MacroFuels Project

FACTSHEET

The Environmental Impacts of Large-Scale Seaweed Cultivation

Findings and recommendations from the MacroFuels

Horizon 2020 research and innovation project

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European seaweed cultivation at large scale

Seaweed for fuels, feed, food and value added products is advancing in Europe. Complementing or substituting land-based crops with seaweeds – in particular for fuels and feed, calls for large-scale production[1]. Cultivation of seaweeds requires space at sea, but no land-use, no freshwater, no fertilizer and no pesticides. European North Atlantic waters are well suited for cultivation of large brown seaweeds (kelps).

Kelps can be seeded onto cultivation substrates, such as ropes or nets, and the kelp grows in the sea from autumn to early summer. Seaweed cultivation is a young technology in Europe, and the processes and materials involved are undergoing rapid development towards higher product yields and quality, and lower costs and impact. Deploying seaweed cultivation systems and cultivating seaweeds in the sea has impact on the local marine environment. Seaweed cultivation, if properly managed, can provide ecosystem services whilst developing marine resources currently underexploited throughout Europe.

Environmental impacts and risks

- ✓ Uptake of CO_2 – climate change mitigation
- ✓ Production of oxygen – counteracting ocean de-oxygenation
- ✓ Local increase of pH – counteracting ocean acidification
- ✓ Uptake of nutrients – counteracting eutrophication
- ✓ Increase of species diversity
- – Changing local patterns of currents and waves
- – Increased sedimentation of organic material
- – Reduction of light to the seafloor
- ✗ Risks of spreading of non-native/harmful species
- ✗ Emissions of other greenhouse gasses
- ✗ Loss of synthetic material

[1] Presently defined as more than 50 longlines of each 200 m (Marine Scotland, 2017).

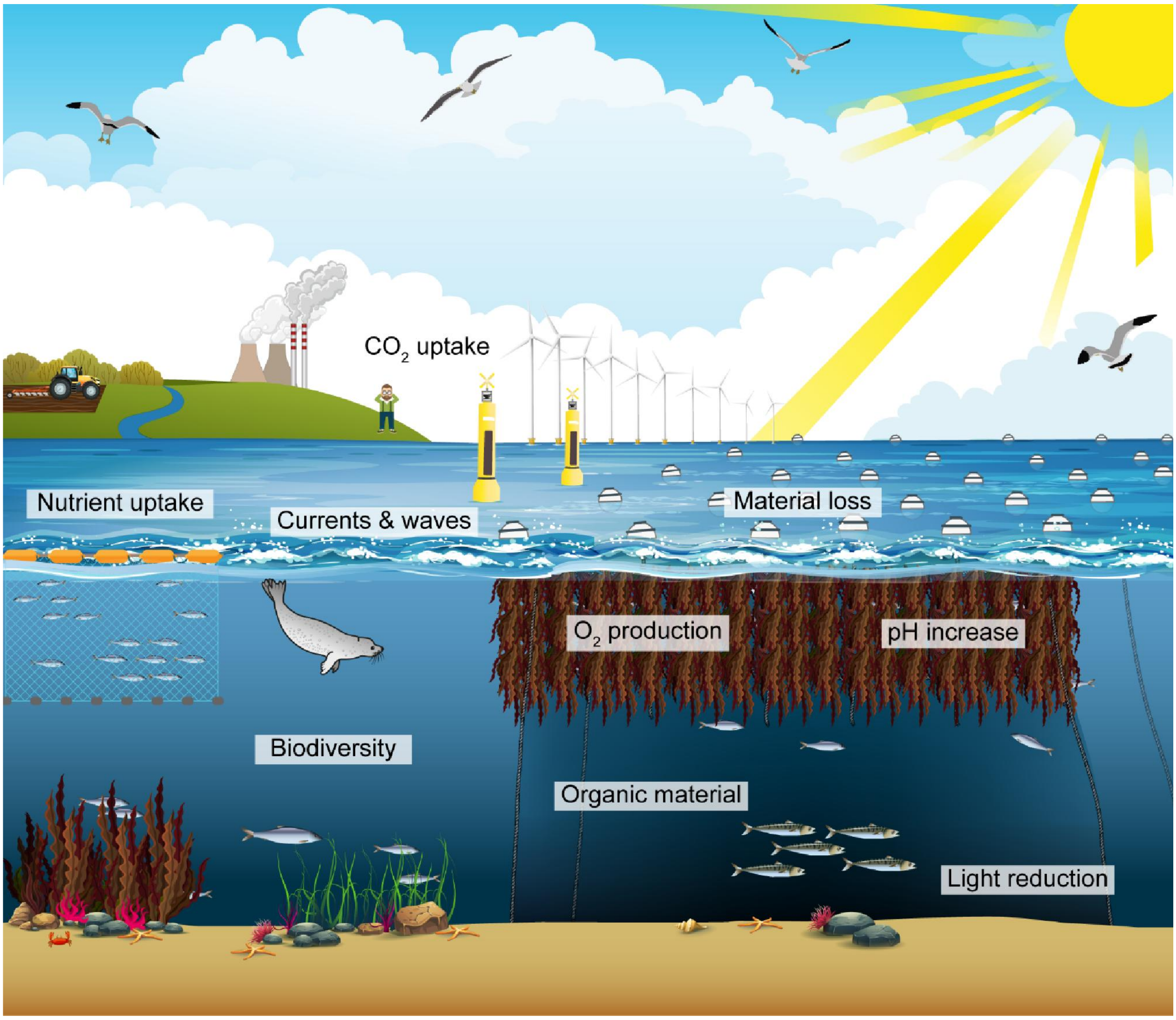

Fig 1. Environmental interactions of a large-scale seaweed farm

1. CO_2 uptake – climate change mitigation

Like plants on land, seaweeds live through photosynthesis, using sunlight to convert CO_2 into sugars. The most important beneficial consequences of the seaweed photosynthesis is the production of oxygen, which is needed by marine animals, and the local increase of sea water pH, which counteracts ocean acidification. Seaweeds also emit other climate gasses that can harm the environment. More research is needed to document the scale and consequences.

