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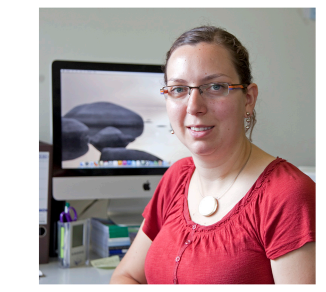

The influence of biogeochemical processes on the pH dynamics in the seasonally hypoxic saline Lake Grevelingen, The Netherlands

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Introduction

Coastal areas experience more pronounced short-term fluctuations in pH than the open ocean due to higher rates of biogeochemical processes such as primary production, respiration and nitrification. These processes and changes therein can mask or amplify the ocean acidification signal induced by increasing atmospheric pCO_2 [1-2]. Coastal acidification can be enhanced when eutrophication-induced hypoxia develops [3]. This is because the carbon dioxide produced during respiration leads to a decrease in the buffering capacity of the hypoxic bottom water.

Research questions

- What is the contribution of primary production, nitrification and CO_2 exchange with the atmosphere to the total rate of change in pH?
- Is Lake Grevelingen a source or a sink for CO_2 on a yearly basis?

Lake Grevelingen

Saline Lake Grevelingen (SW Netherlands) has limited water exchange with the North Sea and experiences seasonal bottom water hypoxia. In our sampling year 2012, the hypoxic period was rather short but severe.

