganisms produce secondary metabolites of great pharmaceutical interest but the supply of these bioactive metabolites in sufficient quantities for clinical assays remains a problem.

Bioactive compounds that have been isolated from sponges have had a variety of pharmaceutical properties including anticoagulant, antibacterial, antifungal, antiviral, antimycobacterial and antiprotozal. Many bioactive secondary metabolites isolated from marine sponges resemble compounds produced by bacterial Polyketide Synthase (PFS) gene and Bacterial Non Ribosomal Peptide Synthase (NRPS) genes. The strategy of the project will be to develop high throughput screening for large metagenomic clone libraries and to analyse sponge metagenome to detect presence of genes involved in bioactive compound generation. Analysis will also be made of novel or improved enzymatic activity of industrial or environmental interest.

A short account was given of metagenomics including the extracting of DNA from sponges, fragmenting of DNA and transformation into expression vector, function based and sequence based screens for heterologous expressions and to detect genes of interest. The presentation concluded by outlining the process of microbial ecology analyses in sponges such as PRC amplication, generation and sequencing of clone libraries and comparisons of microbial sponge profiles between species.

Development and Validation of High-Throughput Screens to Identify Novel Inhibitors against Pathogenic Yeast from Sponge-associated Microbes

Lekha Menon Margassery, National University of Ireland - Galway

The objectives of this projects are to : a) establsh cellular targets of anti-fungal extracts of sponges associated bacteria using Saccharmomyces cerevisiae yeast system; b) develop a scalable high-throughput assey to screen inhibitors of the calciu,-activated phosphatase, calcineurin in yeast; c) screen extracts of marine sponges associated microbes and metagenomic libraries from such microbes to identify novel calcineurin inhibitors: d) biologically caharacterise calcineurin inhibitors to determine specificity and e) determine the chemical nature of novel inhibitory molecules. This presentation summarised fungal pathogenesis which is the cause of death and morbidity in both immunocompetent and immunocompromised individuals. Effective treatment for fungal infections are often lacking and expensive.

A summary of the calcineurin pathway in mammals and it's physiological role was presented as well as the effects of calcineurin on the treatment of candidiasis. Sponges as a source of production of secondary metabolites was also highlighted as was their anti-bacterial, anti-fungal and cytotoxic activities. The current project work centers on culturing bacterial strains associated with the marine sponge, *Haliclona simulans,* testing anti-microbial activities against yeast strains and determining the chemical nature of samples exhibiting anti-fungal activity using deferred antagonist assey,well diffusion assey and disc diffusion assey. Results indicated that some strains showed zones of inhibitions against one of the pathogenic yeast strains whereas other strains gave zones of inhibition against yeast strains in methanol treatment.

Some of the future work will focus on the nature of the anti-fungal compounds in samples which were insoluable in methanol using different asseys and on culturing more bacterial strains associated with the sponges Amphilectus fucorum and Eurypon major. Anti-fungal activity will also be investigated with ew bacterial strains and anti-fungal compounds screened for calcineurin inhibition.

Antimicrobial Activities from Marine Sponges and Sponge Derived Microbes

Burkhart Flemer, University College Cork

This talk introduced marine sponges as hosts to a wide variety of microbes (bacteria fungi and algae) pointing out that over 190 biologically active compounds have been isolated from the sponge *Haliclona spp.* Much of the bioactive substances are thought to come from the metabolities of the microbes. The research work has demonstrated that there are antibiotic activities associated with extracts taken from *Haliclona* including bioactivities against Bacillus and Streptococcus aureus. Other biologically active strains include *streptomyces, pseudovibrio and firmicutes*.

Much of the work so far has focused on characterising sponge extracts for antimicrobial activities, screening sponge derived microbes for novel antimicrobial activities, constructing and analysing sponge metagenomic libraries and discovery of biosynthetic pathways of novel antibiotic/bioactives. The technical work involves extraction of the chemical compounds from the sponge samples, isolation of the bacteria, carrying out antimicrobial assays and screening of chemical compounds. So far, over 16 species of sponges have been samples from Lough Hyne and chemical extracts prepared. Over 350 bacterial strains and 100 fungal strains have been isolated from 12 species of sponges.

