Nutrient compensation as management tool– Sugar kelp production in sustainable aquaculture

Integrated multi-trophic aquaculture (IMTA) is theoretically a sustainable production form, which minimizes waste products from e.g. fish farms, by the co-production of bivalves or/and seaweed. For the Danish fish farmers the extractive organisms could be the solution for increasing fish production, but do the principles of IMTA fully mitigate the nutrient impact from open net-pen fish production at realistic production scales?

In this project, commercial scale cultivation of sugar kelp (Saccharina latissima) was investigated with regard to operation, yield, biofilter capacity and mapping the biomass composition for one year incl. protein content, amino acid profiles, lipids and fatty acid composition, minerals and vitamins. Results were obtained from an IMTA site and compared to a reference site with no impact from the fish (175 t year−1) and mussel farm, both located just outside Horsens Fjord, Denmark. The nitrogen content in sugar kelp varied between 0.5-3.7% of dw with the highest concentration in September 2013 with an estimated maximum yield of 5.1-7.1 tons ww ha−1 year−1. Potentially, a cultivation area of 204-340 ha would be needed to achieve 100% N recovery, based on the tonnage of the specific fish farm. The harvest contained protein (10%), lipids (3%)
and vitamin A (34 mg/kg per dw), however with large seasonal variations. Sugar kelp increased the biodiversity by functioning as hanging reefs, but did not significantly affect the sediment by shading (5% in a scenario of 5 kg/meter dropper rope). During the project a number of improvements of the existing techniques for producing seaweed on suspended line systems were developed, however, further optimization of techniques for deployment, production as well as harvest is needed. This would also allow sugar kelp production as a viable and robust mitigation tool for nitrogen removal and hopefully allow for future expansion of sustainable marine fish production in Denmark.

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Authors: Schmedes, P. S. (Intern), Boderskov, T. (Forskerdatabase), Silva Marinho, G. (Intern), Holdt, S. L. (Intern)
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The effect of light and nutrient availability on growth, nitrogen, and pigment contents of Saccharina latissima (Phaeophyceae) grown in outdoor tanks, under natural variation of sunlight and temperature, during autumn and early winter in Denmark

Late summer harvest of cultivated Saccharina latissima, prior to seasonally determined negative length growth, is considered advantageous in North Atlantic waters to optimize biomass yields. We hypothesized that seasonal increase in tissue protein and pigments over autumn and early winter would counterbalance the loss of biomass, and increase the absolute harvestable amount of protein and pigments. The hypothesis was tested in a land-based, factorial-designed, pilot-scale experiment using whole algae individuals exposed to naturally relevant high or low availability of nutrients and light. The experiment was conducted during fall/early winter in Grenaa, Denmark, in outdoor tanks, exposed to ambient light and temperature variations. With high nutrient availability, the absolute harvestable amounts of nitrogen, fucoxanthin, and chlorophyll a increased by 50.1–60.1, 21.7–53.7, and 47.0–73.5 %, respectively, despite a loss of biomass of 16.2–18.7 %. Under low nutrient availability, there was a net loss of biomass (8.1–9.5 %), tissue nitrogen (10.7–44.1 %), and fucoxanthin (7.1–17.2 %), and a minor increase in chlorophyll a (2.5–22.8 %). Nutrient availability had a significant negative impact on the biomass growth, but a positive control on the tissue concentration of nitrogen, chlorophyll a, and fucoxanthin. Our results, from a land-based experiment, indicate that early winter harvest of S. latissima biomass grown under high nutrient availability in Denmark, fulfills a higher degree of nutrient bioremediation, and has an improved biomass quality in regards of increased concentrations of pigments and nitrogen rich compounds.

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The extraction of nutrients from a Danish fish farm (oncorhynchus mykiss) by mussels (mytilus edulis) and sugar kelp (laminaria saccharina): integrated multi-trophic aquaculture

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The overall goal of Tang.nu is to change the flow of nutrient from land to sea from a linear flow where excess nutrients are lost and causes problems with eutrophication, to a circular flow where cultivation and harvest of seaweed will contribute to recapture the nutrients and put them back into the bio-economical system on land.

Seaweed is a valuable resource presently used e.g. in production of food and feed products. Tang.nu will increase the pull and push mechanisms in the seaweed value chain. This will be done by supporting producers (public, commercial, private), and buyers (businesses (feed and food), agriculture, aquaculture, citizens) – partly by documenting the value of seaweed as a bioactive feed additive, and partly by gathering existing knowledge about seaweed legislation and composition and make it publicly assessable.
All part components of the project will be put together in an analysis and a documentation of seaweed cultivation and harvest as a tool to recirculate nutrients from the sea and back on land as a mean of a future sustainable use of bio-resources.

Tang.nu will deliver essential results for future legislation concerning food and feed safety and marine management and will furthermore add to groundwork for the establishment of a balanced and sustainable management of production systems at sea and on land.

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National Food Institute
National Institute of Aquatic Resources
Danish Shellfish Centre
Aarhus University
Roskilde University
Kattegatcentret
Teknologisk Institut
Fødevarestyrelsen
SEGES, Danish Agriculture & Food Council,
Økologisk landsforening
Seaweed Societe
Multidyk
Nordisk Tang
Bisserup Havbrug
Havhaverne i Ebeltoft Vig

Fjordgaverne
Period: 01/04/2017 → 31/12/2020
Number of participants: 2
Research area: Shellfish and seaweed: Biology, production and management
Phd Student:
Schmedes, Peter Søndergaard (Intern)
Project Manager, academic:
Nielsen, Mette Møller (Intern)

Investigations of hatchery techniques and cultivation systems for cost-effective production of valuable seaweeds

National Institute of Aquatic Resources
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Phd Student:
Schmedes, Peter Søndergaard (Intern)
Supervisor:
Nielsen, Mette Møller (Intern)
Canal-Vergés, Paula (Intern)
Main Supervisor:
Petersen, Jens Kjerulf (Intern)

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