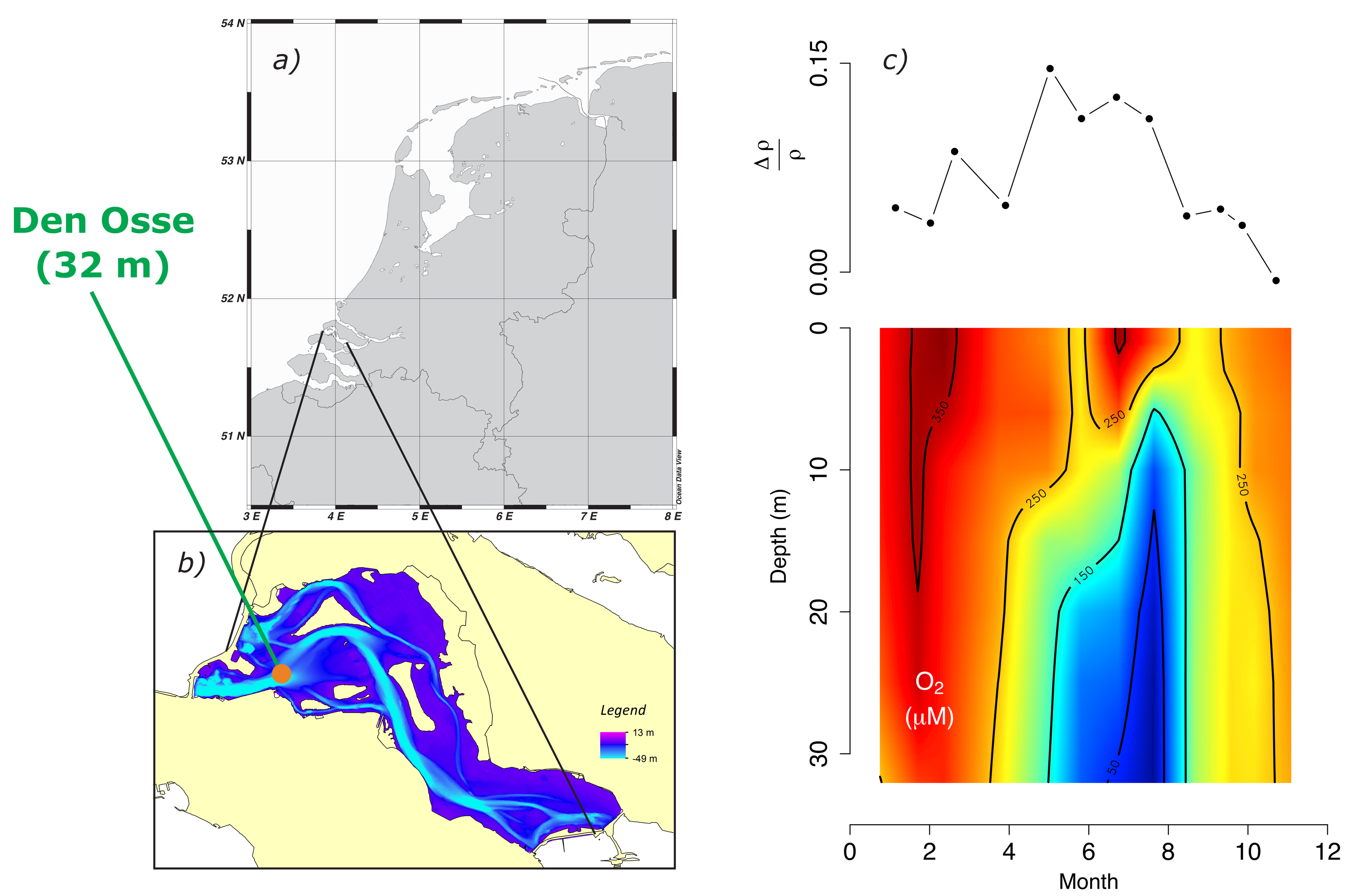

Figure 1: a) Location and b) bathymetry of Lake Grevelingen; c) stratification (relative density difference between bottom and surface water) and $[O_2]$ (µmol/L) at Den Osse in 2012.

Process rates

Rates of primary production, determined monthly by light-dark O_2 bottle incubations, peak in May and July, while respiration is more constant during the year. Nitrification rates, determined seasonally by incubations using $^{15}N\text{-}NH_4$, show highest values in May as a result of high $[NH_4]$ at depth.

