BioMara Newsletter

WINTER 2010/2011

Sustainable fuels from **Marine Biomass**

In this issue

Introduction from lead scientist Michele Stanley

One success in the latter part of this year was the meeting between BioMara partners and the community on Lewis, in the Scottish Outer Hebrides (see page 1). An initial meeting in Stornoway hosted by Comhairle nan Eilean Siar was followed by a public meeting at Lews Castle College. A range of topics were covered including the potential implications seaweed could have as an alternative fuel source, to an island community such as Lewis. In general BioMara and its overall aims were well received and I would like to say thank you to everyone who attended the meeting and who forwent one of the last days of summer on Lewis.

Reaching rural stakeholders

Engaging with the community: **the Outer Hebrides**

As Stakeholder liaison facilitator, Ian Macfarlane regularly meets community groups in Scotland and in Ireland. Most recently he has presented BioMara to the Loughs Agency, a cross-border organisation based in Derry/Londonderry, the Enterprise Board of County Sligo and Donegal Council members and officials.

On 3 September Ian and several members of the BioMara scientific team visited the Western Isles of Scotland. A morning meeting introducing BioMara to Comhairle nan EileanSiar (CnES - Western Isles Council) was addressed by BioMara's Scientific Director, Michele Stanley, Grant Allan from the Fraser of Allander Institute in the Economics Department of Strathclyde University, and Ian Macfarlane.

The meeting was hosted in the Council Chamber and was attended by both council members and officials. The BioMara designated links to CnES are Councillor Annie MacDonald, Vice Chair of the Sustainable Development Committee and Mr Ruairi MacIver, Projects Manager for Renewable Energy, who were both present.

Following the formal presentations and a question and answer session, the Council hosted a lunch during which BioMara participants including the morning's speakers, and Prof. Kim Swales (Fraser of Allander Institute in the Economics Department of Strathclyde University), Prof. Neil Hewitt (Director of the Centre for Sustainable Technologies in the University of Ulster) and Dr. Paul MacArtain (Project Manager in the Centre for Renewable Energy at Dundalk Institute of Technology in County Louth) engaged in vigorous debate about the economics and practical application of emerging techniques from BioMara in the Western Isles.

An open meeting was held in the afternoon to present BioMara to the public, and was hosted by Lews Castle College UHI, a partner with SAMS in the UHI partnership of colleges, learning and research centres. Given that it was a very warm and sunny Friday afternoon, the session was well attended, both 'in the flesh' and by video link, by over 30 participants and two camera crews. Dr Stanley introduced BioMara to the audience, Prof. Hewitt followed with some thoughts on the economics of seaweed use for fuel and Dr MacArtain spoke about anaerobic digestion and biogas production.

Following the formal presentations and some informal discussion over tea and coffee, Prof. Frank Rennie, Professor of Sustainable Rural Development at Lews Castle College, facilitated a question and answer session in which visitors and many of the audience exchanged views and sought to define opportunities for applying BioMara outcomes in the Outer Hebrides.

There was just time, before the BioMara team departed Stornoway, for several of them to pay a visit to the Western Isles Integrated Waste Management Facility at Creed Development Park on the edge of Stornoway where Donnie Macmillan, the plant manager, explained its operation. The plant incorporates mechanical screening, anaerobic digestion and in-vessel composting to produce a soil conditioner and biogas. It was the first UK plant to incorporate anaerobic digestion of source-separated biowaste on a commercial scale using Linde dry-digestion technology. The biogas produced is used to generate electrical power for export to the local network whilst the solid digestate is matured to produce a high-quality compost.

Science update meeting

An exciting and varied BioMara scientific and technical meeting was held in October, to enable researchers from the six institutes in the BioMara project to discuss progress. Hosted by CREDIT at Dundalk Institute of Technology, a group of twenty BioMara researchers attended. Four talks were presented followed by discussion of technical and scientific developments. The formal presentations are summarised below:

Anaerobic digestion and volatile fatty acids

Paul MacArtain from the Centre for Renewable Energy at Dundalk IT (CREDIT) presented results of his preliminary work on volatile fatty acid (VFA) production during anaerobic digestion (AD) of *Ascophyllum nodosum*. The work was done in laboratory-scale 2 litre digesters at 35^{0}C with VFA determination by headspace analysis using a Gasdata LMSxi portable gas tester. White rice was used as a control.

