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Impact of cable bacteria on biogeochemical cycling in sediments of a seasonally hypoxic marine basin

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1. Cable bacteria

The impact of cable bacteria on sediment biogeochemical processes was studied at 3 sites along a water depth gradient in a seasonally hypoxic marine basin (Lake Grevelingen, the Netherlands; Fig. 1) in 2012 [1-5] within a collaborative project of NIOZ and Utrecht University.

Low oxygen in bottom waters in summer is a recurring phenomenon in the lake (Fig. 1 and 2). The hypoxia is most pronounced at the deepest site 1 (Fig. 1).

Cable bacteria were present in Lake Grevelingen sediments in spring of 2012, while *Beggiatoaceae* were abundant in fall (Fig. 2) [1,2].

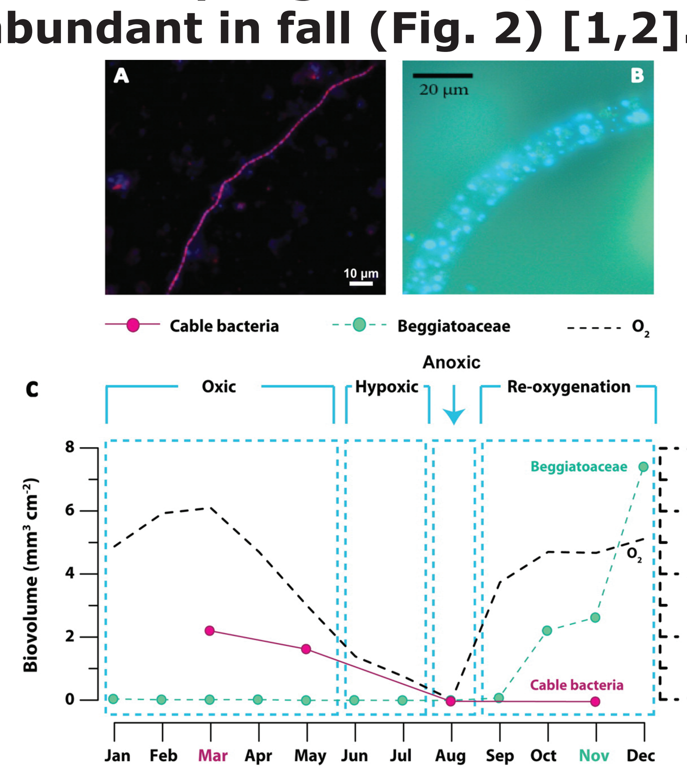

Figure 2. Cable bacteria, as detected through FISH and Beggiatoaceae and bottom water oxygen in 2012. Data are for site 1 [1, 2].

2. Sediment Fe, S, Mn and P dynamics

Whether cable bacteria (spring) or *Beggiatoaceae* (fall) were the dominant sulphur-oxidizing microorganisms had major implications for sediment Fe, S, Mn and P dynamics (Fig. 3).

Our results point towards dissolution of FeS and Ca- and Mn-carbonates by cable bacteria in spring (as shown for March). Upward diffusing dissolved Fe is oxidized by Mn-oxides (besides oxygen). There is no evidence for Mn-carbonate formation in the surface sediments [2, 3].

Cable bacteria promote the formation of Fe-oxides in surface sediments and removal of porewater phosphate [2-4]. The Fe-oxides limit the release of hydrogen sulfide to the water column upon return of the hypoxia [1].

