**Energetic Algae (‘EnAlgae’)**

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**Authors**

Insert author name], [insert author affiliation]

**Contributors**

[Insert author name], [insert author affiliation]

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# Introduction

In 2012-2014 an inventory of North-West European algae initiatives was carried out to provide an impression of research and commercial activities connected to algae production and utilization. The collected data has been reviewed in country specific reports and collated and summarised in an overview report covering the whole North-West-Europe region (including Ireland, Great Britain, Germany, Belgium, France, Switzerland, Luxemburg and the Netherlands).

Data was obtained via a comprehensive questionnaire which was distributed among stakeholders identified in a preliminary scoping exercise. Although not unexpected, unfortunately not all questionnaires were returned. In these cases, publically available information was used for the landscaping study, while some additional information was collected through personal interviews with the respective stakeholders. The questionnaire aimed to gather more information on focus, expertise and applied technology of the addressed institutions. It was also designed in a way that allows its use as an information sheet in EnAlgae’s web-based information portal.

In this context, it must be emphasized that this report cannot claim to reflect an exhaustive list of all stakeholders active in algae research and business. The reasons behind this are that it is a rather broad area and in some cases only very limited information is available about respective activities. In addition, there is lots of movement in this sector with regard to new start-ups and the closing down of business operations, making it difficult to give an up-to-date overview. If too little information could be found about certain institutions they were not included in this survey.

However, this study nevertheless represents the most important institutions active in this area, allowing conclusions to be drawn about the main fields of interests, technology and market opportunities for algal research in Ireland.

# Irish stakeholders

In total 21 institutions working with algae could be identified in Ireland. About half of these stakeholders areindustrial organisations (52 %)and the remaining48 % are research institutes. The following table (Table 1) gives an overview for the identified stakeholders and seven consortiums, networks and multi-partner projects.

The following pages present the results of survey results for UK research institutions and commercial enterprises.