Ascophyllum produced larger quantities of gas than the control throughout the test period (69 hours) and the proportion of methane was also consistently higher. Having established an extremely effective methodology, future work will extend to other seaweed species and will include extending the digestion period for up to 100 days, investigation of the relationship between specific carbohydrates and specific VFA concentrations and of acidification of the substrate on VFA concentration.

Molecular investigation of oil production in algae

Carole Shellcock, a PhD student from SAMS' Scottish Marine Institute explained her molecular investigation of oil production in algae aimed at using gene probes to select oil producers. *Phaeodactylum tricornutum* was used as the study species and an experimental cultivation system was designed incorporating 360 ml culture tubes and temperature, aeration and light control. Methods to evaluate oil content were developed based upon staining the oil with Nile Red, a fluorescent dye which can be used to microscopically examine the cells for oil bodies and also permits flow cytometry to quantitatively assess oil accumulation. The GC-FID method for extraction and purification of fatty acid methyl esters (FAMEs) allowed the fatty acid profile to be determined. Samples were taken and cell counts made daily.

As the literature suggests, oil production lags growth: little oil is produced during the exponential phase and the largest amounts of oil are seen once cells are in the stationary phase. Replicates produced very variable results but growth and oil production generally occurred more quickly at 20^{0}C than at 15^{0}C with a maximum concentration of FAME of around 19.5% in both instances, the former after about 15 days and the latter after about 20. 2.5% CO_2 introduced to the aeration resulted in higher oil production and reduced pH dramatically in the culture medium. Assessment of fatty acid profiles has produced some early results and continues.

Upstream Choices: Downstream Costs

Elaine Groom & Simon Murray from Questor also gave the final presentation at the workshop. They contrasted the upstream choices considered by the petrochemical industry with those that will confront algal oil producers. Major challenges to the upstream stages of conventional oil production – exploration, drilling and extraction – and downstream activity – cracking, refining and distillation – include energy conservation and water availability, clean up and reuse. Algal fuel production will need to address similar issues of energy use and water availability as well as nutrient supply during cultivation. Water availability and nutrient recovery during the harvesting and fuel extraction phases will require consideration.

Some solutions to the challenges of extracting oil from microalgae were examined: harvesting might involve flocculation, sedimentation, centrifugation or membrane filtration though each has pros and cons. Cell rupture is essential for effective recovery of oil. The preferred methodology will depend upon cell size and culture conditions. Methods may include mechanical extraction (about 80% recovery), use of solvents (up to 95% recovery) or supercritical fluid extraction using CO_2 as a solvent at high temperature and pressure (around 100% recovery). These options require an evaluation of resource use; the aim is to inform the project of the optimum energy return on energy invested (EROEI), depending on the scale of the application.

Ecosystem effects of harvesting seaweed

Kyla Orr is a PhD student at SAMS' Scottish Marine Institute who bravely spends much of her time on the beaches of the west coast of the Uists studying the role occupied by beach-cast seaweeds on the local ecology. Her presentation was based on preliminary results to date and was an eye-opener for those who

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might have seen beach-cast as a useful source of material for biofuel production. Of the three sources of biomass - harvested, cultivated and beach-cast seaweed – beach cast appears to provide large quantities of easily accessible and historically available feedstock. Its supply is, however, weather dependent and thus somewhat unpredictable from year to year.

More significantly, beach-cast supports a diverse coastal community of bacteria, detritivores, epiflora and deposit feeders which, in turn, support carnivorous invertebrates, all of which provide feed for large crustaceans, fish and seabirds. Up to one million oligochaete worms per square metre of seaweed can be found: beach deposits of seaweed are clearly a very important feeding ground for migratory shorebirds, as well as breeders inhabiting inland habitats. Clear relationships are demonstrable between shorebird numbers and beach-cast cover but many questions remain unanswered and will form the basis of further work. It is expected that construction of a mass balanced tropho-dynamic food web model will allow its manipulation to assess the impacts of seaweed removal at different levels on food webs on sandy beaches. The impact and appropriateness of beach-cast removal may then become measureable.

PDFs of the posters presented at this meeting are available here. *www.biomara.org/news/biomara-science-progress*

Meet the team

Each Newsletter we shall be introducing a member of the BioMara team. This winter we kick off with two scientists: Dr Arlene Rowan describes her work on the microbes capable of breaking down seaweed in an oxygen-free environment; and PhD student Kyla Orr talks about her work assessing the potential impacts of harvesting seaweed from the marine environment.

Meet a post-doc Dr Arlene Rowan
Using microbes to generate methane

Dr Arlene Rowan is searching for the presence of methanogenic microbes and investigating their potential to produce methane from anaerobic breakdown of seaweed. Wastes rich in organic matter, including sheep and cow gut contents and faeces, and sewage treatment waste, are among the various sources of inoculum being tested. Wild, beach harvested seaweeds and cultured seaweed will then be investigated for their potential to generate methane and their suitability as a source of biofuel.

Meet a PhD student Kyla Orr
Modelling ecosystem effects of harvesting seaweed for biofuel production

Three sources of seaweed have been suggested for the extraction of biomass for biofuel: harvesting of wild seaweed that is attached to rocks; collection of storm-cast seaweed from beaches; and aquaculture of seaweed on long-lines. This PhD project focuses on the ecological importance of beach-cast seaweed and the potential impacts of its removal for biofuel. The study area is North and South Uist in the Outer Hebrides, where large amounts of seaweed are cast ashore each year. I currently travel out to the Uists approximately every six weeks and quantify the seaweed on selected beaches, as well as conduct bird counts and collect invertebrates. These trips have yielded some interesting results, with the last bout of October gales creating mounds of seaweed more than two metres high on some beaches.

When you look at a beach you may think of it as a desert, with little in situ primary production. This is because the mobile sand prevents plants and algae communities from establishing. All the fauna living on beaches have to rely on the import of food, such as storm-cast seaweed, to survive. When the seaweed is cast ashore it starts to decompose and becomes a veritable feast for invertebrates. More than 50,000 invertebrates per square metre were recorded in seaweed mounds in September 2010. Large numbers of shorebirds then arrive to feed on the invertebrates and you get a complex and dynamic food web. The data collected in this project will be used to build a food web model and help us predict what the impacts would be to sandy beach food webs if seaweed were removed.

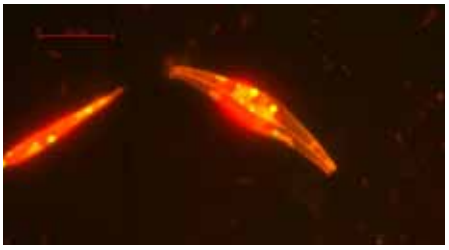
Places we've been, people we've seen

International Plant Lipids meeting in Australia

On 11-16th July Dr Steve Slocombe attended the 19th International Symposium on Plant Lipids held in Cairns (North Queensland, Australia) and was invited to speak on genetic factors that regulate oil accumulation in marine micro-algae. The ISPL is a bi-annual meeting and the principal forum for plant lipid scientists. Key areas were large scale transcriptomics, membrane lipid re-modelling and transport, lipids as signal molecules and oil production in leaves. This year there was a session devoted to algal biotechnology, reflecting a burgeoning interest in this area.