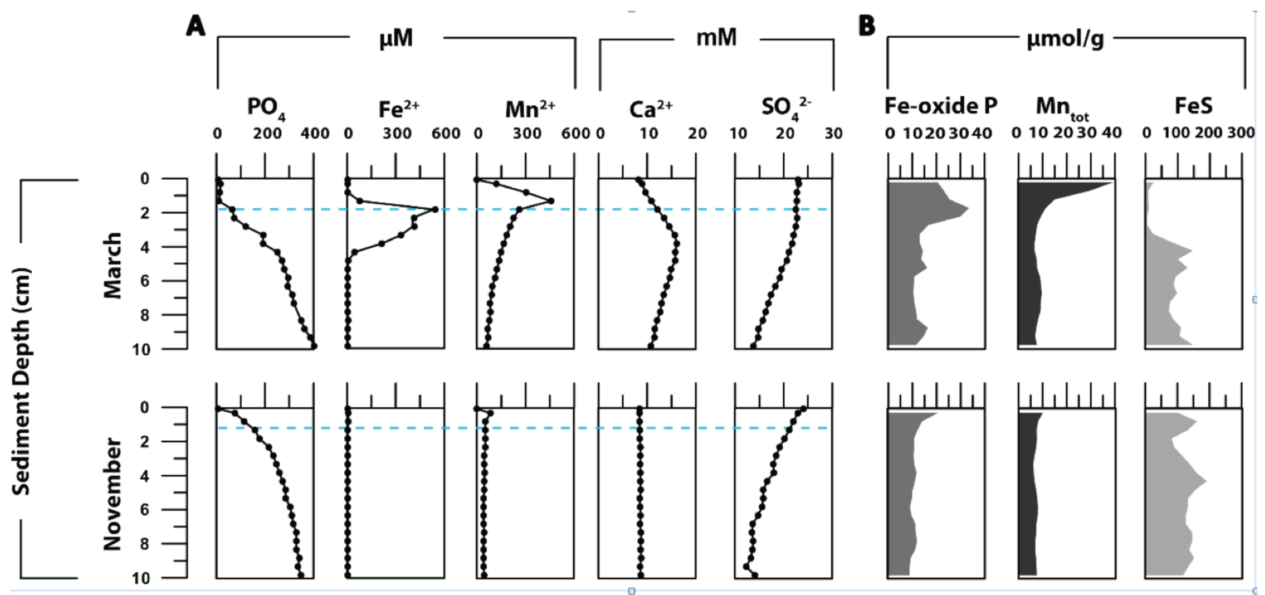

Fig. 3. Porewater and sediment profiles for key constituents at site 1 in March and November 2012 [2].

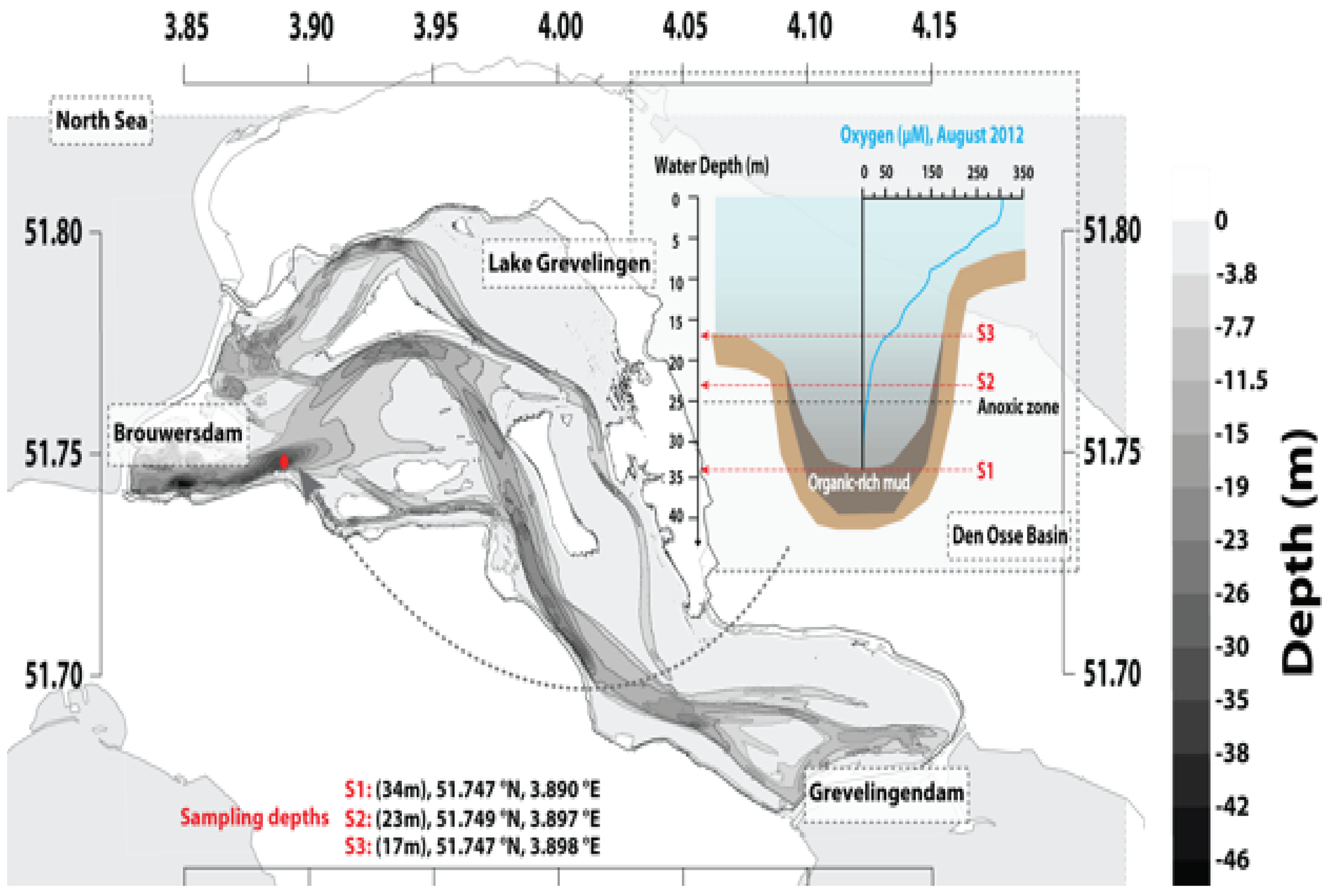

Fig. 1. Location of study sites in Lake Grevelingen (above) and NIOZ ship used for the sampling (below).