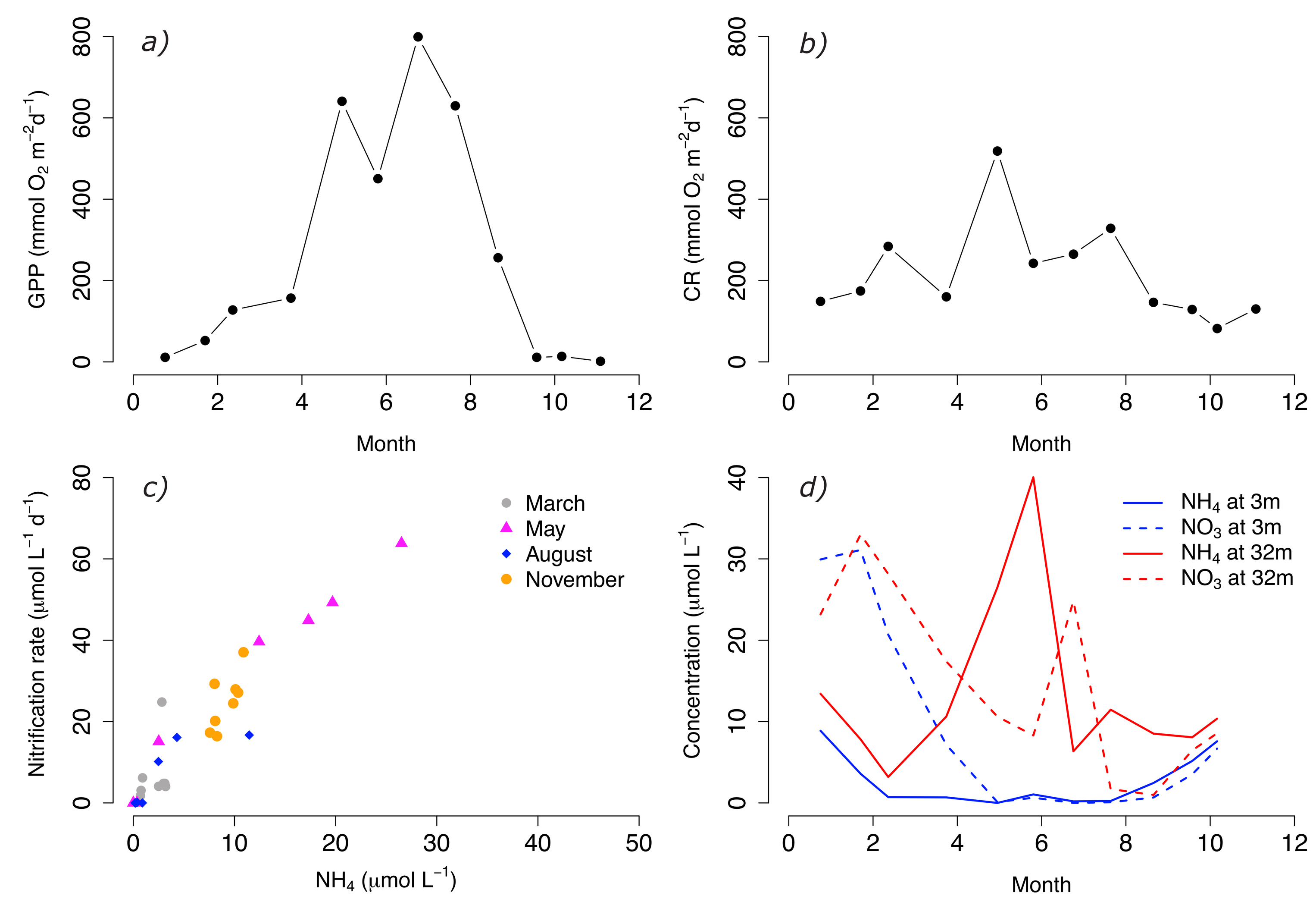

Figure 2: Depth-integrated rates of a) gross primary production (GPP) and b) respiration (CR); c) nitrification rates as a function of $[NH_4^+]$; d) $[NH_4^+]$ and $[NO_3^-]$ in the surface and bottom water.

Carbonate system

During stratification and hypoxia in August, pH_T differed by 0.75 units between the oxic surface water and the hypoxic bottom water. The buffering capacity, determined by calculating the buffer factor as in eq.1 [4], varied a factor 2 with season and up to a factor 5 with depth.

eq.1:

$$\beta = \frac{\partial TA}{\partial [H^+]}$$

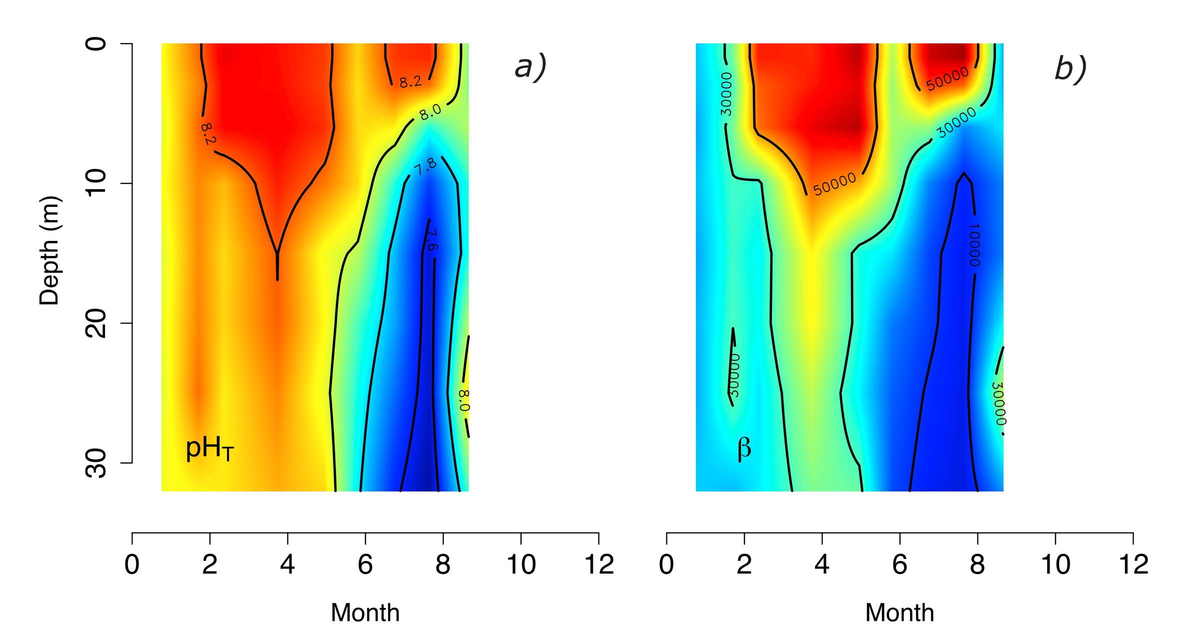

Figure 3: a) pH_T (in situ T); b) buffer factor at Den Osse in 2012.

Effect of biogeochemical processes on pH

We estimated the outgassing of CO_2 based on the difference between surface water (1m) and atmospheric pCO_2. The change in proton concentration due to primary production, respiration and nitrification was calculated according to eq.2 [4]. Here, v_{H+}^{p} represents the stoichiometric change in $[H^+]$ in the absence of buffering. It is noticeable that $[H^+]$ changes due to net production are mainly driven by high primary production rates, while in August the effect of nitrification on $[H^+]$ is mostly driven by the low buffer factor.

