Seasonal dynamics drive anammox as the primary N_2 production pathway in sulphidic Saanich Inlet

CÉLINE C. MICHIELS[1], STEVEN J. HALLAM[1], SEAN A. CROWE[1,2]

[1]Dept. of Microbiology & Immunology, University of British Columbia, Canada, michiels@mail.ubc.ca

[2] Dept. of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Canada

Marine oxygen minimum zones (OMZs) support 30-50% of global fixed-N loss and yet comprise only 7% of the total ocean volume. This N-loss is driven by canonical denitrification and anaerobic ammonium oxidation (anammox), and the factors that regulate these two processes are complex, including organic matter availability and stoichiometry, oxygen levels, and NO_2^- and NH_4^+ availability. The activity of these two processes varies greatly both spatially and temporally. The geochemical outcome of anammox and denitrification are different, as incomplete denitrification can lead to N_2O accumulation, which is a potent greenhouse gas. Biogeochemical models are thus needed to explicitly quantify relative rates of anammox and denitrification and these models require ecophysiological information on the organisms responsible. To gain such knowledge *in situ*, we conducted a 1 year time-series experiment with incubations using ^{15}N-labeled N to track N biogeochemical process rates at monthly intervals over an entire year in the seasonally anoxic fjord—Saanich Inlet (BC, Canada). Both denitrification and anammox operated throughout the low oxygen water column (<20μM) with depth-integrated rates of anammox and denitrification ranging from 0.1 to 40 and $4x10^{-2}$ to 2 mmol N_2 m^{-2} d^{-1}, respectively. Most N_2 production and N-loss in Saanich Inlet was thus driven by anammox. While rates of denitrification were relatively constant throughout the year, rates of anammox varied by orders of magnitude. We attribute this variation to strong fluxes of ammonium from the sediment during the winter, fuelling anammox from below. Moreover, addition of sulphide to our incubations stimulated rates of denitrification, demonstrating the role of sulphide as an electron donor for chemoautotrophic nitrate reduction. The role of this chemoautotrophic nitrate reduction remains uncertain, but leakage of nitrite likely fuels anammox when both ammonium and sulphide fluxes are high, thereby short-circuiting canonical denitrification. Overall, both processes operated throughout the year, contributing to an annual N-loss of $9.5x10^{-3}$ Tg N_2 yr^{-1}, 92% of which we attribute to anammox. Extrapolating these rates from Saanich Inlet to all similar coastal inlets in BC (2478 km^2), we estimate that these inlets contribute 0.2% to global pelagic N-loss.