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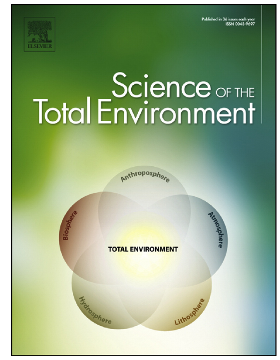

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PII: S0048-9697(20)32182-3

DOI: https://doi.org/10.1016/j.scitotenv.2020.138665

Reference: STOTEN 138665

To appear in: *Science of the Total Environment*

Received date: 29 January 2020

Revised date: 5 March 2020

Accepted date: 10 April 2020

Please cite this article as: S.A. Wikström, N. Hedberg, N. Kautsky, et al., Letter to editor regarding Kotta et al. 2020: Cleaning up seas using blue growth initiatives: Mussel farming for eutrophication control in the Baltic Sea, *Science of the Total Environment* (2020), https://doi.org/10.1016/j.scitotenv.2020.138665

Letter to editor regarding Kotta et al. 2020: Cleaning up seas using blue growth initiatives: Mussel farming for eutrophication control in the Baltic Sea

Sofia A. Wikström[1*], Nils Hedberg[1], Nils Kautsky[2], Linda Kumblad[1], Eva Ehrnsten[1], Bo Gustafsson[1,3], Christoph Humborg[1], Alf Norkko[1,3] and Johanna Stadmark[4]

[1] Baltic Sea Centre, Stockholm University, 106 91 Stockholm, Sweden

[2] Dept. of Ecology, Environment and Plant Science, Stockholm University, 106 91 Stockholm, Sweden

[3] Tvärminne Zoological Station, University of Helsinki, 10900 Hanko, Finland

[4] Dept. of Geology, Lund University, 223 62 Lund, Sweden,

*Corresponding author; sofia.wikstrom@su.se

Keywords: mussel farming, eutrophication, Baltic Sea

In their recent article, Kotta et al. (2020) argue that mussel farming is a viable measure to address the extensive eutrophication of the Baltic Sea and that establishing 900 km^2 of mussel farms in the Baltic proper would be a realistic way to reach the target for reduced nutrient emissions in the Helcom Baltic Sea Action Plan (BSAP). The article provides valuable data on mussel farm yields and costs for nutrient removal in the strong salinity gradient of the Baltic Sea, showing to what extent the slow growth rate in the central and inner Baltic Sea results in lower farming yield and nutrient uptake capacity compared to a more optimal farming environment. However, as shown below, we find the estimated potential for nutrient uptake at the Baltic Sea scale grossly overestimated and poorly supported by empirical data.

According to Kotta et al. (2020), the reduction of nutrient emissions needed to reach the environmental target for the Baltic proper is 75,069 tons nitrogen (N) and 9,521 tons phosphorus (P) per year. Using the nutrient concentrations in mussels from the Baltic proper provided by Kotta et al. (2020), i.e. 0.7 % N and 0.065 % P per ton wet weight, this would require harvesting 14.6 million tons of mussels from the Baltic proper each year. According to their calculations, this harvest could be obtained from only 900 km^2 mussel farms, which would require a yearly yield of 163 tons ha^{-1}.

It is not clear from the paper how this harvest potential was derived. The study reports a production of 82 tons of mussels in about 2 years on 4 ha in the trial farm in the Baltic proper, which corresponds to a yearly yield of about 10 tons ha^{-1}. Based on the reported yield data for the Baltic proper from their growth model (1-3 kg m^{-1} long line over a two year harvest cycle), a harvest of 163 tons $year^{-1}$ would require a farming density of 110-330 km long lines per ha. This can be compared with a long line density of 6-22 km ha^{-1} in the trial farms. Using the maximum modelled yield (1.5 kg m^{-1} y^{-1}) and the maximum density in the trial farms (22 km ha^{-1}), the yearly yield would still not be more than 33 tons ha^{-1}. We do not know if there is a mistake in the calculations or if the authors assume that it is possible to achieve a mean yield of 163 tons ha^{-1} y^{-1} over extensive farming areas (about 16 times more than observed in the trial farm). In the latter case, we think it should be clarified that this is only an assumption until it has been shown to be possible in practice.

We would also like to stress that such increase in farming density comes with the risk of increased environmental impact (e.g. Burkholder and Shumway 2011). Kotta et al. (2020) report that the present short term, very small-scale farming in the Baltic Sea have not led to oxygen deficiency below the farms. However, this tells us very little about what will be the environmental impacts of larger and denser farms run for many years. We anticipate that an increase in the yearly yield from 10-33 to >160 tons ha^{-1} would require at least five times denser farms, which would lead to at least five times larger deposition rates of organic matter. Higher deposition rates increase the risk for oxygen deficiency and increased nutrient regeneration from the seabed, which have been documented from intensive mussel farms in other parts of the world (e.g. Burkholder and Shumway 2011; Stadmark and Conley 2011). The potential risk for increased environmental impacts such as oxygen depletion and changed nutrient cycling definitely need to be addressed when considering farming at the scales suggested.

Further, the paper does not discuss the technical aspects of harvest and handling of >14 M tons of mussels each year. If spread across the year, it would require that 40,000 tons (1000 truckloads) are harvested per day, transported to land and put to use. There is currently no market for Baltic Sea blue mussels (which are undersized for use as human food due to the low salinity) and more research and development is needed before these amounts of mussels can be used in a meaningful way, for instance as replacement for fish meal in animal feed.

In conclusion, although Kotta et al. (2020) show that small-scale, extensive blue mussel farming can capture some nutrients from the Baltic Sea, they do not show that the Helcom nutrient reduction targets could realistically be met by mussel farming as they state in the "highlights" of the article. The paper fails to address a number of important questions that are central for the feasibility and sustainability of large-scale mussel farming as an internal measure for eutrophication control, including the risk for food depletion and environmental effects in large and dense farms and technical aspects such as the use of the mussels. We think the discussion on mussel farming as an environmental measure would gain from a more realistic assessment of the nutrient uptake potential and careful consideration of the potential ecosystem effects when scaling up from small-scale farming trials.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: