

Energetic Algae ('EnAlgae')

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Results of the EnAlgae Stakeholder Workshop on "Benefits and Risks from Biomass Production with Seaweeds"

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Background

The objective of the EnAlgae stakeholder workshop on 28th October 2014 was to gain perceptions of benefits and risks regarding seaweed cultivation. New information on the sustainability of seaweeds should be provided by discussions with stakeholders from different countries. A dynamic discussion was carried out and insights into the experiences and attitudes of participants towards selected sustainability issues were obtained around these questions:

- Could ecosystem services provided by the cultivation of seaweeds compensate the unfavourable energy balance?
- Wild harvest or cultivation of seaweeds?
- Is seaweed cultivation in competition to other users of the marine ecosystem?
- Employment in rural areas but low income jobs only?
- What are the perceptions of the use of non-native seaweeds?

The questions have been provided together with some background information to introduce the participants into controversial sustainability issues of seaweed cultivation and to stimulate the discussion. In the following, the results of the stakeholder workshop are described and summarized.

Could ecosystem services provided by the cultivation of seaweeds compensate the unfavourable energy balance?

The energy return on investment (EROI) of producing energy from seaweeds is rather unfavourable. It is challenging to significantly improve the energy balance in the near future especially in small scale production. However, ideas to improve the EROI and life cycle assessment (LCA) results were presented. Positive effects on yields as well as on biomass quality can be achieved when the seaweed is not completely harvested, but just cut back after the first six months of cultivation. The seaweed can regenerate and a second harvest can occur in late autumn. As for the first cut in spring, there are no epiphytes on the leaves since their development starts with the rise of sea temperature. Consequently, leaves can be harvested unspoiled, leading to high biomass quality.

Another advantage of two harvesting events is the lower energy input (e.g. in the hatchery) per yearly biomass yield, leading to improved LCA results. However, negative economic impacts due to the reduced amount of biomass at the first harvest are expected and are regarded as main obstacle to implement this procedure.

Seaweed plays a number of important roles in marine ecosystems, the most important being its support for marine biodiversity. Seaweed communities provide a range of different and unique habitats for marine plants and animals, e.g. small animals such as worms and crustaceans living in gaps in branching holdfasts of the kelp on the seabed and fish seeking shelter from predators in the shade of plants. Seaweed's position at the base of the marine food chain means that many different animals rely on it as a food source such as fish, sea urchins and molluscs. However, there are just a few studies on ecosystem services provided by cultivated seaweeds in short distance to the coast. Despite the lack of knowledge and uncertainties, it was stated that every benefit could be balanced by a risk for the ecosystem. Considering the bioremediation potential, there could be competition with the initial primary biomass production, i.e. phytoplankton, leading to adaptations of the ecosystem. In particular, a modification of biodiversity can be expected as well as pressure for indigenous plant communities. Just as well an increased diversity of the benthic community is possible. It was assumed that – like in conventional agriculture – seaweed rotation could have positive effects on biodiversity and the maintenance of the benthic stability. Positive effects on biodiversity could be enhanced by usage of improved materials like anchors made of meshed nets filled with stones. The cultivated kelp can have positive effects on the fish population, too. Small fish can find protected habitats in seaweed cultures, leading to higher fish yields.

This nursery effect is already apparent after one year. On the other side potential entanglement of fauna could result from the presence of farm infrastructure such as lines and arrays and is of particular relevance to marine mammals (e.g. cetaceans).

