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SPATIAL MODELLING OF BLUE MUSSEL FARM PRODUCTION POTENTIAL IN THE WESTERN BALTIC SEA

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Introduction

Eutrophication of coastal water bodies by massive anthropogenic nutrient inputs is a serious global challenge. Suspended mitigation cultures of blue mussels have been suggested as a tool to remove nutrients through harvesting from eutrophic systems like the Western Baltic Sea (Petersen et al. 2014). The general idea of mitigation mussel farming is that the mussels remove nutrients contained in particles (mainly phytoplankton) directly from the water through their feeding activity and incorporate them into animal tissue during growth. Site-selection for marine mitigation aquaculture can be an important part of sustainable marine spatial planning considering both farm production, as well as environmental and socio-economic goals and interests. In the present study, mussel farm production potential was estimated for the Western Baltic Sea, which can provide input to a multi-criteria site selection tool in relation to marine spatial planning.

Materials and methods

We integrated data from field experiments and national monitoring programs within a sequence of numerical, statistical, and spatial models. Mussel individual growth was estimated by a dynamic Energy Budget (DEB) model (Maar et al. 2015) calibrated against observations from mussel long-lines and the environmental conditions. The DEB model was then applied to 59 monitoring sites with sufficient data and the results were used to make a more simple statistical model of mussel growth versus monthly data of temperature, salinity and chlorophyll-a (Chl *a*) concentrations. A spatial model estimated long-term (2008-2017) monthly means of environmental variables on 1km^2 scale based on monitoring data from Denmark, Sweden and Germany. The statistical growth model was imposed on the spatial environmental data and up-scaled to farm production taking bathymetry (depth of farm) and mussel densities within a standard farm into account.

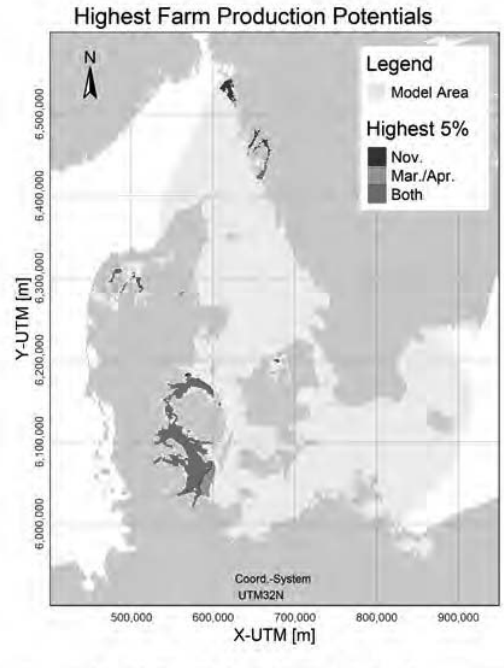

Fig. 1. Spatial model results of 5% highest farm production potentials in the W Baltic Sea indicated for harvest in November, March/April or both periods.

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Results and Discussion

We investigated model results for two growth seasons both starting in July and with harvest times in November or March/April. The modelled (long-term average) maximum biomass of individual mussels was 0.76g-DW and 1.7g-DW at harvest in November and March/April, respectively. Similarly, corresponding maximum farm production potential was 201t-DW and 302t-DW per standard farm. Water depths <4m was defined unsuitable for mussel farms. The smaller increase of maximum farm harvest compared to biomass of individual mussels is attributed to a functional decrease of mussel density on farm collector substrate with increasing mussel size. When selecting the 5% of sites with highest farm production potentials at harvest in November (163-201t-DW), Limfjord, Mariager Fjord, Isefjord, the whole area from the little Belt south to the Kieler Förde, and the north-west coast of Sweden are part of the selection (Fig. 1). The same selection at harvest in March/April (242-302t-DW) results in similar areas, except for the Isefjord. The impacts of different environmental variables on local farm harvest potentials are both of spatial and temporal nature. The typical temperature pattern is a major driver of seasonal dynamics of modelled mussel growth. Salinity expresses two major gradients: (1) There is a large-scale decrease of salinity from the Skagerrak area into the Western Baltic Sea; (2) numerous of the inner fjords show lower salinities. In our model, growth limitation by low salinity plays a major role south-east of the Danish islands Zealand, Falster, and Lolland between April and November. Chl-*a* expresses a strong seasonal pattern with a major peak in March, however, strong spatial heterogeneity is also observed throughout the year. Higher Chl-*a* concentrations are typically met within fjords and in near-coastal areas and especially along the northeast-coast of Germany. Low Chl-*a* concentrations limits mussel growth mainly in the open waters, as well as in the Sound and around the south-coast of Sweden. For the whole study area, water quality affects the growth of individual mussels in the following order of impact: salinity > Chl-*a* > temperature. Effects of bathymetry are super-imposed on the resulting growth of individual mussels, while upscaling to farm production potential. Within the applied spatial model, bathymetry limits the depth extent of mussel mitigation farms; therefore, shallow areas with depths <10m generally result in less farm production potential.

Conclusion and Outlook

Production potentials of mussel mitigation farms have been spatially modelled by integrating different modelling approaches. Results show that there are areas with likely good performance of this mitigation concept in the coastal waters of all three countries involved. In further steps, the results will be (1) validated against available independent mussel growth data from the study area, (2) evaluated with regard to model uncertainty and expected variability of mussel growth, and (3) overlayed with available spatial datasets relevant for marine spatial planning. Finally, a multi-criteria tool for optimal site selection of mussel farming will be developed to support sustainable marine spatial planning in the Western Baltic Sea.

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