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# $CO_2$, $CH_4$ and $N_2O$ dynamics and fluxes in the brackish Lake Grevelingen (The Netherlands)

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Lake Grevelingen in the South West Netherlands is a former estuary locked off from the sea by two dikes and a brackish lake since 1971 (salinities from 29 to 33 during our sampling). It is connected with the North Sea by sluices, has a surface area of 108 $km^2$, a mean depth of 5.3 m, a maximum depth of 48 m, and about 60% of the area the depth is less than 5 m. From January 2012 to December 2013, a biogeochemical survey was conducted at monthly interval at a fixed station (35 m depth) at Den Osse. Here, we focus on the analysis of partial pressure of $CO_2$ ($pCO_2$), and concentrations of $CH_4$ and $N_2O$ obtained throughout the water column. The water column was isothermal in winter, stratification settled in spring, was maximal in summer (August), and vertical mixing occurred in fall. Overall, salinity increased from surface to depth, ranged from 29.57 to 31.57 in surface waters and from 30.55 to 32.74 in bottom waters, and was minimal in winter and maximal in summer. $pCO_2$ in surface waters ranged from 270 to 650 ppm, and followed a typical seasonal cycle for temperate coastal environments shifting from $CO_2$ over-saturation in winter to spring $CO_2$ under-saturation due to the spring phytoplankton bloom, and shifting back to over-saturation in fall. Unlike the adjacent Southern Bight of the North Sea and the adjacent Oosterschelde, $CO_2$ under-saturation prevailed in summer in Lake Grevelingen due to a summer-time bloom, as also evidenced by $O_2$. $pCO_2$ was vertically virtually homogeneous in winter and fall, and showed the strongest vertical gradient during the anoxic event in August. $CH_4$ values were minimal in winter ($\sim$20 nM) and as stratification developed during spring and summer a distinct maximum of $CH_4$ (up to 730 nM) developed at the pycnocline (5 to 10 m). $N_2O$ showed little seasonal variations and only a very faint increase with depth, except in August when bottom waters became anoxic. At this time, $N_2O$ shown a maximum ($\sim$22 nM) at the oxycline (probably related to enhanced $N_2O$ production by nitrification at low $O_2$ concentrations), and decreased in the anoxic layer ($\sim$3 nM) (probably related to denitrification).