Future plans are to perform assays for antimicrobial activities, characterise and sequence the isolates, extract the metabolites and analyse the chemical components and test for bioactivities.

Isolation and Synthesis of Bioactive Natural Products from Marine Sources

Cathal F. Murphy, University College Dublin

Initial tests from samples of marine algae by ICNT and DCU showed promising results as blockers of potassium channels. Two samples showed activity in the area of potassium channel inhibition ALG008 and ALG002. Three samples showed activity in the area of t-cell modulation (1 algae and 2 invertebrates) ALG008, INV001 and INV013. This presentation outlines research carried out on samples to isolate active compounds, elucidate structures and investigate their synthesis.

Extraction techniques were discussed including the general procedure as well as fractionation and the isolation and identification of active compounds. Column chromatography was used as the preferred method on sub-fractionation. It was proposed that potassium channel inhibitor analogues be prepared and the need to gain a better understanding of these inhibitors was also highlighted.

Beaufort Biodiscovery Work Package 4 "Application of Medical and Biomaterials – The Story so Far"

Professor Christine Maggs, Queen's University Belfast, NI

This presentation highlighted the work being undertaken at Queen's University Belfast (QUB) in relation to the Beaufort Biodiscovery Project including the building of an multi-disciplinary team linking medical engineering, pharmacy and the biological sciences. Special mention was also given to the strengthening of taxonomy in relation to marine animals groups that could have important biodiscovery applications especially sponges.

Research work has already commenced at QUB on the bio-medical engineering including bone tissue reconstruction. Research is also proceeding linked with partners at UCC and NUIG on bioactivity of marine micro-organisms and in examining the applications of results in the development of new biomaterials for use as bio-adhesives, anti-biofilms and stress metabolism in marine microbes. The feasibility of hydrothermal conversion of coccolithophores into bone engineering products is also being looked at. A strong capacity building link is currently being developed in the pharmacy, biological sciences and engineering laboratories as part of this work package.

Bioengineering for Medical Applications

Dr Fraser Buchanan, Queen's University Belfast, NI

This presentation highlighted the importance of bone grafting and operations to repair dental, neuro and orthopaedic defects in humans and how bone tissue engineering aims to provide a means of supporting bone regeneration. Clinical problems associated with autograft, allograft and synthetic bone substitutes were also outlined. The use of coral in synthetic bone substitute and the identification of marine organisms with structural and chemical features that were suitable for bone substitute were also discussed. Particular emphasis was given to materials form marine sponges including the extraction and use of collagen.

Hydrothermal conversion of calcium containing algae such as *Corallina officinalis* to calcium phosphate and hydroxapatite showed particular promise. The unique pore structures of sponges allowed for ceramic tissue to be generated and indicated a pore size distribution that was optimal for bone in growth. In conclusion, it was reported that marine derived biomaterials especially from sponges showed good promise and that sponge interconnected pore structure can be replicated in hydroxyapatite.

Future work would continue to search for organisms with unique structures that could potentially be used in biomaterials with coccolithophores showing considerable promise.

Marine Bioactive Anti-biofilm Compounds

Alessandro Busetti, Queen's University Belfast, NI

This presentation described the two basic states of bacteria (planktonic and sessile) and how biofilms are generated which are the predominant mode of microbial growth. It outlined how biofilms are formed and the basic life cycle from attachment at the surface, growth and maturity and release of single cells. Much of human infections both chronic and recurrent involve the production of bacterial biofilms. Mechanisms of biofilm resistance include slow penetration of anti-biotics, slow growth of cells, increased rate of genetic transfer, gene resistance and hypermutation.

