

BioMara

Sustainable Fuels from Marine Biomass An INTERREG IVA Project

The Biomara project is co-ordinated by the Scottish Association for Marine Science (SAMS) to investigate the feasibility of producing biofuels from marine biomass.

Six institutions across the UK and Ireland are involved, looking at the potential use of micro and macro-algae as alternatives to terrestrial agri-fuel production. The practicalities of using algal biomass as a competitive, sustainable biofuel source are considered in concert with wide stakeholder engagement.

The €6 million project is funded by the INTERREG IVA Programme, the Crown Estate, Highlands and Islands Enterprise, the Department for Energy, Trade and Industry (NI) and the Department of Communications, Energy and Natural Resources (RoI).

NEWS UPDATE.

Biomara Researchers have been very busy during 2010, travelling to China, Brazil and throughout the UK and Ireland, promoting the project, developing important links, identifying and building on synergies and exchange of ideas. Michele Stanley was invited on a knowledge exchange visit to China, organised by the Foreign and Commonwealth Office (pictured below). In April 2010 Professor Kim Swales hosted the first Biomara Research Workshop at the University of Strathclyde. There were a series of presentations delivered by Biomara Researchers followed by a networking session over lunch. For more on these stories see inside.



The picture shows from left to right Peter Harrington Foreign and Commonwealth Office China, Dr Michele Stanley, Scottish Association for Marine Science, Dr Gary Cadwell University of Newcastle and David Van Alstyne Scottish Bioenergy in Chongqing.

Message from Ian Macfarlane, Chair of the Stakeholder Group.

Stakeholder discourse in Scotland As Chair of the Stakeholder group I manage the BioMara stakeholder group and seek to raise the profile of BioMara's activities and disseminate its outputs. My immediate efforts have been focussed on increasing awareness of BioMara amongst local authorities, their statutory consultees, NGOs and other public sector agencies. Meetings have been held with the councillors, planning officers, sustainability & environmental managers and economic development specialists in the Scottish Councils within the cross-border co-operation area and with Western Isles Council (Western Isles constitutes an "adjacent co-operation area"). More recently this series of meetings has been extended to the maritime counties of the Republic of Ireland including discussions with Donegal and Sligo Councils and their various development agencies.

Interests amongst these bodies often centre on local job creation but meeting government and EU targets for atmospheric carbon reduction and renewable fuels are also in the forefront of local authority thinking and economic development, especially in remote, rural, isolated and 'off-grid' communities. Once the holiday season is over, this series of meetings will continue. In addition, as part of on-going stakeholder liaison activities, I will be in regular contact with many of the 500+ stakeholders on our database, who are seeking to be part of the developing bioenergy community or suppliers to it. Most recently I have visited a number of stakeholders with businesses collecting, utilising and processing seaweeds in the mainland and islands of the west of Scotland and in the west of Ireland.

Biomara Research Workshop

In April Professor Kim Swales hosted the first Biomara Research Workshop at the University of Strathclyde. This workshop brought all the researchers working on Biomara together for the first time, along with an invited group of stakeholders. The workshop consisted of a series of talks presented by Biomara Researchers followed by a Q & A session and networking lunch. The talks covered the full range of Biomara activities, from socio-economics, oil production of algal strains, anaerobic digestion, bio-fuels, biorefineries, the molecular aspects of algal biofuels, and the environmental impacts of seaweed cultivation and harvesting. A summary of each talk and posters presented at the workshop are given below. The talks were recorded and are available from the Biomara website, along with pdf files of the PowerPoint presentations.



How should we model the regional economic impacts of biofuels production from marine algae? *Grant Allan, (Fraser of Allander Institute, University of Strathclyde).* examined lessons which can be learned from modelling of “conventional” biofuels production. A number of factors are crucial: the specific biofuels production technology employed; the embeddedness of that technology into the regional economy (for instance, through purchases of goods and services, and employment); and the extent to which new economic activity in the region is created. The regional multi-sectoral models typically used require

the use of assumptions which could be inappropriate for the specific case of biofuels production, potentially contributing to misleading calculations of economic impacts. More sophisticated regional models might offer a way to estimate the economic impacts of biofuels production with greater rigour. This work provides a crucial starting point for future modelling of the economic, social and environmental impacts that biofuels from marine algae could have on regional economies.



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Investigating factors that regulate oil accumulation and their affect on gene expression in the marine Eustigmatophyte alga *Nannochloropsis oculata*. *Stephen Slocombe, Scottish Association for Marine Science.* Plants and algae have been exploited for centuries for food production but research has recently turned to these as a source of renewable alternatives to petroleum. Micro-algae have the potential for large-scale production of biofuels and high value lipid-based industrials. Furthermore, the broad diversity of micro-algae favours screening for novel products and for strains that can be genetically manipulated to accumulate these at high levels.

N. oculata is a high-oil accumulating marine algal strain that is already in commercial use and represents a suitable model system for investigating oil synthesis. Utilizing marine strains can avoid competition for freshwater supplies. Oil accumulation, as with many other micro-algae is induced by environmental factors such as nitrate depletion. The precise mechanism involved is poorly understood in algae however. We have taken a molecular biology approach to determine first if expression changes in lipid synthesis pathway genes are involved and to identify gene markers for nitrate depletion. This paves the way for large-scale EST analysis at defined stages of nitrate depletion and oil accumulation to identify regulatory genes. Our molecular approach is complemented by a physiological analysis of factors affecting production such as nitrate depletion and screening of the CCAP micro-algal collection for other high oil producers.