2. Nutrient uptake – counteracting eutrophication

In most European coastal waters, nutrient emissions from human activities on land and aquaculture lead to excessive growth of unwanted species and reduced marine environmental quality. Seaweeds need nutrients to grow, and efficiently take up nitrogen and phosphorus from the surrounding sea water. When harvesting the seaweeds, nutrients are removed from the marine system and made available for the food chain on land. In nutrient-poor marine areas however, competition for nutrients may limit seaweed productivity whilst having a negative impact on natural marine ecosystems. Site selection based on hydrological and ecological modeling is needed to select the best sites for growing seaweed and offer ecosystem services.

3. Biodiversity

Introducing a seaweed cultivation system into the marine environment will increase habitat complexity through the creation of many artificial habitats. The cultivation structure itself, as well as the seaweeds, will provide feed, shelter and substrate for marine organisms, increasing the local biodiversity. However, it is possible that some "unwanted" species – non-native species, diseases and parasites – may use the cultivation system to grow. Intensive cultivation of a seaweed mono-crop might contribute to spreading seaweed diseases and pests if not properly managed. It is recommended to cultivate native species and local genetic cultivars.

4. Reduction of light to the seafloor

A "hanging seaweed forest" in the surface waters will absorb a fraction of the incoming light, and hence reduce the input of light to the sea floor for natural populations of seagrass, seaweeds and microalgae living in the seafloor sediment. The impact will depend on the scale and density of the cultivation. Good site selection as well as placing cultivation areas beyond the depth limits of natural benthic vegetation will minimize negative impacts.

5. Loss of synthetic materials

Cultivation materials are typically produced from durable synthetic materials such as nylon and polypropylene. Loss of material is difficult to fully prevent, and may cause damage to maritime activities or to marine animals, due to entangling or consumption. Standards and regulations for site management, equal to other aquaculture activities, will minimize the risk.

6. Loss of organic material

During growth, the seaweeds will naturally lose organic material to the environment. This is likely to be minimal as biomass will be harvested before significant losses occur. Biomass lost will be recycled naturally through the local food web, and some may be buried in the seabed. If larger amounts of organic material are accumulated in depositional areas, local oxygen deficiency and impoverishment of the seafloor biodiversity may occur. Site selection and site management will contribute to minimizing risks of negative impact.

7. Local current and wave patterns

Seaweed cultivation structures will influence the local hydrology (current patterns and wave action). This may affect the water exchange inside the cultivation area, which changes the access of the seaweeds to nutrients, the local patterns of sediment transport, the coastline, as well as the structure and productivity of local marine food webs. Site selection based on hydrological modelling will contribute to minimizing risks of negative impact.

Environmental Risk Mitigation and Monitoring Needs

- ✓ Thresholds for acceptable change must be set in regulations for large-scale farms
- ✓ Site selection and site selection tools must be developed
- ✓ Best cultivation practice must be determined: education, standards for material selection, maintenance, timing of processes
- ✓ Take precautionary approach to cultivation of non-native species and non-local ecotypes

1. Definition of acceptable impact

Seaweed cultivation at large scale will alter many of the physical, biological, chemical characteristics of the environment. With proper site selection many of these changes can be considered positive. However, as with other types of aquaculture, there are risks of negative impacts. Authorities must define the thresholds for acceptable impact so as to ensure that the carrying capacities of the environments suitable for cultivation are not exceeded and natural resources are managed effectively.

2. Site selection

Impacts on the local marine environment of large-scale seaweed cultivation will depend on the local conditions of geology, hydrology and ecology. Development of systematic site selection tools based on hydrological and ecological modeling will be crucial to optimize production and promote positive changes and minimize negative changes.

3. Best cultivation practice

Standards and regulations need to be developed for a 'Best Cultivation Practice' for establishing and operating seaweed cultivation systems. Standards and regulations should include: Site selection, baseline surveys, selection of structure and materials, site management, monitoring practice, education.

4. Biosecurity

A large potential risk on the local marine environment is the spreading of non-native or harmful species such as seaweed diseases and pests to natural seaweed populations, or the introduction and spreading of genes from non-local cultivars that outperform local genes in the short run, but in the long run cause genetic depression and reduced fitness of local cultivars. Baseline knowledge of local species and genetic diversity needs to be established, including prevalence of non-native species, seaweed diseases and pests. Development of biosecurity programs including rapid diagnostic tools, and quarantine procedures must be included in future standards and regulations.

Knowledge gaps

- Environmental change dependency on site and scale
- Validated Marine Strategy Framework Directive indicators for assessing environmental status in cultivated seaweed systems, including biodiversity at the levels of ecosystems, species and genes
- Physical changes to coastal hydrography
- Local, regional and global changes to environmental chemistry, including seaweed emissions of greenhouse gasses
- Biosecurity planning for seaweed, i.e. seaweed diseases and pest – prevalence, diagnostic tools, quarantine procedures

Seaweed ecosystem services

- Climate change mitigation:
  - Cultivation and harvest of kelps
    - extracts 1.3 ton CO_2 per ton dry kelp produced
    - Increases local pH and counteracts ocean acidification
    - Produces and releases oxygen into the seawater

- Counteracting eutrophication:
  - Cultivation and harvest of kelps extracts 5-60 kg of nitrogen per ton dry kelp produced

If you have any further questions and for further discussions, please contact us at:

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