Project work being undertaken aims to isolate, identify and evaluate novel anti-fouling anti-microbial or anti-biofilm compounds from selected marine organisms. The work involves isolating and identification of bacteria strains from the periwinkle Litttorina littorea and screening for caseinolitic activity (Protease production). Several species of algae were also examined. DNA was extracted and sequenced in the process. Several species of bacteria were identified and Quorum Sensing Inhibition (QSI) assays were carried out on cultures. Eighty-six bacterial strains were identified from the periwinkle with 26 bacterial isolates displaying caseinolitic activity. The 16S rRNA gene sequencing was used to identify the isolates.

Future work will continue assay techniques for screening and extraction, characterizing of proteases responsible for caseinolitic activity and investigation biofilm formation and dispersal assays.

Exploring the Anti-inflammatory Potential of Marine Extracts

Ciara Mc Carthy, Dublin City University

This presentation summarised experimental research work on fractionation of two rounds of marine extracts that showed anti-inflammatory properties – an increase in anti-inflammatory cytokines and decrease in pro-inflammatory cytokines. The activation of T cells by dendritic cells is responsible for the effects. Further fractionation and screening work is required to elucidate the molecules involved in the process and to determine the mechanisms of actions of the compounds. Additional assessments need to be carried out in animals with inflammatory diseases to determine effectiveness.

Bioactive Compounds from Primary Waste Streams and Seaweed Sources

Dr Maria Hayes, Teagasc

Maria Hayes outlined the marine functional foods research initiative which is a partnership project with the Marine Institute, AFRC, MFRC, UL, UCD, UUC and UCC. It's aim is to identify promising and sustainable marine sources of bioactive compounds with provable health promoting effects and to incorporate these into foods while maintaining bioactivity. The key market opportunities were aimed at joint health, inflammation reduction, cardio-vascular disorders, glucose management, weight management and women's health issues.

The chief bioactive materials being sources are compounds extracted from black scabbard, blue whiting, cardinal fish, mackerel and squid. Much of the raw material is fish offal, guts and off-cuts but also includes waste from mussels and crab processing. The process involves extraction and screening for nutraceuticals or functional food components through fermentation such as chitin oligosaccharides and anti-microbial peptides. A case study in relation to biodiscovery and seaweeds discussed extraction of antioxidants (polyphenols and carotenoids) from marine macro and micro algae and the mining and purification of peptides and amino acids with health benefits. The main species of interest were *Palmaria palmate*, various species of kelp, *Ascophylum, Gracalaria* and *Ulva.* Details were also given on the extraction, processes and uses of some of the bioactive agents and the physiological functionality of bioactive peptides and oligosaccharides.

The presentation concluded with three case studies on a) extraction and uses of ACE-I-inhibitory peptides from marine sources b) Anti-inflammatory sugar (COS) screening and c) screening for inhibitors of prolyl endopeptidase (PEP).

Data Architecture for the Biodiscovery Project

Dr Helka Folch, Queen's University Belfast, NI

This presentation summarised the main aims of constructing the biodiscovery database which will include archiving and tracking of samples collected within the Beaufort Biodiscovery project and integrating existing data sets from the Marine Institute's work e.g. fish surveys and HAB's data. Other objectives will be to query and merge information from distributed data sources and harvest biodiversity information from GBIF and OBIS networks and to query chemical and genetic databank information relevant to a given species e.g. GenBank, DDBJ and EMBL). The Beaufort Biodiversity data base will support multiple forms of data analysis and visualisation including GIS software and use of data analysis packages and tools. A subset of the database will also be published as a web data provider on the OBIS network. The database will have to be standardised to support multiple applications for query / analysis and will need rich metadata for describing context of sample collection, archiving and tracking throughout the analysis pipeline.

There will be a need for querying and merging of data from distributed sources and for semantic harmonisation. Conformity to Darwin Core and OBIS will be a key aspect of the data base architecture to provide a core set of elements to describe the most common information about a specimen such as curatorial, taxonomic classification, geospatial location, biological data about specimen and references. The Beaufort biodiscovery data base will be designed to harmonise with the Marine Institute data standards and will be compatible with data models and integrated biological data schema. Standardisation of measurements and shared use of taxonomies, controlled vocabularies and thesaurus will be used.

