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Supplement of

Rising Arctic seas and thawing permafrost: uncovering the carbon cycle impact in a thermokarst lagoon system in the outer Mackenzie Delta, Canada

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This is the supporting information for the publication "Rising Arctic Seas and Thawing Permafrost: Uncovering the Carbon Cycle Impact in a Thermokarst Lagoon System in the outer Mackenzie Delta, Canada" of Jenrich et al. 2025.

S1. Grain size analyses

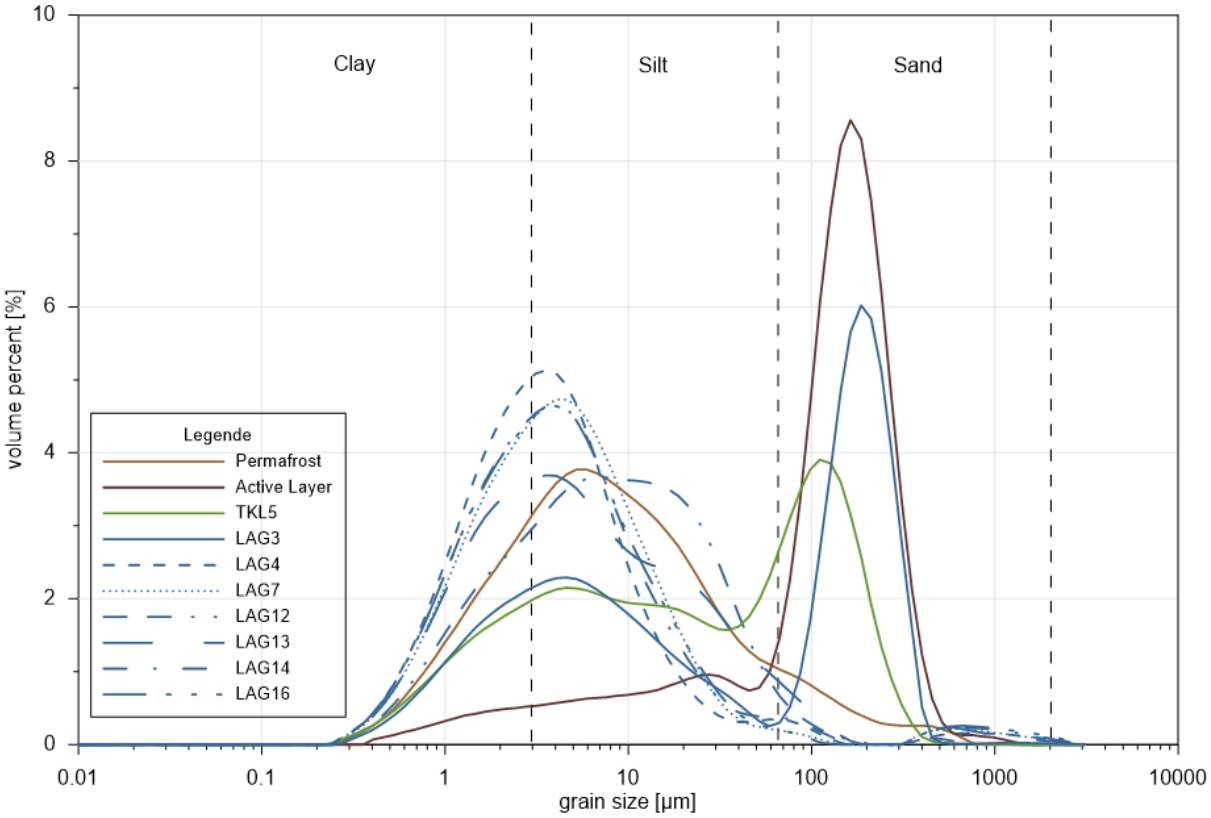

Figure S1. The particle size distribution of the surface sediment (mean of 0-10 cm subsamples) varies among different environments: permafrost and active layer (brown colours), thermokarst lake (green), and thermokarst lagoons (blue).