The keynote presentation from Paul Roessler of Synthetic genomics reviewed synthesis of new organisms and also showed that our knowledge of lipid biochemistry in micro-algae is still fragmentary, research has generally focussed on higher plants. The issue of public access to micro-algal genomic information was raised in this session given the major involvement of private companies. Some research labs are deciding to go it alone and produce genomes for immediate public access. The cost of producing biodiesel from micro-algae in Australia was discussed by David Batten of CSIRO, Melbourne, suggesting that valuable side-products are required to make the process economically viable, given estimates of 1-2 US$/litre even in this ideal location. Several poster presentations grappled with the problem of evaluating micro-algal screens for oil using multiple criteria (yield, composition, growth rates etc.). A few dealt with alternatives to auxotrophic growth, such as a heterotroph capable of utilizing glycerol, the waste product from biodiesel manufacture.

Energy from Algae



In September, Dr Michele Stanley attended a meeting on New Energy technologies. Organised by Synnogy, a company that instigates and facilitates cross-organisational strategic thinking on New Energy technologies, the New Energy Forum aims to bring together decision makers from a wide range of stakeholder organisations to help optimise strategic thinking in the new energy arena. Michele gave a presentation on BioMara, providing an overview of the project's progress in micro- and macro-algal research, to a group including representatives from BP Europe, Alstom, the Carbon Trust and the Algal Bioenergy Consortium.

Renewable energy in the Middle East

Professor Neil Hewitt, Director of the Centre for Sustainable Technologies, University of Ulster, attended a workshop in Abu Dhabi in November. Hosted by the Abu Dhabi Marine Operating Company (ADMA-OPCO) as part of its Corporate Social Responsibility commitments towards the UAE society, the workshop on renewable energy solutions was organized by the Petroleum Institute. The workshop's theme was "Industrial Renewable Energy Applications" and was opened by ADMA-OPCO CEO Mr. Ali Rashid Al Jarwan. It was attended by a number of the company's divisional managers, local government representatives and Petroleum Institute members along with international speakers specializing in areas of renewable energy. Dr Hewitt's talk illustrated the techno-economic benefits of macro- and micro-algae as a renewable energy source and reviewed the current state of the art regarding harvesting and processing marine algae.

Biomass and biogas

November saw the BioMara team from IT Sligo attending two international conferences in Europe. Carlos Vanegas attended the Third International Symposium on Energy from Biomass and Waste in Venice. It was an excellent opportunity for him to meet other researchers in the biomass to biogas area and to see the "state of the art" technologies available. Meanwhile, Alan Hernon presented a paper entitled "A biorefinery approach to the production of Biogas from Algae" to the 15th European Biosolids & Organic Resources Conference in Leeds. Europe's foremost conference for the biosolids and biowaste industries, the conference brought together over 280 environmental professionals and 30 exhibitors. It was an excellent opportunity for Alan to meet with groups operating industrial scale anaerobic digestion plants.

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Sustainable communities initiative

During the weekend of 13 and 14 November Ian Macfarlane attended the Sustainable Communities conference held in the schools campus in Lochgilphead, Argyll. Run by Big Green Tarbert, supported by the Sustainable Development Commission, the Co-operative Group Limited, NFU Scotland, Community Energy Scotland, Wright, Johnston & Mackenzie LLP, South Kintyre Development Trust, and ALIenergy, the meeting was chaired on the Saturday by Ken McDonald of BBC Scotland and on the Sunday by Jim Mather MSP, Scottish Minister for Enterprise, Energy & Tourism.

The first day of the meeting focused on community resilience and sustainable growth and was addressed by representatives of Transition Scotland, the Sustainable Development Commission Scotland, Argyll and Bute Council and, by videolink from Vancouver, the Canadian Centre for Community Renewal. Some lively round table discussion ensued. On day 2 the focus was on generating local income from renewables. After several presentations from the Minister and developers of a number of local initiatives, the meeting broke up into a series of workshops which sought to identify priorities and practical ways forward. This meeting served to demonstrate just how much can be done with local resources and using local skills.