The presentation concluded with a summary slide showing the biodiscovery data base architecture and the integration of heterogeneous data sources.

Data Management in the Marine Institute

Eoin O'Grady, Marine Institute, Ireland

In this presentation, data management in the Marine Institute was presented in terms of it's context, the current issues, the data management process and projects underway. Data management covers many disciplines over MI's brief since it is a service provider, research performer and research funder. Service areas cover: aquaculture, environment and food safety, fisheries science, ocean science, information services and development and the Sea Change programme. An outline of the knowledge and information management projects under Sea Change was also given which includes development of a national coastal and marine information service, promotion of marine knowledge infrastructure and policy at national level, identification and development of emerging technologies and the establishment of data management standards.

Current difficulties related to location of data, quality, standards, multiple uses and increased volumes of data sets. The data management areas in MI address meta data and cataloguing, data storage and integration, quality control, delivery, analysis and standards. It is stressed that data management should be integrated as part of the planning and work process and not just seen as IT. The presentation summarised the data lifecycle process used at MI as well as data flow and the data delivery infrastructure and support for MI projects including SMARTBAY and INFOMAR. The Marine Institute works closely with the Irish Spatial Data Exchange to have standard based metadata and interfaces and to find data from multiple organisations.

The future challenges and opportunities facing MI are to integrate new data generating programmes, to support the Sea Change strategy and to ensure that data management becomes part of the process.

Education, Outreach and Technology Transfer Activities within the Beaufort Marine Biodiscovery Project

Professor Christine Maggs, Queen's University Belfast, NI

This presentation and subsequent dialogue summarised and discussed the aims and outputs of Work Package 6 which is to provide effective educational, outreach and technology transfer activities for the Beaufort Marine Biodiscovery Project. It will focus on the dissemination of information on the research activities and results from the Beaufort Marine Biodiscovery Project through seminars, workshops and meetings with partners, government and non-governmental organisations, as well as the public and private sector. One of the main aims of the outcome of this work package to establish strong links and collaboration with between Beaufort partners and the National Biodiscovery Programme. This includes communicating research findings and liaison with industry, other institutions and agencies as well as developing new research projects and partnerships and funding sources for further marine biodiscovery research. The facilitated discussion of this work package focused on activities within the Project. It was agreed that in this early phase of the Project, a further meeting should be held after another 6 months with May 2009 as a possibility, hosted at the Marine Institute.

It was also proposed that an annual Marine Biodiscovery Workshop should be held in December each year and it was agreed that the 2009 meeting should be held at QUB, Belfast, Future annual researcher's workshop should rotate, with UCC to be the venue for 2010. The format of the workshop should include very short presentations, in the style of the "open mike" seminar such as that organized by the Enterprise Ireland bioprospecting meeting. These could be short 3 minute talks, very diverse, including topics such as "this is the equipment I need; where can I get it?". Researchers could break up into three working groups of those with particular interests. Participants to re-assemble for plenary sessions with common themes. A few expert speakers could be invited to provide focus and industry representatives should be encouraged to take part. The workshop would also provide opportunities for updates on Irish Graduate Training Programme and possibilities for specialist short training workshops e.g. use of equipment; identification of organisms and other technical areas.

International Funding Opportunities for Biodiscovery Research

Dr Niall McDonough, Marine Institute, Ireland

This presentation provided a detailed analysis of the international funding opportunities available for biodiscovery research. It summarised the EU Policy Environment, funding structures and opportunities under the 7th Framework Programme, the EU Interreg Programmes and support services available. The 7th Framework comprise 4 specific programme areas (cooperation, ideas, people and capacities) and has a budget of €50 billion over seven years (2007-2013).The marine area is a priority cross-cutting area with €1.9 billion being allocated to food, agriculture, fisheries and biotechnology. This supports the knowledge based bio-economy (KBBE) which are made up of the following activities:- a) Sustainable production and management of biological resources from land, forest and aquatic environments; b) Fork to farm – food including seafood, health and well-being and c) life sciences, biotechnology and biochemistry for sustainable non-food products and processes. Within the latter cluster of research activities are:- Novel marine bioactives compounds for European industries and sustainable use of seas and oceans – biomass from micro and macro algae for industrial applications.

Progress on the development of the 2010 work programme for KBBE was outlined together with key factors influencing the research agenda which include existing specialist working groups, technology platforms (e.g. aquaculture, biofuels and food for life), and ERA-NETs (FP6) targeting plant genomics, bioenergy, industrial biotechnology, nanosciences and marifish. Significant funding has been made available through the Marie Curie Actions under the FP 7 "People actions" for training and capacity building as well as developing international training networks and partnerships between industry and academia. Under the capacities actions, funding for key actions cover the areas of innovation research and competitiveness and research for benefit of SME's and research infrastructures. The presentation also outlines a range of financial support available for project development, travel grants, academic coordination groups and for proposal preparation as well as eligibility and guidelines for applicants. The NDP 2008 networking initiative was also mentioned which can provide grant aid to Irish researchers and partnerships for workshops and conferences, training grants and travel awards. A brief summary of the existing Interreg programmes was also presented with six programmes currently being funded over the period 2007-2013. These are cross-boarder (IVA), trans-national (IVB) and inter-regional initiatives (IVC) with €1 billion in ERDF funds being available for research in which Irish partners can participate. They cover the Ireland-Northern Ireland-Scotland programme, the Ireland-Wales programme, the North West European Programme, Atlantic Area programme and Northern Periphery programme.

Concluding Remarks

The workshop concluded with a discussion on a number of issues. Of particular importance was defining protocols for sampling, processing, tracking and coding of materials. It was also emphasised that there was a real need to establish a library system for archiving samples early on and to put a data management process and procedure in place. It was recommended that a specialist workshop should be held early in 2009 to address these issues and provide direction to researchers and team members on the Marine Biodiscovery Programme on procedures and protocols for sampling and primary processing of marine organisms as well as data management.

The absence of the Principal Investigator (PI) was delaying the progress of the project's implementation and an appointment needed to be made as soon as possible. It was noted that the position would be advertised shortly and would be based at NUIG. Once the PI was on board, then a more focused effort would have to be made on establishing formal links with other national biodiscovery and biotechnology research efforts.

It was felt that there was a need to establish a biodiscovery website at an early date in order to commence information exchange, increase public awareness and facilitate networking between scientists across institutions and share information on research projects and their activities. It may also be advisable to bring in key international experts from time to time to evaluate aspects of the project and provide specific inputs in complex issues that may arise.

There was widespread agreement on the need for an annual researchers' workshop on marine biodiscovery with the first to be held in QUB in December 2009. It was also agreed that the holding of a national seminar on marine biodiversity involving all stakeholders and well as industry would be very useful.

One of the main challenges highlighted in relation to marine biodiscovery was the poor understanding of the taxonomy of marine sponges. This required a strong focused research effort so that specimens can be identified correctly and archived properly. The issues of sourcing, identifying and tracking specific scientific reports, referenced articles, grey literature and reviews also required attention and needed to be established and incorporated into a data base.

Exposure and participation by researchers in international biodiscovery conferences was also encouraged. The Bioprosp Conference, to be held in Norway in February 2009 was put forward as one that would be worthwhile for some researchers from Ireland to attend.

Participants were thanked for attending and for making their individual contributions and presentations. Special appreciation was expressed to Professor Mike Guiry (NUIG), Professor Alan Dobson (UCC), Professor Fergal O'Gara (UCC) and Professor John Benzie (UCC), Professor Christine Maggs (QUB) and Professor Olliver Dolly (DCU) for their valuable inputs and leadership and to Eoin Sweeney (MI) for his dedicated efforts and overall coordination of the Beaufort Marine Biodiversity Programme to date.

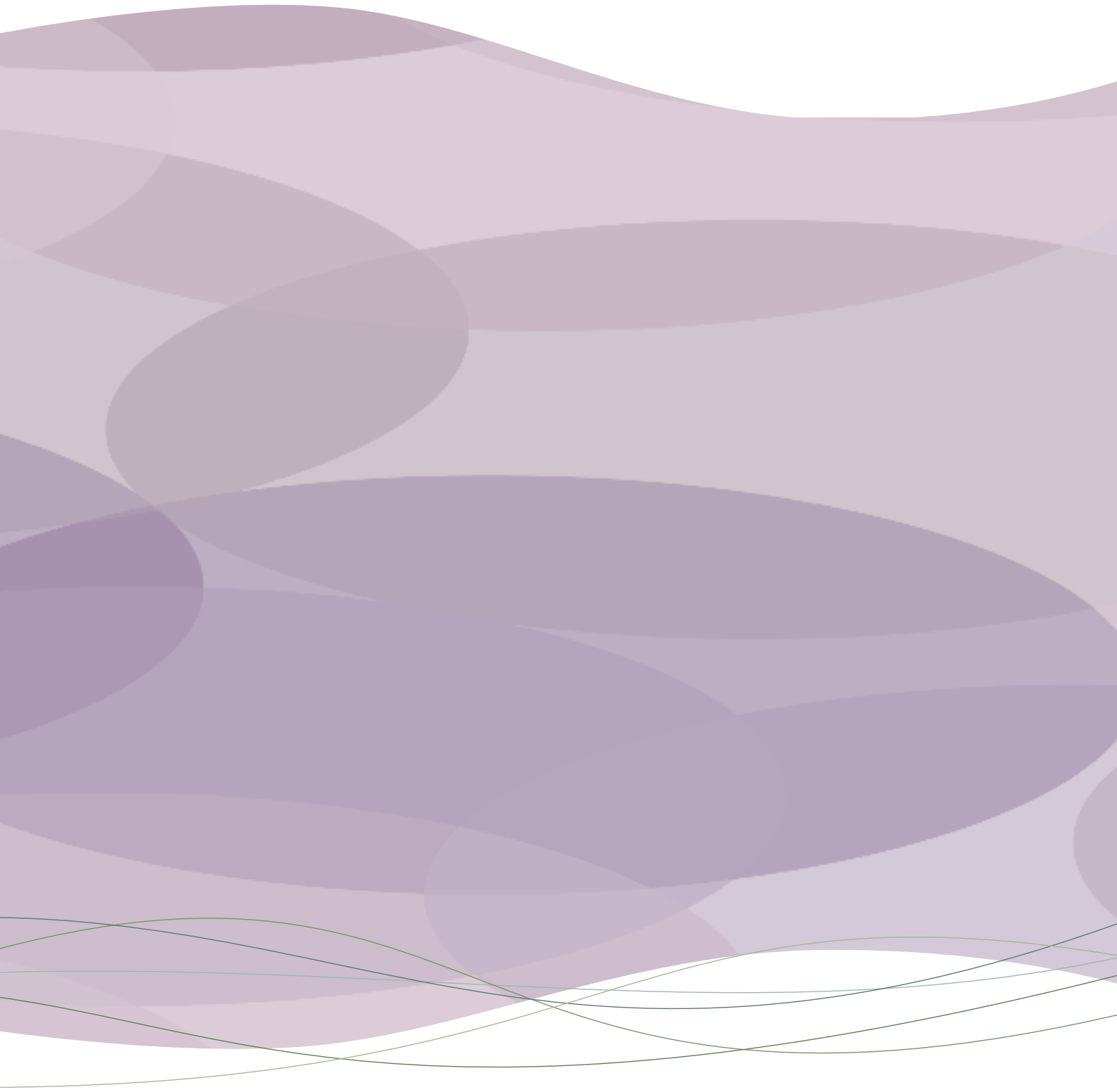
Appendix 1- Workshop Programme

	Beaufort Marine Biodiscovery Workshop
Day 1	***Chair: Peter Heffernan, Chief Executive Officer, Marine Institute***
13h30 – 13h35	**Welcome and Opening Remarks** *Peter Heffernan*
13h35 – 13h50	**Irish National Marine Biodiscovery Programme** *Eoin Sweeney*
13h50 - 14h05	**Overview of Beaufort Marine Biodiscovery Project and Work Programme** *Michael O'Toole*
14h05 – 14h20	**Marine Biotechnology - International Developments** *Dermot Hurst*
14h20 – 15h40	**Sampling Extraction and Identification**
	CHAIR: Michael Guiry **Beaufort Biodiscovery Work Package 2 [Sampling Extraction and Identification] the story so far** Prof. Michael Guiry, Martin Ryan Institute, NUI Galway. **Glycobiology of a Marine Cnidarian** Uri Frank, NUI Galway **Systematics of Irish Marine Sponges** Grace McCormack, NUI Galway **Exploring Irish seaweeds as a source of pharmaceutically valuable compounds** Fabio Rindi, NUI Galway **Biodiscovery sample and extract banking** Margaret Rae, NUI Galway
15h45 – 16h00	Tea/Coffee

16h00 – 17h30	**Screening, Culturing, Isolation and Synthesis of Bioactive Compounds**
	CHAIR: Alan Dobson **Biodiscovery Work Package 3 [Screening, Culturing, Isolation and Synthesis of Bioactive Compounds] the story so far** Prof. Alan Dobson, Environmental Research Institute and Microbiology Department, University College Cork. **Metagenomic Strategies to Exploit Marine Microbial Biodiversity** Dr Jonathan Kennedy, Environmental Research Institute and Microbiology Department, University College Cork. **Exploiting the diverse microbial ecology of marine sponges** Stephen Jackson, Environmental Research Institute and Microbiology Department, University College Cork. **High-throughput screens to identify novel inhibitors of pathogenic yeasts, from marine sponge-associated microbes** Lekha Menon Margassery, Environmental Research Institute and Microbiology Department, University College Cork. **Culture dependent approaches to identify bioactive compounds from bacteria associated with the marine sponge *Haliclona simulans*** Burkhardt Flemer, Environmental Research Institute and Microbiology Department, University College Cork. **Isolation and synthesis of bioactive natural products from marine sources** Cathal Fionn Murphy, Centre for Synthesis and Chemical Biology, UCD
