CO2, CH4 and N2O 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 km², 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. During summer, bottom waters of Lake Grevelingen become anoxic. 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 CO2 (pCO2), and concentrations of CH4 and N2O 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. pCO2 in surface waters ranged from 270 to 650 ppm, and followed a typical seasonal cycle for temperate coastal environments shifting from CO2 over-saturation in winter to spring CO2 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, CO2 under-saturation prevailed in summer in Lake Grevelingen due to a summer-time bloom, as also evidenced by O2. pCO2 was vertically virtually homogeneous in winter and fall, and showed the strongest vertical gradient during the anoxic event in August. CH4 values were minimal in winter (20 nM) and as stratification developed during spring and summer a distinct maximum of CH4 (up to 730 nM) developed at the pycnocline (5 to 10 m). N2O showed little seasonal variations and only a very faint increase with depth, except in August when bottom waters became anoxic. At this time, N2O shown a maximum (22 nM) at the oxycline (probably related to enhanced N2O production by nitrification at low O2 concentrations), and decreased in the anoxic layer (3 nM) (probably related to denitrification).