For a weekend meeting in a rural location it attracted wide participation with well over 100 delegates and some from well outside the local area. BioMara's stand proved popular and our activities attracted a great deal of interest. The conclusions of the conference, once summarized, will be incorporated into the next newsletter. More information about Big Green Tarbert can be found at *http://greentarbet.wordpress.com/*

The importance of seaweed across the ages

A short history of seaweed exploitation in the western British Isles

Seaweed as food

Seaweed has formed a part of the diet of Irish and Scottish coastal dwellers for at least 4,000 years. The earliest recorded account of its use is in a poem dated around *AD563* and attributed to St Columba, a native of Donegal, after his move to Iona in the west of Scotland. Dulse (*Palmaria palmate*), a red seaweed, was traditionally eaten with oatmeal in a thick broth or served boiled and tossed in butter. The monks on Iona collected it to provide food for themselves and for the poor. Indeed, seaweed has associations with poverty in both Scotland, where it supplemented the diet of those displaced from their lands and forced to coastal locations to make way for sheep between 1790 and 1820, and Ireland, where it also became part of the diet during the potato famine after 1846.

Dulse, dillesk in Ireland and Carageen (*Chondrus crispus*), known in Ireland as Irish moss, or carrageen moss, continue to be harvested for food in small quantities in both Ireland and Scotland and purple laver (*Porphyra umilicalis*), a traditional component of the better known Welsh lavabread ('Bara lafwr'), remains the key ingredient of laverbread or pudding in Scotland and Ireland, where it is known as slake, sloke or slocan. Sea lettuce (*Ulva lactuca*) – 'green laver' - can also be used in a similar way to purple laver but is regarded as inferior. Recently suppliers of "sea vegetables" have also sought to market some kelps and wracks for human consumption.

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Seaweed kept the land fertile

For many generations, seaweeds have played a much larger part in the production of foodstuff, being used as fertilisers. Their ability to concentrate minerals and trace elements from the sea render them a potent source of nutrients for vegetable cultivation. Traditionally storm-caste seaweeds were collected from the shore, especially in the western coastal areas of Scotland and Ireland, briefly composted and dug into the soil as a fertiliser and soil conditioner providing high levels of nitrogen and potassium, particularly useful in the shallow, often low potassium, soils of these west coast areas. Crofters still use this method to the present day.

Later, with increasing coastal population, lazy bed cultivation became commonplace. Wide trenches were dug and the seaweed thrown up by winter storms was laid on the earth piles for several weeks. Eventually the piles of earth were turned back into the trenches and root crops, especially potatoes, planted. No further fertilisation was undertaken, the seaweed providing all necessary nutrients.

Old areas of lazy beds are still visible on the islands and in western coastal areas of both Ireland and Highland Scotland.

Minerals from Seaweed

From the later part of the 17th Century seaweed was found to have a number of industrial uses. In Europe, burning kelp to produce an alkaline ash probably started in France. It began in the British Isles in 1694, first in Fife and later, around 1720, in the Orkneys. By the 1740s the practice was well established in western Ireland and the Hebrides and by 1800 Scotland alone was producing 20,000 tonnes p.a.

Kelp ash contains soda and potash and was used initially in glazing and glass-making. It was an effective substitute for expensive Spanish “Barilla Soda” prepared from salt marsh plants. During the Napoleonic Wars, Britain was largely isolated from Europe and Barilla Soda became unavailable. As a result the value of kelp ash rose, especially as it became increasingly used in soap making. During the first 15 years of the 19th century *Laminaria spp*. (kelp) collected as cast after storms, and *Ascophyllum* (knotted or egg wrack), cut from rocky shores at low tide, was collected and dried in increasing quantities. Such seaweeds could be burned in round, stone-lined pits or shore kilns (as soon as two days after collection in good weather conditions). 20 tonnes of wet weed yielded five tonnes of dry and one tonne of kelp ash. Many kilns were established along Irish and Scottish shorelines.