17h30	Close
18h00	Workshop Dinner

DAY 2	***Chair: Yvonne Shields*** ***Director Strategic Planning and Development Services, Marine Institute***
09h30 – 10h45	**Application of Medical and Biomaterials**
	CHAIR: Christine Maggs **Beaufort Biodiscovery Work Package 4 [Application of Medical and Biomaterials] the story so far** Prof. Christine Maggs/Dr. Brendan Gilmore, School of Biological Sciences, Queen's University Belfast. **Bioengineering for medical applications** Fraser Buchanan, Queens University Belfast **Bioactives against biofilms** Alessandro Busetti, Department of Pharmacy, Queens University Belfast **Exploiting marine biodiversity to develop drugs for normalising neural communication in disease** Mr. Nagesh Muniyappa, International Centre for Neurotherapeutics, Dublin City University **Characterisation of anti-inflammatory potential of marine extracts** Ms. Ciara McCarthy, School of Biotechnology, DCU **Bioactives from crab waste** Dr. Maria Hayes, Teagasc **Introduction to research at CAMBIO (TBC)** John Slater, Letterkenny Institute of Technology
11h00 – 12h00	**Integrated Data Management, sample tracking and archival**
	CHAIR: John Evans **Data architecture for the Biodiscovery Project** Helka Folch, QUB **Data Management in the Marine Institute** Eoin O'Grady, Marine Institute
12h00 – 13h00	**Education, Outreach and Technology Transfer**
	CHAIR: Dermot Hurst **Education, outreach, links and technology transfer within the MBP – Discussion session** Christine Maggs, QUB **International funding opportunities for Biodiscovery researchers** Niall McDonough, Marine Institute
13h00	Close

Produced by the Sea Change Management Unit, Strategic Planning and Development Services, Marine Institute



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