The ability of many seaweeds to bio-accumulate nutrients and pollutants (including heavy metals) can contribute to improving water quality, assisting in reducing eutrophication and delivering associated benefits for the marine and coastal communities they inhabit. On the other hand, seaweed cultivation relies on nutrients supplied naturally in seawater, and this has the potential to result in nutrient depletion in surrounding waters. This may affect secondary productivity and thereby affect the wider ecosystem. In addition, there may be increased competition for nutrients between seaweed farms in close proximity to one another, and between cultivated and wild seaweed stocks. Nutrient capacity will therefore be a key issue for seaweed cultivation, as a consistent input of nutrients is required for growth. In China, seaweed production has already reduced the nutrient content in a way that it's not sufficient anymore to achieve high productivity. There the seawater is fertilized to maintain seaweed cultivation. This measure is not applicable in Europe due to strict environmental regulations. The integrated multi-trophic aquaculture (IMTA) with either finfish or shellfish aquaculture seems to be a more sustainable concept which has been widely investigated in Northwest Europe. The primary benefit of seaweed cultivation in IMTA is the potential alleviation of water quality and benthic habitat impacts from aquaculture. The practice of IMTA combines the cultivation of fed aquaculture species (e.g. finfish) with species that extract both organic and inorganic material (e.g. seaweed) to create balanced systems for environmental sustainability (bioremediation), economic stability (product diversification and risk reduction) and social acceptability (better management practices). In this system, the nutrient waste from one species becomes the nutritional input for another. By this, the productivity and sustainability of aquaculture sites in Northwest Europe could be increased. The unbalanced uptake of nitrogen and phosphorus by seaweeds could have an influence on the phytoplankton and shellfish population, and this interaction has to be investigated for clarification as well as the ecological effects on wild fisheries, natural habitats, and flora and fauna or the environment generally.

Seaweed can contribute to wave attenuation and to reducing the erosive impact of waves on coastline. It has been shown to play an important role in protecting marine and coastal areas, particularly in storm events. The erosion control and coast protection through the reduction of marine flow velocity however has only a short-term effect because the seaweed belt gets harvested and the erosion control is destroyed at the end. Especially if the conditions for seaweed regeneration are not ensured, the cut back of the seaweed can even result in an increase of erosion. Besides, seaweed cultivation can lead to a lower flow velocity resulting in an increased sedimentation. The reduction of waves and flow velocity can also have impacts on an IMTA system including oyster production. Being immobile, oysters highly require a sufficient intertidal water flow to filter nutrients out of the sea water. Again, an environmental impact assessment was regarded as urgently needed to bridge the knowledge gap. Besides, the carrying capacity of the local coastal environment should be considered in finding suitable sites for seaweed cultivation

Wild harvest or cultivation of seaweeds?

Wild seaweed resources are not sufficient to cover the demand, especially when seaweed is regarded to produce commodities such as energy. In Northwest Europe it is assumed that seaweed cultivation will not replace wild harvest but complement it in special applications. Wild harvesting is much cheaper than cultivation and some species like *Ascophyllum* are simply not cultivated because there is plenty of it naturally growing. In some regions of Europe such as Ireland, wild harvesting is a long-lasting job for fishermen providing an additional income. To ensure sustainable exploitation of the natural stocks, wild harvesting has to follow resource management rules such as it is the case in France. Due to more efficient boat use and harvesting devices, natural kelp production has increased during the last few

decades, but the limits of wild harvesting have already been reached and further seaweed production is only possible with cultivation systems.

Wild seaweed is susceptible against extreme weather conditions and the quality is varying due to the mix of species with different biomass composition. Wild harvest of seaweeds can be seen as a “self-regulated” system. In Ireland, mainly older people, who traditionally used wild harvested seaweeds as fertilizer, collect wild grown kelp and sell it to internationally operating food companies to increase their pension payment. Seaweed cultivation of specific species provides a steady product quality and is more stable towards storms and more reliable concerning yields. In addition, quality control can be carried out easily, the right time for harvesting can be chosen and harvesting can be standardized and mechanised. Besides, seaweed production can be adapted depending on the customer's needs and tailor-made products can be offered. In Northwest Europe the majority of the seaweed utilised is originating from wild harvest, thereof 25,000 t are from Ireland and 70,000 t from North West of France (Brittany). Only less than one percentage is produced in cultivation systems. Worldwide, 95% of the seaweed production arises from cultivation systems, mainly located in China. There is potential for expansion of the seaweed cultivation industry in Northwest Europe, not just in incorporating seaweed cultivation into existing aquaculture operations (IMTA), but also for larger-scale production in the future. In South Brittany, an offshore marine concession sizing 350 hectares located into a classified European "Natura 2000" Zone is projected to seaweed cultivation for the production of medicines, functional food and beauty products.