3. Fe, Mn and P minerals

Synchrotron-based X-ray spectroscopy reveals the presence of the Mn oxides birnissite and hausmannite in the surface sediments in spring (Fig. 4).

Fe XANES and EXAFS suggest that most of the Fe in the surface sediment is present in the form of poorly crystalline Fe-oxides [3].

P XANES supports binding of P to Fe-oxides [4]. Despite the abundant presence of polyphosphates in cable bacteria (Fig. 5) and *Beggiatoaceae*, we find no evidence for the formation of authigenic Ca-P in the sediment [2-4].

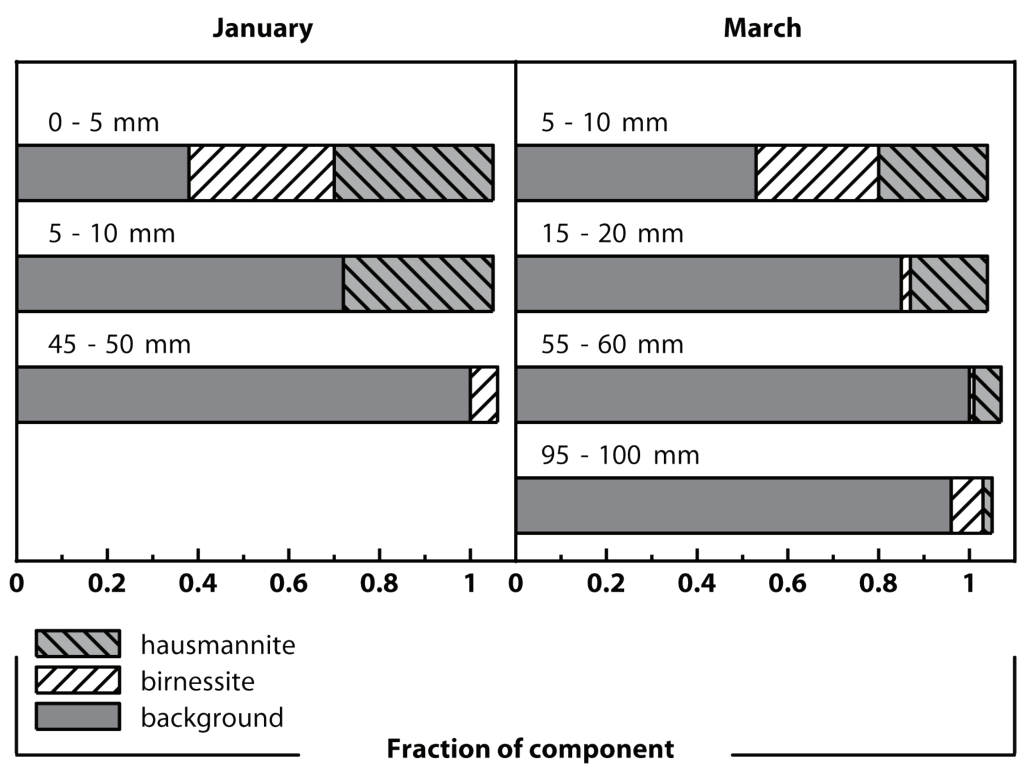

Fig. 4. Estimated Mn fractions in samples at site 1 based on Mn-XANES [3].

