

Processes regulating pCO<sub>2</sub>  
in the surface waters  
of the central eastern  
Gotland Sea: a model  
study\*

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**KEYWORDS**

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**Abstract**

This work presents a one-dimensional simulation of the seasonal changes in CO<sub>2</sub> partial pressure (pCO<sub>2</sub>). The results of the model were constrained using data from observations, which improved the model's ability to estimate nitrogen fixation in the central Baltic Sea and allowed the impact of nitrogen fixation on the ecological state of the Baltic Sea to be studied. The model used here is the public

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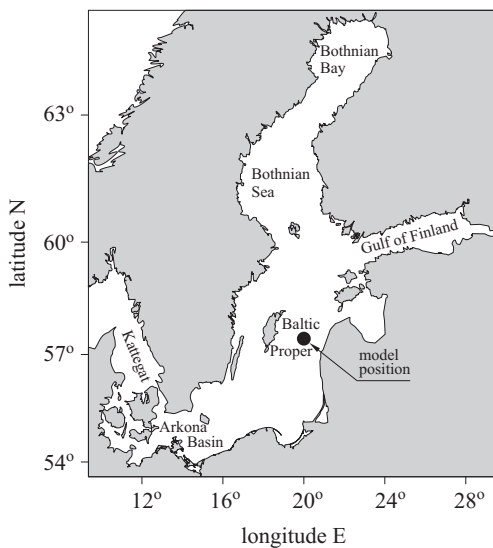
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domain water-column model GOTM (General Ocean Turbulence Model), which in this study was coupled with a modified Baltic Sea ecosystem model, ERGOM (The Baltic Sea Research Institute's ecosystem model). To estimate nitrogen fixation rates in the Gotland Sea, the ERGOM model was modified by including an additional cyanobacteria group able to fix nitrogen from March to June. Furthermore, the model was extended by a simple  $\text{CO}_2$  cycle. Variable C:P and N:P ratios, controlled by phosphate concentrations in ambient water, were used to represent cyanobacteria, detritus and sediment detritus. This approach improved the model's ability to reproduce sea-surface phosphate and  $\text{pCO}_2$  dynamics. The resulting nitrogen fixation rates in 2005 for the two simulations, with and without the additional cyanobacteria group, were  $259$  and  $278 \text{ mmol N m}^{-2} \text{ year}^{-1}$  respectively.

## 1. Introduction

The Baltic Sea is a small sea on a global scale, but at the same time one of the largest bodies of brackish water in the world. With an average depth of  $53 \text{ m}$ , it contains  $21\,547 \text{ km}^3$  of water, and every year rivers contribute  $2\%$  to this volume (HELCOM 2003). The narrow and shallow Danish Straits (Kattegat region, Figure 1) connect the Baltic Sea with the North Sea and limit the exchange of water between the Baltic Sea and the world's oceans. Because of this strongly limited water exchange with the North Sea, the residence time of Baltic Sea waters can be as long as several decades (BACC Author Team 2008). Surface salinity varies from  $20 \text{ PSU}$  in the Kattegat



**Figure 1.** The Baltic Sea. The area of the model is indicated by a black dot (the deepest area of the eastern Gotland Sea)

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