Table 1: Overview of Irish stakeholders active in the broader algae area

|  |  |
| --- | --- |
| Research institutions | |
| Irish seaweed group, The Ryan Institute, National University of Ireland, Galway | Expertise includes cultivation of native brown kelps, and red and green seaweed, Multi-Trophic Aquaculture (IMTA), seaweed ingredients and as food and feed products, sustainability aspects of harvesting (and use of) macroalgae for the production of 2nd generation biofuels. |
| University College Dublin | Expertise includes harvesting and processing of microalgae via pyrolysis, use of microalgae as soil fertilizer, integration of microalgae production with flue gas and wastewater bioremediation, LCA analysis and environment modelling for microalgae systems, bioprospecting of seaweed, and use of seaweed oligosaccharides for sow and piglets gut microflora. |
| University of Limerick | Expertise includes microalgae and cyanobacteria cultivation in brackish and fresh water, metabolic engineering and protein engineering of converting enzymes of cells, ethanol fermentation, downstream processing, upscaling of technologies to pilot. |
| DaithiO’Mhurchu Marine Research Station, Cork/ Indigo Rock. | Expertise includes microalgae cultivation in plastic bags and tubular bioreactors, reactor design, macroalgae cultivation in hatchery and in long lines, fermentation of macroalgae and production of biopolymers and fish feed, LCA and environmental modelling for macroalgae cultivation, taxonomy studies for both macro and micro algae. |
| Teagasc | Expertise includes cultivation of macroalgae, production of nutraceuticals, food, and feed, biotic and abiotic interactions of seaweed, thermal extraction of ingredients. |
| Marine Institute | Expertise includes marine  Harmful Algal Blooms (HABs), biotic and abiotic interaction of algal blooms (micro and macro), diseases and toxicology, wastewater open ponds, interaction of algal and bacterial biomasses. |
| Sustainable energy research group - University college cork | Expertise includes macroalgal cultivation, processing technologies for production of biopolymers and edible/biodegradable films/coatings, and food ingredients |
| Dundalk Institute of Technology | Expertise includes production of ethanol and biogas from seaweed, extraction of oils and biogas production from microalgae. |
| Institute of Technology Sligo | Expertise includes developing and scaling up of processes in the areas of AD and fermentation technologies for micro and macro algae, use of wastewater for production of seaweed, toxicology and algal competition, advanced pre-treatment and co-digestion technologies for biogas production/ |
| Waterford Institute of Technology | Expertise includes mining of seaweeds for pharmaceutical activity, bioactives for feed, remediation of heavy metal and chemical contamination. |
| Industrial Organisations | |
| AERBIO | The company specialises in ‘wet’ extraction process for manufacturing bio-based oils, proteins and other valuable products from algae biomass. |
| Algae Green | Production of plant conditioner for Golfcourses, Racetracks and agriculture/horticulture markets from wild seaweed. |
| Algae Health | Holds proprietary cultivation technology to produce the carotenoid Astaxanthin from microalgae. |
| ArramaraTeoranta | Expertise includes process and product development of plant hormones, soil enrichers from macro algae, vitamin and trace elements source, protein, polysaccharides for feed and fish feed. |
| Atlantic + | Production and sales of nutrition boosters for dogs, cats and horses from macroalgae. |
| Blathna Mara Seaweed | Harveting, process and production of fine milled seaweed for food & spa uses. |
| Celtic Sea Minerals | Development, manufacture and marketing of natural animal feed, hygiene and fertiliser products. |
| Cybercolloids | Research (technical and market) and product development group specialising in hydrocolloids, focusing on food, nutrition and industrial applications. |
| Irish Seaweeds | Harvests and sells edible wild seaweeds, sea vegetables and other seaweed products from Ireland. |
| Ocean Harvest Technology | Specialises in production of animal nutrition & health products from wild and cultivated microalgae. |
| Technology Centre for Biorefining and Bioenergy | Collaborative industry group to expedite the commercial development of Irish biomass resource. |
| Consortiums, Networks & Multi partner projects | |
| Biomara | The Sustainable Fuels from Marine Biomass project, BioMara, was a joint UK and Irish project that aimed to demonstrate the feasibility and viability of producing third generation biofuels from marine biomass.  Project partners: Scottish Association for Marine Science (SAMS), Centre for Renewable Energy at Dundalk Istitute of Technology, Fraser of Allander Institute at University of Strathclyde, University of Ulster, Institute of Technology Sligo, Queens University Belfast. |
| Technology Centre for Biorefining and Bioenergy | The TCBB is established and led by Irish industry, and initially funded by Enterprise Ireland and the IDA Ireland.  The centres to demonstate and demonstrate technologies relevant to 2G feedstocks, such as algae to bioenergy and biorefinery applications. Also, centre is developing processing technologies via biological and thermochemical pathways for production of energy and other products.  The Centre is co-hosted by 3 Irish universities, NUI Galway, University of Limerick, and University College Dublin. The Centre engages with other Irish Universities such as Trinity College Dublin, to enable it to expand its expertise and resources to serve the greatest possible audience. |
| DEMA | The Direct ethanol from microalgae, DEMA, is an EU Framework project that aimed at use of cyanobacteria for direct ethanol production via metabolic engineering for biofuel application  Project partners: Imperial College London, University of Amsterdam, A4F Portugal, University of Cambridge, Pervatech, the Netherlands. |
| IDREEM | The €5.7 million project is coordinated by the Scottish Association for Marine Science (SAMS) and delivered in collaboration with fourteen industrial and research partners from across Europe.  The project demonstrates the benefits of IMTA through pilot commercial-scale testing, field research and modelling. Interdisciplinary research within IDREEM will examine the obstacles and risks to the use of IMTA systems and develop tools to overcome these constraints, whether they are economic, environmental, technical, social or regulatory.  Project partners: Scottish Association for Marine Science (SAMS), DaithiO’Murchu Marine Research Station, Loch Fyne Oysters, Viking Fish Farm, Norwegian Institute for Agricultural and Environmental Research, Scottish Salmon Company, Longline Environment Ltd, University of Haifa, Suf Fish Mariculture Ltd, GIFAS Ltd, Seawave Fisheries Ltd, Marine & Environmental Research Lab Ltd, Aqua Soc. Agr. s.r.l., UniversitàdegliStudi di Genova, Universiteit Leiden, ETA-Florence Renewable Energies. |
| SEABIOPLAS | Seabioplas proposes the use of seaweeds to produce bioplastics. PolyLactic Acid (PLA) is a bio-based, biodegradable polymer which, along with other biopolymers, is demonstrating impressive growth rates. The seaweed fermentation procedures for lactic acid production will generate seaweed residues. These by-products have potential market value in the animal feed sector. The scientific approach comprises a technical phase followed by the validation and dissemination phases.  Project partners: DaithiO’Murchu Marine Research Station, AlgaplusProducao e Comercializacao De Algas e SeusDerivados LDA, StichtingDienstLandbouwkundigOnderzoek, Centro Interdisciplinar de InvestigaçãoMarinha e Ambiental, Instituto de Ciências e TecnologiasAgrárias e Agro-Alimentares, Centre d’Etude et de Valorisation des Algues (CEVA), HerfstenHelderbv, NordbiochemOu, Sleever Technologies, AgrolaboS.p.A., Cartron Point Shellfish. |
| ACCLIPHOT | AccliPhot is a Marie Curie Initial Training Network funded by the European Commission. The main research aim of AccliPhot is to investigate and understand short-term acclimation mechanisms to changes in light conditions in photosynthetic organisms. Our aim is to employ this understanding to optimise and upscale biotechnological exploitation of photosynthetic microalgae for the production of biofuels and high-value commodities.  Project partners:  Heinrich Heine University Düsseldorf, Università degliStudi di Verona, Université de Genève, Centre national de la recherchescientifique (CNRS). Université Pierre et Marie Curie, Martin Luther Universität Halle-Wittenberg, EidgenössischeTechnischeHochschule (ETH) Zürich, Switzerland, Oxford Brookes University, DaithiO'Murchu Marine Research Station (DOMMRS), University of Nantes, Fermentalg. |
| NutraMara | NutraMara aims to explore natural marine bioresources for novel bioactive substances with the potential to be used as ingredients in functional foods. Marine natural bioresources include a diversity of under-explored and under-exploited materials derived from macroalgal and microalgal sources as well as marine byproducts such as fish skins and viscera, shellfish waste and crab/prawn shells.  Project partners:  Teagasc Food Research Center, NUI Galway, Univeristy College Dublin, Univeristy College Cork, Univeristy of Limerick, Univeristy of Ulster. |