Is seaweed cultivation in competition to other users of the marine ecosystem?

There is the potential for conflict between seaweed cultivation and other marine users, largely associated with the potential for collisions and competition for space in the marine environment. Regarding the different stakes of business or private persons and of institutions, companies or NGOs, several areas of conflicts are arising. While the available information suggests that commercial activities result in relatively few marine accidents or fatalities, the potential for incidents (i.e. collisions with vessels and/or site infrastructure) and safety concerns remain. The perceptions of the stakeholders can drive or inhibit the development of seaweed cultivation and consequently influence possible competition. Generally, people who are traditionally used to harvest wild seaweeds support research activities around kelp cultivation. People who are not living at the coast are predominately open-minded towards seaweed cultivation, whereas people living close to the coastline are more concerned. Positive attitudes towards seaweed cultivation can be observed by scientists and people with an academic background or people with a “green” attitude or the objective to obtain a “green image”. However, it was pointed out that one should be aware of the industrial appearance of large scale seaweed farms.

Locals who are making their living with activities related to the sea fear that seaweed cultivation will be a new competitor for marine surface. Especially fishermen refuse the concept of seaweed cultivation. Bad experience and a paucity of information and knowledge are making people dubious about seaweeds. They fear allowing salmon and seaweed industries to live side by side could also see one farm contaminate the other. They also argue that efforts to prevent contamination could lead to increased use of chemicals and more pollution in the waters. Their refusing attitude can lead to the boycott of any approach to cultivate seaweeds, even at small scale or for research purposes. For example, up to 18 objections were lodged by residents against the development of a six-hectare size seaweed farm at Gearhies in the West Cork bay (Ireland). Some fishermen have the perception that compared to their business it's much easier for scientists to get licenses and build up a seaweed cultivation system because research activities are governmentally supported. Since the fishery sector has been suffering for a long time they feel neglected by policymakers. It seems completely understandable that fishermen distrust scientists and reject scientific facts like the potential increase of fish yield through newly established habitats in seaweed farms. However, evidence for fishermen to support seaweed cultivation

is missing because studies on fish population do not show unambiguous results, but uncertainties concerning the impacts of cultivated seaweed on wild and commercial fisheries.

Wind energy foundations of offshore wind parks, including the boulders that often encircle wind turbines for scour protection, are artificial reefs that may locally enhance wild seaweed production or provide fastening possibilities for seaweed farms. When attaching the longlines to the concrete piers the marine areal efficiency can be increased without competition to fishermen who are not being allowed to fish in that area. However, fasted longlines are neither foreseen in the statics of wind energy foundations nor in the insurance contracts of wind farm operators. Besides, the seaweed has to be cleared away within a day in case repair work at the wind turbine is necessary, Seaweed harvesting could get complicated by circumventing the platforms. Thus the co-location of seaweed farms with offshore wind parks seems to be not feasible at present.

The “cherished views” of the sea could be damaged by seaweed farms and that could harm marine recreation and have negative influence on touristic activities, just by the visual appearance – seaweed farms have to be marked with buoys – but also by possible restrictions on sea. Marine recreation forms a valuable and growing industry for Northwest Europe, with activities ranging from walking along coastal beaches to open-water activities. Any type of sports like bathing, kite and wind surfing, diving or sailing as well as coastal and marine wildlife tourism could pose risks to people, e.g. when buoys are overlooked, incidents can happen. At least during harvesting there should be a prohibition to pass the area, when longlines get lifted with a crane. With different people passing the area there can also be a risk for the seaweed farm, e.g. when boats are attached to the buoys, the longline structure can change, potentially leading to a biomass loss. Especially, when it comes to questions of responsibilities and insurance, particularly in commercial large scale production sites, there is no proceeding and regulation, yet. Extensive-scale developments may affect seascape as well as landscape along the coastline, and potentially the setting of coastal sites of historic importance. However, the significance of such impacts will depend on the nature and extent of the development and the sensitivity of the surrounding area as well as their distance from the coast. For example, the introduction of seaweed cultivation to an existing aquaculture site as part of IMTA may not significantly impact on landscape or seascape by itself.

Seaweed farms could also be placed in military occupation zones and nature reserves. In military zones however foreign activities are not allowed and access is very restricted. Whenever other economically feasible and licensed activities take place, like gravel mining, a potential conflict with seaweed cultivation can occur. Since suitable sites for seaweed are restricted, other uses of these limited areas drastically reduce the potential for (large scale) seaweed production. Therefore, other marine users and activities must be considered in the siting of seaweed farms and integrated concepts should be developed as a promising solution to reduce competition.

Employment in rural areas but low income jobs only?

Generally the seaweed business is mint by seasonal work. Therefore high flexibility of workers is required. Since the numbers of employment in the fishery sector are decreasing there might be the chance for former fishermen to get employed in the seaweed production, especially because they are very experienced with handling boats under different tidal phases and difficult weather conditions. Nevertheless, it was assumed, that mainly low qualification is needed for harvesting and consequently only low wages are paid. It was stated that it is unclear whether wages in the seaweed production would equal to those gained in the former fishery business. However, few high qualified jobs could be created when large scale seaweed farms are considered, e.g. for marketing and management to build up an industry which is commercially competitive. In a seaweed business case, processing steps have also to be taken into account which can contribute to create new jobs for specialists. After harvesting, the biomass should be processed fast to avoid any degradation. Efficient transport and just in time delivery

like in every business is crucial, leading to jobs in the logistics. From an economic perspective, for large scale biomass production it would be better to co-locate the processing and avoid long distance transport. The capacity of the seaweed production drives the decision for “in house” processing or outsourcing, either way connected with the development of low and high qualification jobs. Seaweed production occurs locally and the pre-processing (drying) to stabilize biomass is located close by. Companies from Japan, China or Vietnam buy wild harvested seaweeds to sell it on the Asian food market. The further the seaweed production is developed and established the more automated the production will be, which will again reduce the quantity of workers. Concerning the gender issue, it is remarkable that in seaweed production jobs are equally distributed though one could expect more male workers especially during harvesting. Still it should be mentioned that this observation applies for small scale facilities. However, in large scale production there could be the trend of employing fewer women, comparably to the labor market in agriculture but they might fill niche roles within a company or a specific production chain. In general phycology (related) jobs are balanced to women.

What are the perceptions of the use of non-native seaweeds?

The cultivation of seaweed has the potential to affect seaweed species, and therefore wider ecosystem biodiversity. The use of non-native species could result in weakening of the genetic integrity of local seaweed species or in a displacement of local seaweed species, with consequent effects on community structure and composition, e.g. through competition, displacement of wild seaweed stocks by cultivated species. There are non-native species which could be more productive than native ones if they were cultivated in Europe. These species are considered to be invasive and consequently they could have huge impacts on the natural ecosystem. Promoting the benefits of non-native species is regarded as a taboo. Apart from that, the EU legislation does not allow the introduction and cultivation of non-native species. An experience from the past, where *Caulerpa taxiflora*, an invasive seaweed species, conquering the naturally prevailing seagrass fields, was accidentally brought to the Mediterranean Sea and distributed uncontrolled, has led to a generally negative attitude towards non-native species. Moreover, the long-term impacts of new species are unknown. It was stated that the prevention of uncontrolled spread seems to be impossible. Regarding the exemplary species *Sargassum* from an economical point of view, it might be ambivalent: Keeping a stable size of the *Sargassum* farm is very time consuming and therefore cost intensive. Besides, if once introduced there's no chance to eradicate the neophyte again, but from a feedstock perspective there could be advantages for biofuel production. Nevertheless, there was consensus that the focus of research (especially on biofuels from seaweeds) should be on new yeast strains to improve the efficiency of sugar usage for bioethanol production, rather than on new seaweed species.