eq.2:

$$\frac{dH_p}{dt} = \frac{v_{H^+}^{p}}{\beta} R_p$$

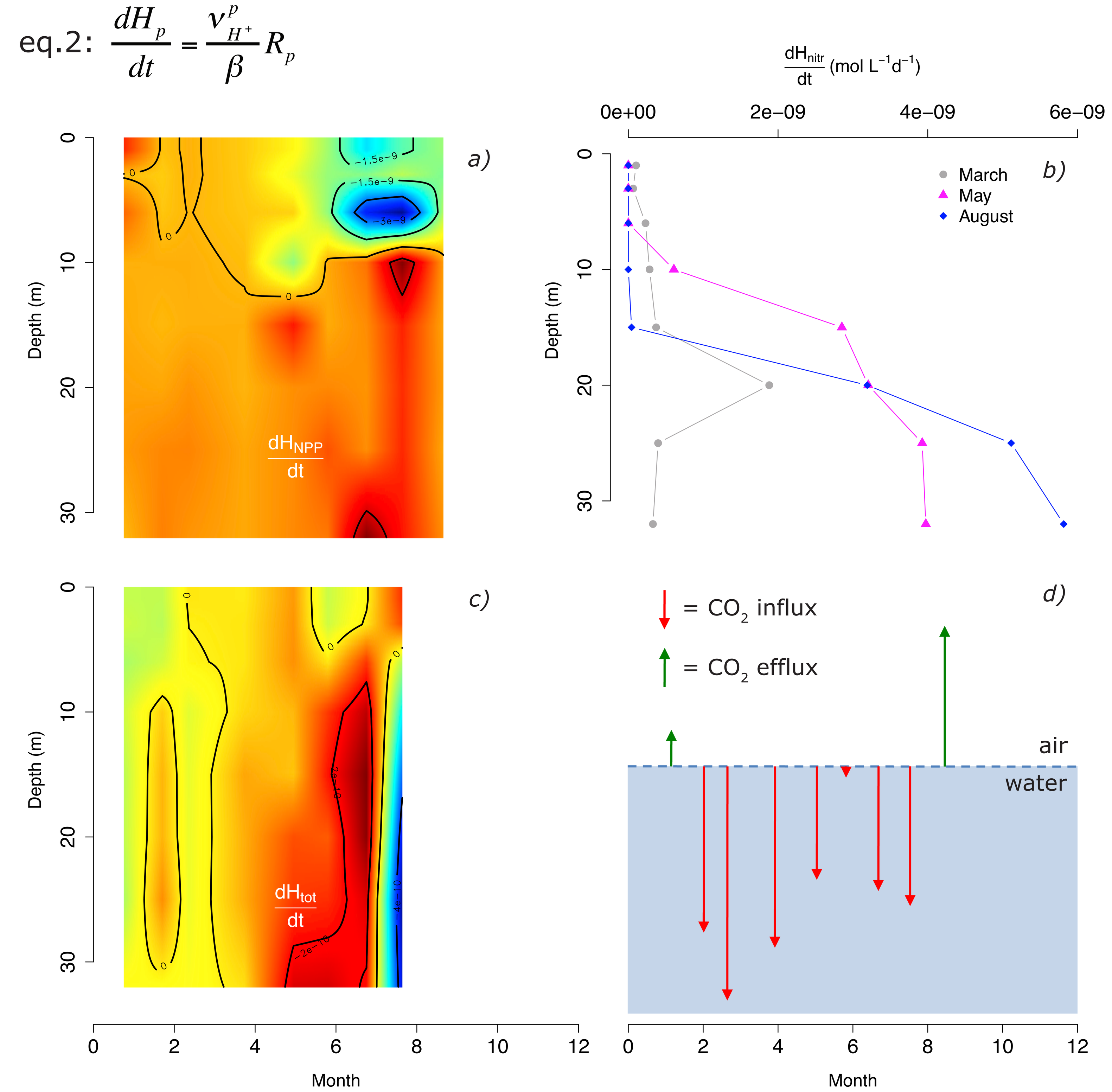

Figure 4: Changes in proton concentration due to a) net primary production (NPP) and b) nitrification; c) total change in proton concentration; d) exchange of CO_2 between Den Osse and the atmosphere (fluxes on a relative scale).

Main conclusions

- Lake Grevelingen carbonate dynamics are mainly driven by production and respiration. Nitrification plays a role in the deeper water in summer.
- Hypoxia influences pH in summer by weakening the buffering capacity
- Overall, Lake Grevelingen was a sink for atmospheric CO_2 in 2012

References

[1] Provoost *et al.* (2010) *Biogeosciences* **7**, 3869-3878 | [2] Wootton and Pfister (2012) *PLOS ONE* **7(12)**, e53396 | [3] Cai *et al.* (2011) *Nature Geosci.* **4**, 766–770 | [4] Hofmann *et al.* (2010) *Mar. Chem.* **121**, 246-255