# Types of algae

Most of the stakeholders are working with macro algae (47%), while 42% works with both macro-and micro algae, and with a minority working solely with micro algae (11%).

Figure 1: Broad types of algae utilized by Ireland’s algae stakeholders

A small number of respondents provided details of the precise algae species they are working with, those identified are listed in table 2.

Table 2: Types of algae listed in survey results

|  |  |
| --- | --- |
| *Laminariadigitata* | *Cyanobacteria Synechocystis* |
| *L. hyperborea* | *Palmariapalmata* |
| *Saccharinalatissima* | *Tetraselmissuecica* |
| *Saccorhizapolyschides* | *Isochrysisgalbana* |
| *Alariaesculenta* | *Chaetocerusmuelleri* |
| *Phaeodactylumtricornutum* | *Isochrysisgalbana* |
| *Tetraselmissuecica* | *Chaetocerusmuelleri* |
| *AscophyllumNodosum* | *HaematococcusPluvialis* |
| *Lithothamnion* |  |

# Cultivation facilities

Few responders provided details of the facilities they used.

Wilde harvest and longlines are the most common strategies for sourcing macroalgal biomass. Little information was provided on the scale of cultivation facilities, the largest reported scale was 50m3.

With regard to microalgae, tubular photobioreactors are the most common system for cultivating microalgae in Ireland, followed by plastics bags.

Figure 2: The cultivation facilities used by Irish stakeholders

# Growth conditions

Many of the responders provided no details of the growth conditions, either the water or light sources used. The results of those that did are illustrated below.

From the responses, majority used salt water to cultivate algae, and few used fresh, but also 1 respondent is doing research with wastewater.

Also with regard to light, most of stakeholders use natural light, and only few use artificial light. However, many did not provide details on this aspect.

Figure 2 shows the results for water source, and Figure 3 shows results for light source.

Figure 2: Number of Irish stakeholders employing each water source

Figure 3: Number ofIrish stakeholders employing each light source

# Markets

There is a spread market interest forresearch incommodity chemicals and fine chemicals, food and feed products,bioenergy,andbioremediation.

For macro-algae the research interest is mainly on development of nutraceuticals, cosmeceuticals and pharmaceuticals, but also production of food and feed, as well as bioremediation of wastewater. Production of biogas,and other biofuels are also high on the list. See Figure 5 for more details.

For micro-algae major product development is research on production of nutraceuticals, cosmeceuticals and pharmaceuticals, but also biofuels like biogas, bio-oils,bioethanol and biodiesel production. Also with micro-algae bioremediation is combined. See figure 6 for more details.

Figure 4: Target markets for Irish stakeholders using algae in Ireland (multiple answers permitted)

Figure 5: Target market products for Irish stakeholders using macro algae in Ireland

Figure 6: Target market products for Irish stakeholders using micro algae in Ireland

# Research

The focus of research carried out in Irish stakeholders includeslife cycle analysis, biotic and abiotic interactions, disease, and modelling.See figure 7 for more details.

Figure 7: The algae research interests of for Irish stakeholders

# Underpinning activities

18stakeholders have underpinning expertise in processing technology, 12 stakeholders in bioprospecting, 6 in harvesting technology, and few others practice research in culture collection, taxonomy, and synthetic biology.See figure 8 for more details.

Figure 9: Number of Irish stakeholdersinvolved in various algae related underpinning activities.