S2. Principal component analysis (PCA)

S2.1 Variations in CO_2 and CH_4 within a lagoon system

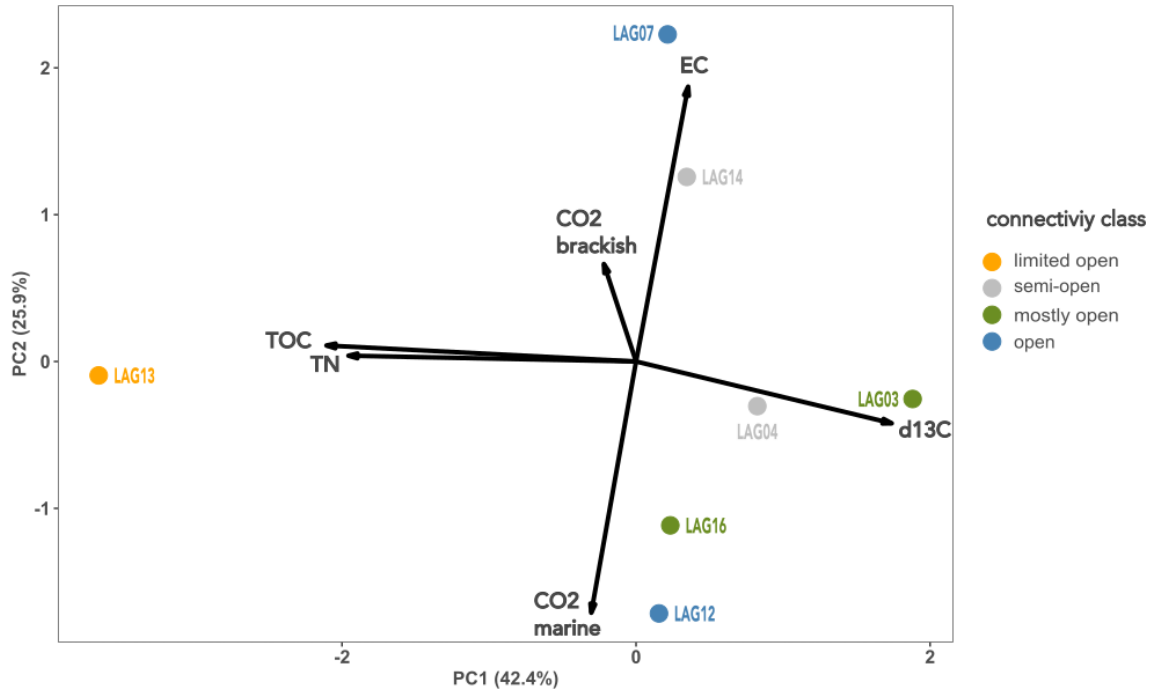

Figure S2. Principal component analysis of cumulative CO_2 production under brackish and marine conditions after 415 days, biogeochemical parameter (TN, TOC and $\delta^{13}C$) and hydrochemical parameter (surface water EC) for the 7 lagoons.

The PCA results for CO_2 production within the lagoon system show that the data clusters into two distinct groups: the young, most closed lagoon LAG13 is distinct to the more open lagoons. The main variance is explained by biogeochemical sediment properties, namely differences in TOC and TN content as well as $d^{13}C$, indicating that organic matter quality and quantity is the driving factor for CO_2 production in the lagoon system.

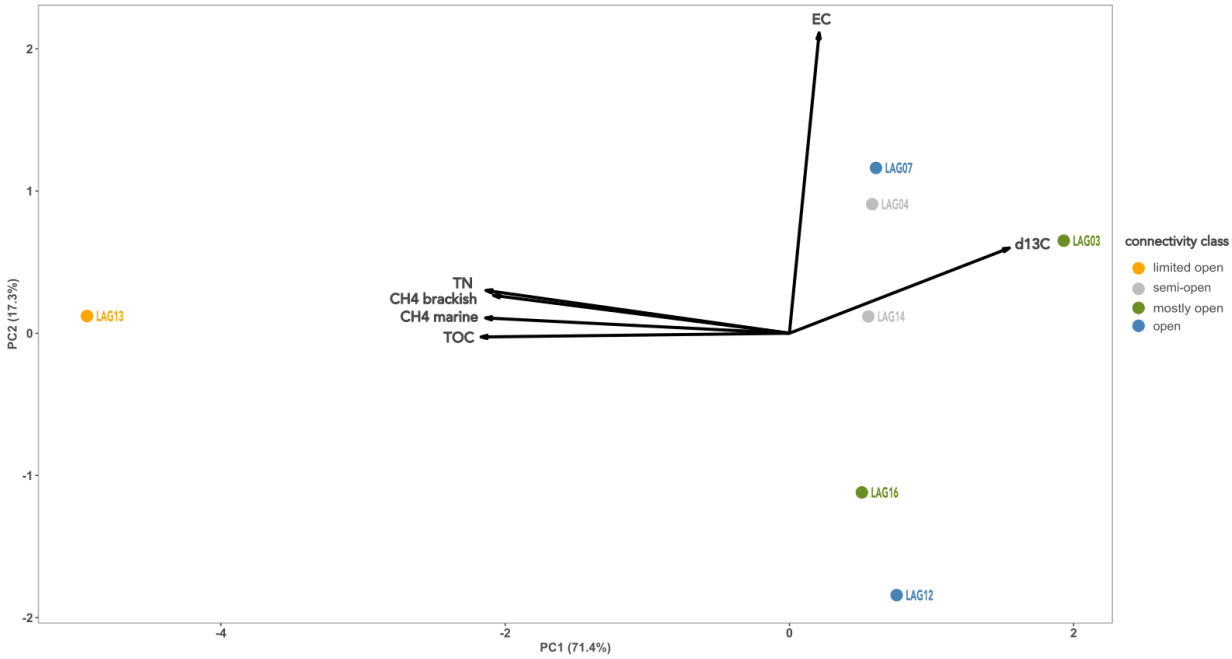

Figure S3. Principal component analysis of cumulative CH_4 production under brackish and marine conditions after 415 days, biogeochemical parameter (TN, TOC and $\delta^{13}C$) and hydrochemical parameter (surface water EC) for the 7 lagoons.

The PCA results for CH_4 production within the lagoon system show that the data clusters into two distinct groups: the young, most closed lagoon LAG13 is distinct to the more open lagoons. CH_4 production correlates with substrate parameters in brackish and marine incubations. Surface water EC does not seem to have an influence on CH_4 production.

S2.2 Variations in CO_2 and CH_4 along a land-sea transition transect

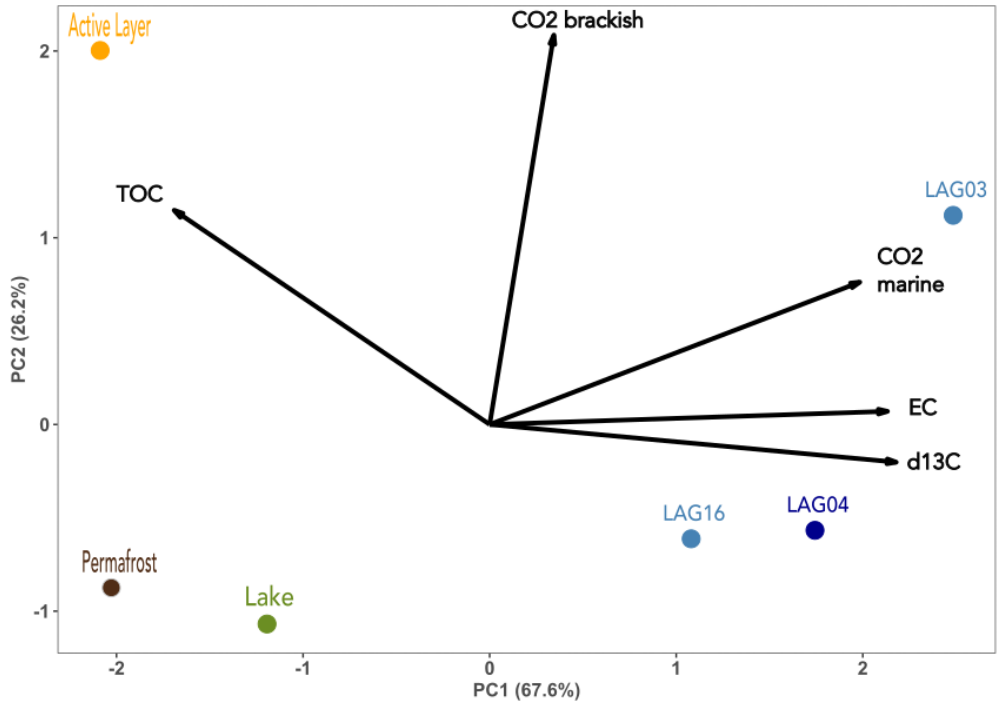

Figure S4. Principal component analysis of cumulative CO_2 production under brackish and marine conditions after 244 days, biogeochemical parameter (TOC and $\delta^{13}C$) and hydrochemical parameter (surface water EC) for the transect sites (PF, AL, TKL, LAG4, LAG3, LAG16).

The PCA results for CO_2 production show that the data clusters into two distinct groups: terrestrial sites and lagoons. Under brackish conditions, CO_2 production does not correlate with TOC, $\delta^{13}C$, or surface water EC. However, under marine conditions, a clear correlation emerges. Terrestrial sites, while high in TOC content, exhibit low CO_2 production under marine conditions, likely due to the microbial communities not yet being adapted to the higher salinities. This results in a misleading negative correlation between TOC and CO_2 production under marine conditions in the PCA.

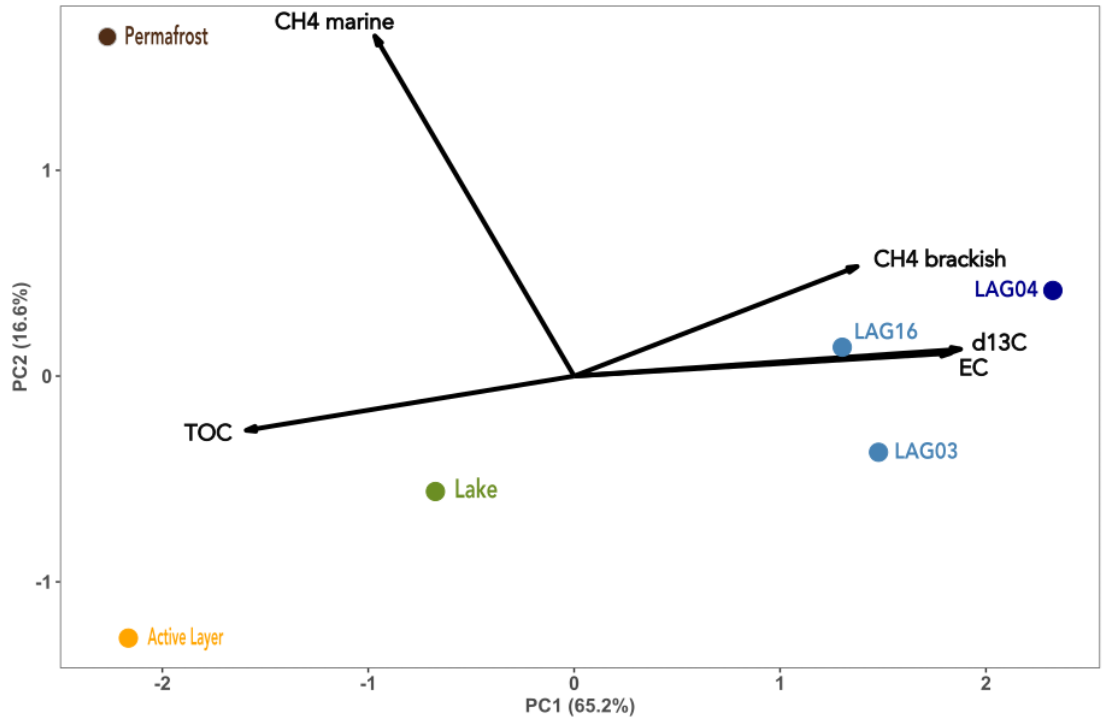

Figure S5. Principal component analysis of cumulative CO_2 production under brackish and marine conditions after 244 days, biogeochemical parameter (TOC and $\delta^{13}C$) and hydrochemical parameter (surface water EC) for the transect sites (PF, AL, TKL, LAG4, LAG3, LAG16).

The PCA results for CH_4 production show that the data clusters into four distinct groups: permafrost and active layer, lake, mostly-open lagoons, and semi-open lagoons. In brackish incubations, CH_4 production negatively correlates with TOC and positively correlates with $\delta^{13}C$ and surface water EC. Similar to Figure S4, the high TOC content of the terrestrial sites leads to a misleading negative correlation between TOC and CH_4 production. In marine incubations, CH_4 production does not show any significant correlation with TOC, $\delta^{13}C$, or surface water EC, indicating that other parameter, most likely microbial composition, are the driving factor for CH_4 production.