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The Next Generation of Biofuels. *Peter Schiener, Scottish Association for Marine Science.* This talk presented a journey through the world of biofuels. On our road of low carbon emissions the talk stopped at places such as "What are biofuels" and why we need them. Carbon balances show that carbon capture and recycle through biofuels is much quicker than using fossil fuels. As transportation fuels account for up to a 1/3 of greenhouse gas emissions biofuels have got the potential to reduce those pollutants significantly and fulfill governments targets. The talk also explained the political background which provides us with the driving force to lead us on this road of low carbon emissions by 2020. However, this road is still uneven and industrial figures of bioethanol production and consumption show the need for further development, such as algal biofuels.



A Biorefinery Approach A biorefinery approach to the production of Biogas from Algae . Dr Alan Heron, ITSligo.

Significant advancement in biofuel production technology has enabled large scale production of bioethanol from simple sugars such as starch and sucrose and biodiesel from plant oils; however, the production of these “first generation” biofuels requires vast quantities of arable land. With the worlds population fast approaching 7 billion and expected to reach 9 billion by 2040 there is mounting pressure on the earth’s finite supply of arable land to meet the nutritional needs of humankind. This competition between food and fuel has become a hotly debated topic and has been cited as a contributing factor in the spike of global food prices in 2007/2008. In an effort to address this issue, the INTERREG funded BioMara project will demonstrate the feasibility and viability of producing mari-fuels from marine biomass derived from both macroalgal (seaweeds) and microalgal (single celled plants) sources as an alternative to agri-fuels production from terrestrial land plants. Within the BioMara group, researchers at Institute of technology, Sligo focus on the production of biogas from algal biomass.

Feasibility studies into the production of biodiesel from algae have highlighted the importance of a “biorefinery” approach to biofuel production. Mindful of this, the chief focus of this study is the co-digestion of algal sludge with other byproducts of the biorefinery.

In addition to the talks given during the workshop the two PhD students based at the Scottish Association for Marine Science presented posters of their work to date. These posters are summarised below.



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Molecular Aspects of Algal Biofuels. Carole Shellcock. Scottish Association for Marine Science.

Microalgae comprise a vast group of “oil-producing” organisms with an immense range of genetic diversity. They exist as unicells, colonies and extended filaments, are ubiquitously distributed throughout the biosphere and grow under the widest possible variety of conditions. They can be cultivated under a range of conditions from freshwater to situations of extreme salinity meaning they can be grown under difficult agro-climatic conditions.

Using the model organism, diatom *Phaeodactylum tricornutum*, it has been possible to follow and profile lipid production throughout the growth cycle, under differing culture conditions. A specific focus has been to examine the effects obtained when cultures are exposed to varying concentrations of carbon dioxide. Flow cytometry coupled with Nile Red neutral lipid staining has indicated that oil synthesis lags behind cell growth and that the highest oil levels occur once the culture has entered stationary phase. GC-FID analysis has shown the occurrence of fatty acids including eicosapentaenoic acid (20:5 *n*-3), a valuable polyunsaturated molecule. This preliminary work has been combined with the development of molecular based protocols aimed at elucidating key genes involved in this diatom’s lipid synthesis pathways. Suitable house keeping genes have been determined which will enable investigation into gene expression and regulation during periods of low and high oil production and storage. The work will be carried out on samples from specific time points in the growth cycle.



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Role of Beach Cast Seaweed in beach ecosystems on the west coast of Scotland, and possible impacts of removal for bio-fuel. Kyla Orr. Scottish Association for Marine Science.

Large amounts of seaweed are cast ashore onto Scottish beaches every year, particularly on the west coast of south and north Uist in the Outer Hebrides during inter storms. Mounds of seaweed measuring several meters high and wide and hundreds of meters long have been recorded on beaches after strong gales. Kelp (*Laminaria* spp.), which forms a major component of the beach cast seaweed is a proposed source of biomass for biofuel. However, beach-cast seaweed plays a vital role in both terrestrial and marine food webs, and its ecological importance needs to be fully assessed before it can be commercially harvested for biofuel production. This project aims to assess the role of beach cast seaweed as a subsidy to sandy beach ecosystems in Scotland.

Biomara builds links with China.

BioMara lead scientist Dr Michele Stanley was recently invited by the Foreign and Commonwealth Office to join a knowledge exchange mission to China. Of particular interest was the potential for carbon dioxide, the powerful greenhouse gas, to be removed from the emissions produced by heavy industry and used to help cultivate microalgae.



Two Chinese delegations have visited SAMS at the Scottish Marine Institute this year to meet BioMara scientists. In March, the Director General of the Yellow Sea Fisheries Research Institute (YSFRI), Chinese Academy of Fishery Sciences, (pictured above) met Michele and other SAMS scientists, to discuss the possibility of reciprocal visits between BioMara scientists and Chinese scientists based at the YSFRI in Qingdao, China, who share expertise in anaerobic digestion technology. In June, Dr Maeve Kelly of BioMara met with visitors from the Oceanic and Fishery Administration of Shandong Province and the Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences. The Rongcheng area of Shandong province is home to some of the largest seaweed cultivation areas in the world. The delegates were very interested in various aspects of BioMara research, including marine spatial planning, the potential for cultivating seaweed for use as biofuel, the possible integration of seaweed culture with other forms of aquaculture and ways to optimise the biogas yield from cultured seaweeds.

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