Supporting information

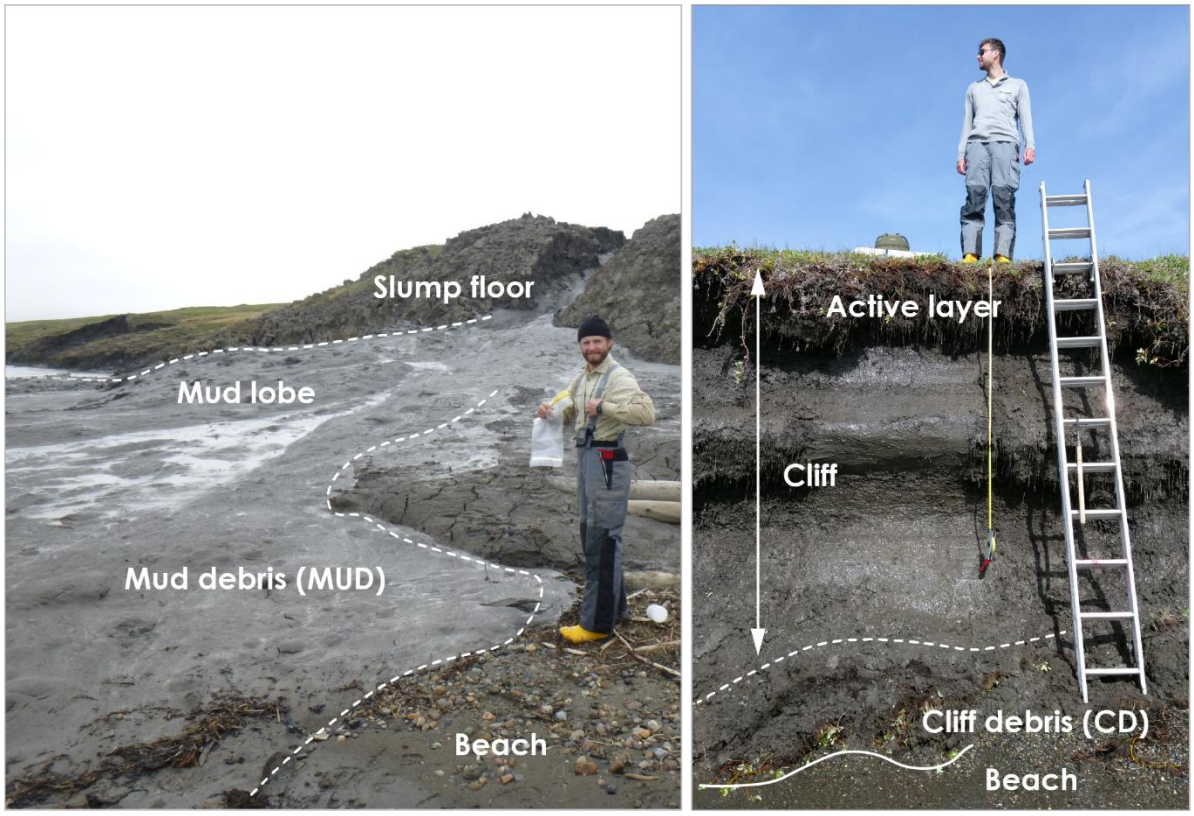

Figure S1. Study sites and sampling locations on Qikiqtaruk – Herschel Island. A mud lobe draining a retrogressive thaw slump system (left panel) and cliff debris from a low cliff (right panel) were sampled. *Mud debris* (MUD) and *cliff debris* (CD) were used for incubations.