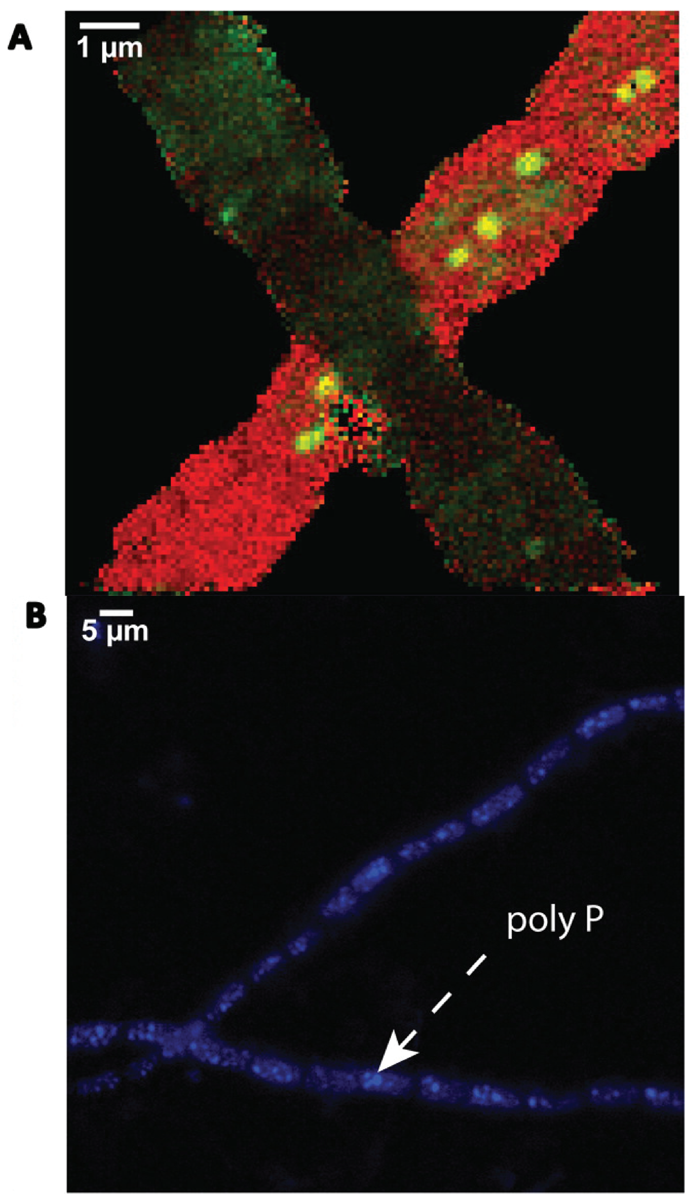

Fig. 5. (A) Composite NanoSIMS image of cable bacterial cells. Bright red cells are active. Bright yellow spots correspond to P-rich inclusions.
(B) DAPI-stained image of cable bacterial cells from the same core showing polyphosphates [2].

4. Benthic exchange of P, Fe, Mn

In spring, when cable bacteria are present, retention of P in the sediment is highly efficient, as indicated by measured benthic fluxes of phosphate. When their activity ceases, the release of P from the sediment to the overlying water is amplified (Fig. 6).

Calculated diffusive Fe fluxes suggest that the largest potential release of Fe to the overlying water occurred between April and July, when the cable bacteria were in decline [3]. Benthic release of Fe during the phase of FeS dissolution was limited. Thus, cable bacteria likely contribute little to Fe shuttling in coastal environments [3].

For details on the benthic exchange of Mn, the resulting "Mn-refluxing" and the impact on trace metals we refer to [3, 5].

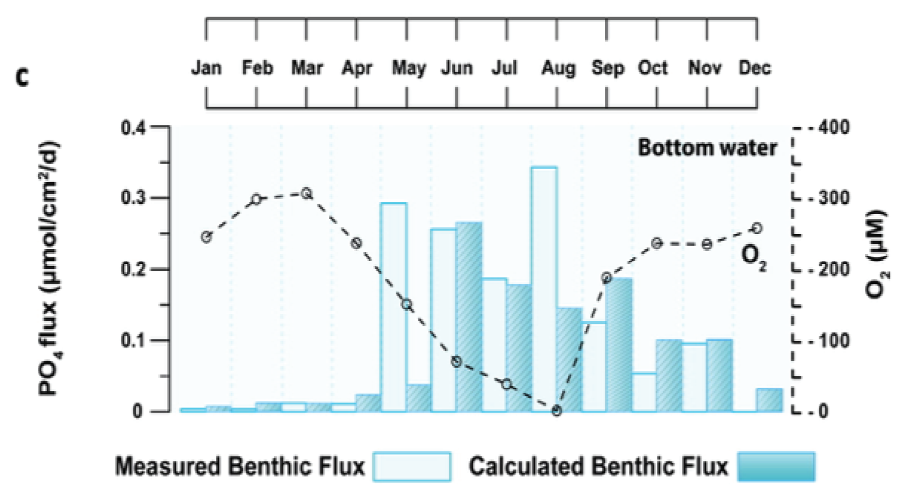

Fig. 6. Benthic release of phosphate in 2012 at site 1.

4. Conclusions and outlook

- The presence of cable bacteria strongly impacts the biogeochemical cycles of Fe, S, Mn and P in seasonally hypoxic marine Lake Grevelingen.
- Further research is needed to clarify whether our findings also hold for other seasonally hypoxic marine systems and to provide insight into the competition between cable bacteria and *Beggiatoaceae.*

5. References

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