FACTSHEET

Algae cultivation results and quantification of positive ecological effects

Key findings from the ALGAEDEMO project

https://www.algaedemo.eu/

"AlgaeDemo is an EASME/EMFF funded project in the area of Sustainable Blue Economy. AlgaeDemo has demonstrated the carbon, nitrogen and phosphorous fixation potential of 7 ha scale seaweed farm in the Oosterschelde (NL),determining the environmental bioremediation capacity of such seaweed cultivation fields"

Background

Seaweed is primarily obtained through wild harvest in Europe but recently there is a strongly growing interest in cultivating seaweed in the European waters. The seaweed can be a renewable source for feed, food, cosmetics and a replacement for fossil sources. Growing it also takes up excess nutrients and hereby potentially serves as to improve the marine environment.

Excess nitrogen and phosphorous (nutrients/fertilisers) can negatively affect waterways. Seaweed can “capture” this excess phosphates and nitrates if cultivation areas are placed in suitable locations (e.g., near delta areas) and act as a natural barrier to avoid ocean eutrophication. When harvested, the nitrogen and phosphorous become part of the seaweed and are removed from the environment. This way, seaweed will absorb lost nutrients, washed out from agricultural and other human activities on land and transported to the ocean by the waterways. Furthermore, off-shore seaweed cultivation can positively affect fish populations because the cultivation areas can function as nurseries for smaller fish in areas restricted for ships and fishermen. Within the AlgaeDemo project, the remediation capabilities of a large-scale seaweed farm have been assessed.

This fact sheet outlines the main results regarding the seaweed yield and nutrient capture of one cultivation round with two winter species (*Saccharina latissima* and *Undaria pinnatifida, sugar kelp and wakame respectively)*. The seaweed composition (Carbon, Nitrogen, ashes, and metals) was determined to estimate the total remediation capacity. The biochemical composition (carbohydrates and amino acids) was determined as part of this assessment.

Cultivation at the Schelphoek site

The Oosterschelde water arm is well recognized for its shellfish farms. More recently, seaweed cultivation has been initiated. An area of 7 ha in the Schelphoek was selected to deploy the seaweed cultivation system (Figure 1). In total 30 km of ropes were placed in a 1D configuration (twine seeding), as it was proven to be the most effective in area’s of limited water depth. (2-3m at low tide). Local water samples were taken to determine the water quality. Water quality measurements (pH, conductivity, metal content, etc.) were performed at the TNO laboratories.

Figure 1 (Right) Geographical location of Schelphoek site (squared) in the southwest of the Netherlands and Wissenkerke location (circled). (Centered) Detailed view of the Schelphoek estuary via Google Earth. The red polygon indicates the area allocated for the farm. (Left) Farm configuration and system orientation.

An one-year cultivation round was conducted within AlgaeDemo project with two brown algae winter species: *Saccharina latissima* was cultivated during the winter time (November 2021 to May 2022), whereas *Undaria pinnatifida* was cultivated during winter and after harvesting with an additional seeding during the summer.

Once the seaweed was harvested, the seaweed composition was determined. The major components are the carbohydrate molecules, proteins and ash components. This data was collected for each species and combined with productivity data.

Cultivation results

Both winter seaweed species (*Undaria and Saccharina*) were harvested fresh on the 12th of May 2022 and freeze-dried within the day of collection. At temperatures higher than 18 °C, the growth rate of both kelps drastically stagnates and may even die. Thus the seaweed was harvested before the water reached 16°C. *Undaria* was re-seeded on the 5th of July of 2022 to grow within the summertime (July-October) to complete an one year cycle. The water reached temperatures above 20°C in July 2022, causing the complete loss of *Undaria* by contamination of other seaweed species (*Ulva lactuca*) and mussels (*Mytilus edulis*).

Table 1 lists the main parameters of the cultivation round: biomass yields and productivity after harvesting. *Saccharina* has double the productivity of *Undaria* per seeding line (2.27 and 1.28kg/m wet basis, respectively). The weighted biomass production was similar, but the *Undaria* cultivation seeding line was twice as large as the *Saccharina* line. *Saccharina* productivity rated similar ranges reported in the EU projects MacroFuels (1.5-2.5kg/m^2 dw) if five lines are set every one metre.

Table 1 Seaweed cultivation productivity results

	Saccharina	***Undaria***
Cultivation rope (km)	15	15
Seeding line (km)	15	30
Total production (t wet) (one round)	34	38.5
Moisture content (%)	83.4	85.4
Total production (t dry)	5.64	5.62
Productivity (kg (wet)/m of seeding lines)	2.27	1.28
Productivity (kg (dry)/m of seeding lines)	0.38	0.19

Nutrient capture results

The overall composition of the seaweeds is listed in Table 2, The phosphorous fixation capacity is lower for *Saccharina* than *Undaria* 0.16 and 0.23% dry basis, respectively. This means a phosphorous removal potential of 0.6 and 0.42 g/m (dry basis) for *Saccharina* and *Undaria.* Potassium is a very abundant element in seawater, and quantifying the seaweed capacity to fix such an element can give a potential use of the seaweed in soil enrichment. *Saccharina* and *Undaria* fixed about 5.6 and 4.3% dry matter basis, respectively.

Table 2 Seaweed main composition analysis in dry weight basis

	Carbon % dw	Potassium % dw	Oxygen % dw	Nitrogen % dw	Phosphorous % dw	Total ashes % dw
Undaria	33.3	4.3	33.7	3.2	0.23	29.9
Saccharina	32.6	5.6	38.4	3.6	0.16	27.1

The carbon remediation potential in dry weight basis is similar for both species; however, as the *Saccharina* productivity is twice as high as *Undaria*, the capacity of capture carbon per meter of seeded line is twice as much for *Saccharina*. The carbon removal potential in grams per meter of seeded line per harvest is 125 and 63 for *Saccharina* and *Undaria*, respectively, see Table 3.

The nitrogen fixation capacity is 3.6 and 3.2% dry basis for *Saccharina* and *Undaria*, respectively. This means a nitrogen removal potential of 14 and 6 g per meter of seeded line per harvest for *Saccharina* and *Undaria*, respectively, see Table 3.

Table 3 Seaweed C, N, P and K remediation potential in gram per meter of seeding lines

	Saccharina	***Undaria***
CRP (carbon removal potential) (g/m)	124.71	63.33
NRP (nitrogen removal potential) (g/m)	13.86	5.89
PRP (Phosphorous removal potential) (g/m)	0.59	0.42
KRP (Potassium removal potential) (g/m)	20.15	8.19

The nutrient uptake from the sea is fixed in the form of carbohydrates, proteins (amino acids), ashes, etc. For instance, *Saccharina* total carbohydrates are 48.4%, while *Undaria* reached 43% of the total seaweed dry weight. Detailed analysis results can be found in the Phyllis database. The total amino acid composition reaches up to 2.72 and 3.83 wt% dry matter basis for *Saccharina* and *Undaria*, respectively

Conclusion and recommendations

Within AlgaeDemo project, it has been proven that seaweed captured important nutrients and thereby counteracts eutrophication. – The composition of the cultivated species within one cultivation round were similar regarding nitrogen and carbon composition 3% (wt, dry) and 33% (wt, dry), respectively. *Undaria* contains 0.23% phosphorous while *Saccharina* contains 0.16% of the total dry mass.

One round of seaweed cultivation sequestered 3,700 kg of carbon for the combined *Saccharina* and *Undaria*, which is equivalent to capturing 13.7 tonnes of CO_2 for this cultivation round. The total eutrophication remediation of one cultivation round of *Saccharina* was 208 and 8.8 kg for nitrogen and phosphorous, respectively. The *Undaria* eutrophication remediation potential was 176 kg for nitrogen and 12.7 kg for phosphorus.

The method of combining seaweed composition analysis with measuring the productivity of the cultivation is a good method for estimating the local nutrient remediation capacity. For more detailed information on dynamic effects, detailed modelling is required. For year-to-year variations which are inherent to seaweed cultivation, long-term measurements are advised.

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If you have any further questions and for further discussions, please contact via the contact form at

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