Hypoxia and biogeochemical processes concomitantly influence acidification in the seasonally stratified coastal marine Lake Grevelingen, the Netherlands

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Coastal waters experience stronger short-term pH fluctuations than the open ocean due to higher rates of biogeochemical processes such as primary production and respiration. These processes and fluctuations therein can mask or amplify the ocean acidification signal driven by increasing atmospheric pCO_2. Acidification in coastal areas can also be enhanced as eutrophication-induced hypoxia develops, since the CO_2 produced during respiration decreases the buffering capacity of the hypoxic bottom water. Coastal Lake Grevelingen (SW Netherlands) has limited water exchange with the North Sea and experiences seasonal bottom water hypoxia. Hence this lake provides an ideal site to study how seasonal hypoxia and biogeochemistry concomitantly affect coastal acidification.

In 2012, we examined the carbonate system in the water column of Lake Grevelingen over the full annual cycle. Monthly carbonate system, chlorophyll-a, oxygen and nutrient measurements were complemented with estimates of primary production and respiration using O_2 light-dark incubations. Gross primary production (GPP) was also estimated via ^{14}C-incubations and sedimentary DIC and TA fluxes were estimated from core incubations.

During stratification and hypoxia, pH differed up to 0.75 units between the well-buffered oxic surface and less-buffered hypoxic bottom waters. Rates of GPP peak in summer and range up to 200 $mmolC\ m^{-2}\ d^{-1}$. On a yearly basis, Lake Grevelingen is a sink for atmospheric CO_2, although significant outgassing takes place in autumn after the termination of stratification, concurrently with high sedimentary DIC fluxes. A proton budget calculated from measured process rates indicates proton cycling was fastest in the hypoxic bottom water and buffering capacities were lower after the stratified period than before. This highlights the significance of buffering in controlling pH dynamics and explains the increasing vulnerability of hypoxic coastal waters to any acidifying process.