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The impact of a mussel farm on water transparency in the Kiel Fjord

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ABSTRACT

Mussel farming is a highly discussed opportunity for inner coastal management measures to counteract the eutrophication of the Baltic Sea. There is currently a lack of detailed feasibility analyses for mussel aquaculture in German coastal waters. In 2010, a blue mussel (*Mytilus edulis*) farm began operating in the Kiel Fjord. In this study, we present an analysis combining measurements from this farm with a 3D-circulation and ecosystem model. We show that the mussel farm in the Kiel Fjord is incapable of producing harvests as large as farms in Swedish coastal waters. We assess and formulate the impact of the mussel farm on water transparency and calculate the attenuation coefficient and the Secchi depth from model data. Although water quality improvements are low due to the size of the farm, our results show that the area of increased water transparency is not limited to the farm area and even reaches the shoreline. We also examine the economic feasibility of the mussel farm and calculate the size of farm area, necessary to remove 10% of the riverine nutrient loads into the Kiel Fjord. We conclude that mussel farming can be a suitable supporting measure to improve water quality by removing nutrients and increasing water transparency in Kiel Fjord.

1. Introduction

According to the Baltic Sea Action Plan (HELCOM 2007), eutrophication remains a major problem in the Baltic Sea. Eutrophication is caused by excessive inputs of the nutrients phosphorus (P) and nitrogen (N), of which over 90% (P) and 70% (N) enter the Baltic Sea via rivers (HELCOM 2005). Therefore, coastal waters are most severely affected by eutrophication. During recent years, it has become obvious that improving river basin management within the bounds of cost-effectiveness will have only a limited effect on nutrient loads (Schernewski et al., 2008). In some areas, it will not be sufficient to ensure a good water quality in coastal waters according to the EU Water Framework Directive (WFD). Therefore, a more comprehensive management is required, such as introducing nutrient removal measures to coastal waters. Mussel cultivation is widely seen as an efficient solution for controlling nutrient concentrations in coastal waters (Lindahl et al., 2005) and is assumed to be the most promising measure for southern Baltic coastal waters as well (Schories et al., 2004; Stybel et al., 2009). For example, on the Swedish west coast roughly 140–180 tons of Blue mussels (*Mytilus edulis*) were produced in suspended cultures for 12–18 months, removing 1.4–1.8 t of N and 80–100 kg of P (Lindahl et al., 2005). Mussel farming has the additional benefit of increasing water transparency, promoting the growth of macrophytes, whose presence is a positive water quality indicator in the WFD. Furthermore, blue mussels are suitable for human consumption and can be used as feed in agricultural processes like husbandry and fish aquaculture (Jakobsen and Hermansen, 2001; Waldenstedt and Jönsson, 2006; Jönsson and Elwinger, 2009).

In the Baltic Sea, blue mussel growth is constrained by several factors, such as low salinity, low winter temperatures, and fluctuations in the food availability, all of which can reduce the mussel's maximum size (Kautsky, 1982; Westerbom et al., 2002). The Baltic Region also largely lacks experience and tradition in mussel cultivation, processing, and consumption.

In the Kiel Fjord (Kieler Förde) in the south-western Baltic Sea, a small experimental blue mussel farm has been established in 2010.

Our objectives are: a) to show the effects of the mussel farm on water transparency; b) to present, calibrate, validate, and apply a model for the growing season; c) to calculate the mussel production and nutrient removal potential; and d) to critically assess the

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possibilities and limits of mussel farming in Kiel Fjord from an economic and a water quality management perspective. For this purpose, we created a monitoring programme to measure the farm's effects on the water body. Additionally, we spatially refined the 3D-flow and ecosystem model of the Baltic Sea (ERGOM-MOM) and added a mussel variable in order to enable simulating various future scenarios.

2. Study site and methods

2.1. Study site

The research area for this study is the Kiel Fjord, located in the south-western Baltic Sea (Fig. 1). The Kiel Fjord is a mesohaline inner coastal water body with salinities ranging from 2.6 to

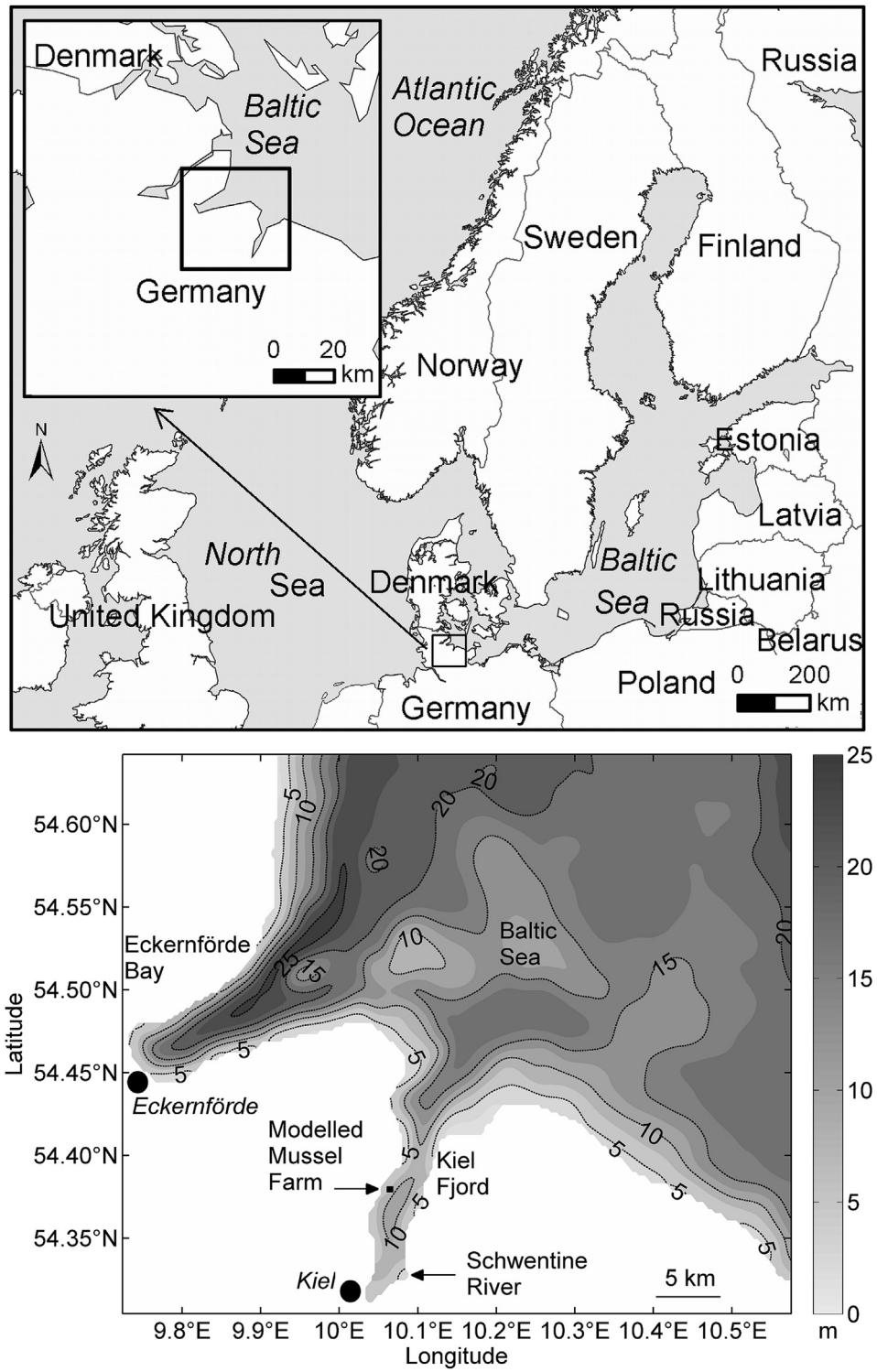

Fig. 1. Upper Figure: North-western Europe and location of the Kiel Fjord in the Western Baltic Sea. Lower Figure: Topography of model from Kiel Fjord and location of mussel farm.