# Compensation for Nitrogen and Phosphorous Release from Baltic Mariculture by Nodularia spumigena Harvest During Summer Blooms - A Possible Path towards Sustainable Aquaculture


**Abstract**

An alternative technology for removal of nutrients released from mariculture is here suggested. Harvest of cyanobacteria Nodularia spumigena during summer blooms may compensate for release of N and P from mariculture or other sources. Not only content of N in the cyanobacteria but also prevention of N fixation will contribute to nutrient removal from the sea. The harvested product may be used for biogas production, biofuel or agricultural fertilizers.



**Keywords:** Baltic sea; Mariculture; Nutrient release; Compensation; Cyanobacteria; Harvest



Opinion

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## Background

Aquaculture is expanding globally and reached a total output in 2010 of 60 Mio tonnes [1]. Norwegian, Chilean, Canadian, Tasmanian, Scottish, Irish, Icelandic and Faroese culture of Atlantic salmon alone reached more than 2 Mio tonnes [1] mainly by use of net pen systems in marine areas. This technology is connected with release of organic material (BOD), nitrogen and phosphorous directly to the habitat [2] which may reach 47kg N and 6kg P from the production of 1 tonnes of maricultured rainbow trout (Environmental agency, Danish Ministry of Environment). Concern about release of these nutrients into environmentally vulnerable areas is currently hampering expansion of production and sustainable solutions should be implemented.

## Sustainable Solutions

Land-based mariculture, using recirculation of sea water by continuous cleaning and filtering, has been suggested as a possible way of rearing salmonids with a minimal environmental impact. However, the questionable profitability due to high investment and rearing costs seems to limit investment within this branch [3]. Another option to obtain a sustainable mariculture production in a certain habitat may be the use of compensation rearing of blue mussels and macroalgae [2] which may prove economically feasible. Both blue mussels and macroalgae can obtain a market value which may inspire the fish farmer to reduce N and P output by use of these systems. It has been estimated that a harvest of 3.82 tonnes blue mussel or 10 tonnes sea weed such as *Laminaria* spp corresponds a nitrogen removal equaling the release from 1 tonnes rainbow trout produced.

## Alternatives for the Baltic

Certain marine areas do not support a profitable production of blue mussels and *Laminaria* spp. The Baltic Sea is a brackish semi-enclosed sea located between Denmark, Sweden, Finland, Russia, Baltic republics (Estonia, Latvia and Lithuania), Poland and Germany which merely allows a poor growth of thin-shelled blue mussels and dwarf forms of *Laminaria* spp with no commercial value. Therefore, compensation rearing of these organisms is not an economically viable option for removing N and P released from the fish production. Other solutions may none-the-less be available in this particular marine habitat. It is therefore here suggested that extensive harvest of naturally occurring cyanobacteria may be a way to compensate for release of nutrients from fish farms or water restoration in general in the Baltic Sea. The cyanobacteria *Nodularia spumigena,* occasionally in association a few other cyanobacteria such as *Aphanizomenon flos-aquae,* is producing extensive blooms during summer time throughout the Baltic. This nitrogen fixating organism is a naturally occurring organism but it contributes with high amounts of organic material, nitrogen and phosphorous to the Baltic [4]. Their ability to take up dissolved atmospheric $N_2$ which is then incorporated into organic N has been estimated by various authors during summer blooms to be 0.03-1.85 µmol $N_2$/l/h [5]. This amounts to 0.8-23.8mg N/h corresponding to 0.571g N/l/24 h or 14g/l/month. The C, N and P contents of *N. spumigena* dry weight are 43, 8 and 0.6%, respectively [6] but in order to estimate the full benefit from harvest of these cyanobacteria their capacity to fix nitrogen should be taken into account and added to the N directly removed in filtering. Cyanobacteria and thereby their content of N is generally considered to be of lower value to the ecosystem [7]. *N. spumigena* is toxic to zooplankton [8] due to its content of the toxin nodularin [9] and may contribute to oxygen depletion of the sediment during mineralization. Residents along the shores of the Baltic may recognize these cyanobacteria during periods for one to four months during summer time (June to September) but the major high density blooms last from a few days and up to 23 days as monitored by the Swedish Meteorological and Hydrological Institute [6].

## Technology

Technology for harvest of *N. spumigena* is available. The considerable size of the organism allows a satisfactory harvest by using standard phytoplankton nets with mesh sizes of 0.5mm. However, if applied in large scale more powerful devices with higher capacities are needed. Gröndahl et al. [10] developed a 25m long oil boom equipped with a skirt of fabric for harvest of cyanobacteria primarily located in the upper 1m of the water column. It could be dragged between two vessels at low speed (2 knot). Further assessment showed that the boom could harvest between 2.7-730kg dry weights per h. This corresponds to removal of up to 59kg N and 4.4kg P per hour by this particular equipment. By catching these organisms they are prevented from N-fixation during the next weeks. So when the nitrogen fixating capacity is calculated and then added for periods of 7-28 days the actual nitrogen removal from the Baltic may be several times higher. Accordingly, if nitrogen release from the production of 1 tonnes rainbow trout in the Baltic should be compensated by harvest of *N. spumigena* it would be necessary to use the oil boom device for 1-2h dependent on concentrations of cyanobacteria.

## Green Energy Production

Harvested cyanobacteria can be composted but it is possible to use it for green energy production. The suitability of the harvested cyanobacteria for biogas production has been documented previously [6] and the lipids in the harvest may be used as biofuel [11].

## Implementing the System

When setting up sustainable mariculture solutions in the Baltic Sea it can be suggested that fish farmers, as part of the license agreement, must be made responsible for removal of 47kg N and 6kg P in *N. spumigena* for each ton of fish produced. Mariculture companies may then, as a part of their budgets, include expenses to cover capture devices including plankton nets, fishing vessels for cyanobacterial capture, systems for transport between harbour and a relevant biogas fermentor plant. Local authorities may generally be interested in removal of these toxic cyanobacteria and private/public joint ventures may be established to fulfill these objectives.

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