During these early 19th century boom years, Scotland produced 20,000 tonnes of burnt kelp from Orkney, the Western Isles and the west of Scotland, implying a harvest of 400,000 tonnes p.a. of wet seaweed. One might expect that, given a 4-month cutting season and west coast weather, this would need an army of at least 3,000 cutters. It is said that as many as 40,000 souls may have depended on kelp harvesting at its 19th century peak. The harvesting was all by hand, supported first by horses to carry the weed from the shore in “creels” and later by adapted hand and horse carts for which special paths – “wrack roads” (now often corrupted to Wreck Road) were constructed.

A few made fortunes from seaweed. Most Scottish soap and glass factories were in Glasgow and at one time a single Glasgow merchant handled 80% of the Scottish harvest. In 1720 kelp ash sold for about £2 per ton, between 1740 and 1760 it was sold at £7 to £8 per ton. By 1800 this had risen to £18 to £22 per ton. Around 1810 the price of Barilla Soda from Spain fell to £10 per ton and following the end of the Napoleonic Wars, after British victory at the Battle of Waterloo in 1815, and the removal of import duty in 1820, the price of

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kelp ash rapidly fell back to the £2 per ton of 100 years earlier. Kelp burning was over and its collapse contributed to Highland poverty and the misery of the clearances.

Iodine extraction from kelp began as the burning of kelp became less commercially attractive. It was a much more skilled process. The weed had to be fresh and protected from rain. The burning temperature had to be controlled and stopped at precisely the correct time. It was important not to burn weed contaminated with sand such as storm cast kelp because this affected burning temperature and thus iodine yield. Iodine pricing was speculative. From 1841 to 1845 it averaged 11s-9d per lb. By 1860 it was 8s per lb. Cheaper mineral deposits were later imported from Chile and by 1900 the industry was petering out. The last Highland shipment left South Uist in 1933 and by the start of World War II, it had ceased in Ireland too.

Camouflage, custard and parachutes – Aginates take centre stage

In 1893 the English chemist Edward Curtis Stanford, a specialist in iodine extraction, isolated alginate from seaweed. In 1864 he had established an iodine extraction plant for the North British Chemical Company at Middleton on Tiree (known as the "glassary"). As well as producing iodine and, eventually, alginates, this plant also produced charcoal, used as a fertiliser and deodorant for earth closets, and biogas used to light the buildings.

West Highland alginate production began in Argyll in 1935 when another English chemist, C. W. Bonniksen set up "Cefoil" at Putechantuy (Putechan, near Bellochantuy in Kintyre). His aim was to produce a wrapping film which he began to sell in 1939, just as war started and "cellophane", a much superior product, was launched. The business failed but the Ministry of Supply recognised the benefits of alginates to the war effort. It was known that chromium alginate could be spun into green yarn and used for manufacture of camouflage netting. Outputs of the wartime work are vague but there is a story that alginic acid was used as a substitute for balsa wood and that at least one de Haviland "Mosquito" aircraft was built of it. Other wartime products such as camouflage paint, custard and artificial silk for parachutes were reputedly made from alginates.

The Ministry of Supply built factories at Kames and Barcaldine (Argyll) and Girvan (South Ayrshire) which were managed by Cefoil. A weed collection and drying station was established at Orosay (South Uist) in 1944. When war ended, Cefoil bought these factories and subsequently changed its name to Alginate Industries. The small factory in Bellochantuy was subsequently closed and later, in 1956, Kames was also shut down.

During the second half of the 20th century extensive uses were found for alginates. Sodium alginate is a jelly-like carbohydrate and was used in a variety of ways to hold water, gel, emulsify and stabilise in the food, pharmaceutical and industrial sectors. It was widely incorporated into foods and drinks to thicken drinks, form gels in pies and jellies, and to stabilise pet foods, meringues and ice cream. It improved the head on beer and allowed fast setting of puddings and was used in textile printing to produce sharp edges and to thicken textile pastes. When dried it could coat quality paper to produce a sheen. The dental business used it in toothpastes and as a dental impression powder and it was used to coat tablets in the pharmaceutical industry. Alginate's properties were useful in cosmetics, paints and medical products and sodium alginate could also be used to form alkali-soluble fibres.