S3. CO_2 and CH_4 production over the time of the incubation

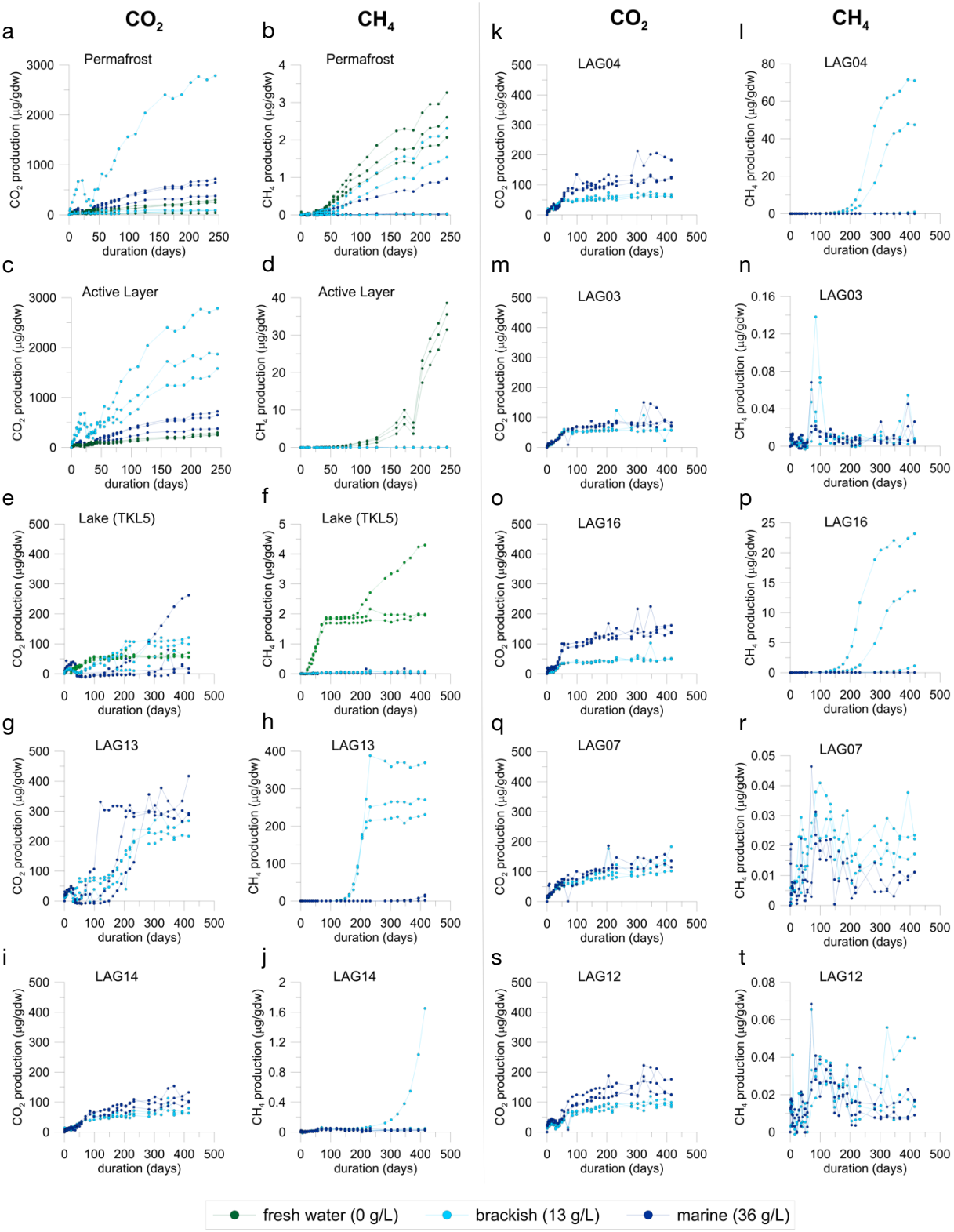

Figure S6. Cumulative anaerobic CO_2 and CH_4 production in µg per gdw for the terrestrial permafrost and active layer (a-d) during the 244 day incubation experiment and for lake and lagoons (e-t) during the 415 day incubation experiment at freshwater (green), brackish (turquoise) and marine (dark blue) conditions. Error bars representing the standard deviation.