Alginate Industries grew apace through the 1960's and 70's. In addition to the Orosay collecting station, further stations were set up in Sponish (North Uist) in 1955 and Keose (Lewis) in 1965 in addition to local collecting in Argyll and Ayrshire. Nevertheless, Scotland could not meet the increasing demand for seaweed and supplies were eventually imported to Scotland from Ireland, Iceland, Norway, South Africa, Chile and Tasmania.

In 1979 Alginate Industries was sold to Kelco, a Californian company, and renamed Kelco/AIL Limited. This was a time of competition from Chinese producers of alginates and other competing products. The 1980's saw production reducing and staff being laid off. The name changed to Kelco International and its then parent, Merck, in 1996 sold the company to Monsanto. It was renamed Nutrasweet Kelco Company in 1996, when Barcaldine was closed and production focussed in Girvan. Alginate production finally ceased in Scotland, after acquisition in 2008 of the Girvan plant by FMC Corporation of the USA. At its peak, the world alginate industry probably utilised a quantity of wet seaweed similar to that harvested in the western British Isles in 1814.

Seaweed into the future

Although Edward Curtis Stanford was using algal derived biogas to light his factory in Tiree in the 19th century, the history of seaweeds as a source of bioenergy – biogas and alcohols – is just beginning. US experiments in the 1970s demonstrated methane production but failed to be followed through primarily because of a lack of adequate supply. This is no longer a significant constraint and the economic and social importance of renewable energy have been revolutionised in the past 25 years.

We expect BioMara to be at the forefront of the novel developments upon which the next, and possibly the greatest, seaweed- based industry in Ireland and Scotland will be based. The production of transport fuels, particularly in remote, rural, isolated and island communities, such as many in rural Scotland and Ireland, may well come to depend upon liquefied algal-derived biogas and bioalcohols. Watch this space…

This article was partly based on a very interesting talk delivered by Mr Alan Wolstenholme, when visting the Scottish Association for Marine Science. Alan is ex-CEO of Alginate Industries, an expert on alginates and now an independent advisor.

Getting it right Improving our BioMara newsletter

After distribution of the Summer 2010 newsletter, Ian Macfarlane sought feedback to find out how well the newsletter was serving its function of keeping people informed.

The reaction to its contents varied from "exactly what we need … very informative" to "… contains nothing useful". Broadly those from a scientific background wanted more technical content whilst regulators and their statutory consultees, NGOs and other public bodies were generally happy with the information provided. With such a varied group of over 500 recipients to satisfy, differences inevitable.

Some suggestions as to layout and design were made. About half of the respondents thought the content pitched at about the right level though several thought it should contain more technical information and links to scientific data. One made the point that it was important that the stakeholder group was made aware of the whole range of activities contained within BioMara as this would enable them to ask for particular information if appropriate.

The role of newsletter management has now passed on to Laila in our communications team. Aiming to continue to engage with the widest possible range of stakeholders and others with an interest in BioMara, we will keep the newsletter content broad-based and accessible. Nevertheless, we are keen to hear from anyone interested in receiving more information on a particular topic and will do our best to meet these needs. We would also value feedback on this edition and the extent to which it meets your needs.

Contact: biomara@sams.ac.uk, or Ian Macfarlane on +44 (0)1631 559322

Upcoming events

Ian Macfarlane will be visiting stakeholders in Northern Ireland in mid April. He is happy to meet others at this time so please contact him directly if you would like to discuss BioMara:

biomara@sams.ac.uk or Ian Macfarlane on +44 (0)1631 559322

We have no new meetings to announce at this time. Please keep an eye on the website (www.biomara.org) for news of all upcoming activities.

The six BioMara partner institutes

Scottish Association for Marine Science at Scottish Marine Institute. (Lead Partner)
Centre for Renewable Energy Dundalk Institute of Technology • **Centre for Sustainable Technologies** University of Ulster
Fraser of Allander Institute University of Strathclyde • **Institute of Technology** Sligo • **The Questor Centre** Queen's University Belfast

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