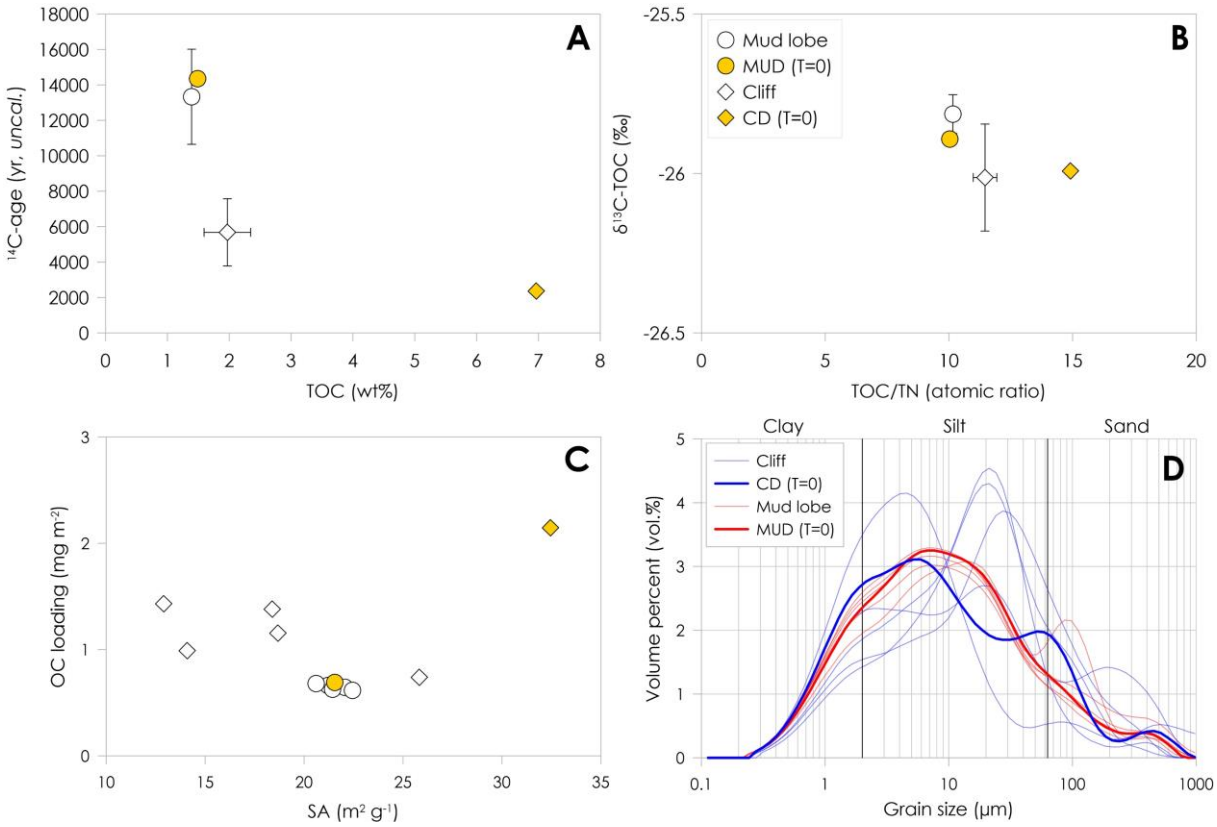

Figure S2. Composition and age of organic carbon at the permafrost coastal erosion sites. *Mud debris* (MUD) and *cliff debris* (CD) were used for the incubation (T = 0).

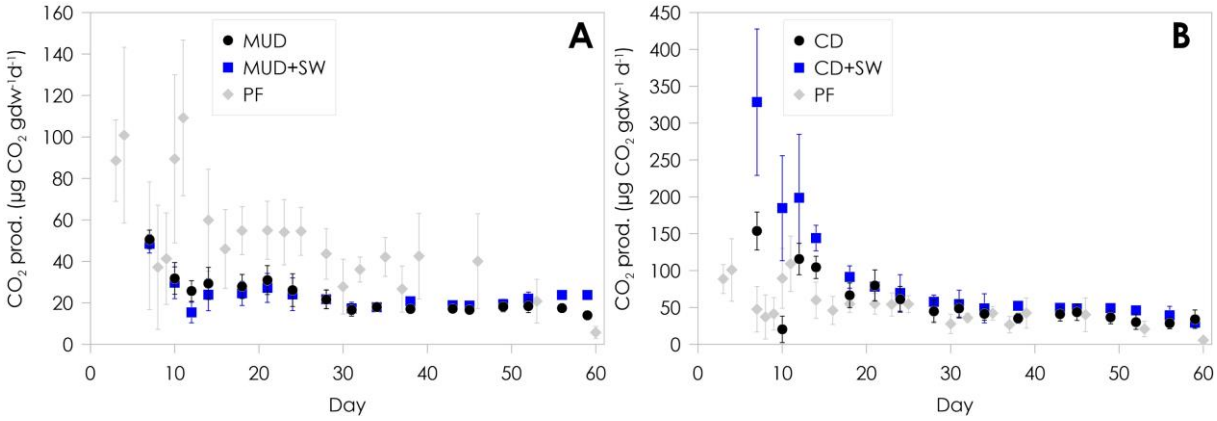

Figure S3. Aerobic CO_2 production rates from incubated *mud debris* and *cliff debris*. *Mud debris* (MUD) and *cliff debris* (CD) were incubated without and with seawater (SW) for a duration of two months at 4 °C under aerobic and dark conditions. Cumulative CO_2 production from permafrost (PF) is displayed as a local reference for CO_2 production from *in situ* permafrost (Tanski et al., 2019). The PF samples originate from the headwall of the thaw slump system from which the *mud debris* is released.

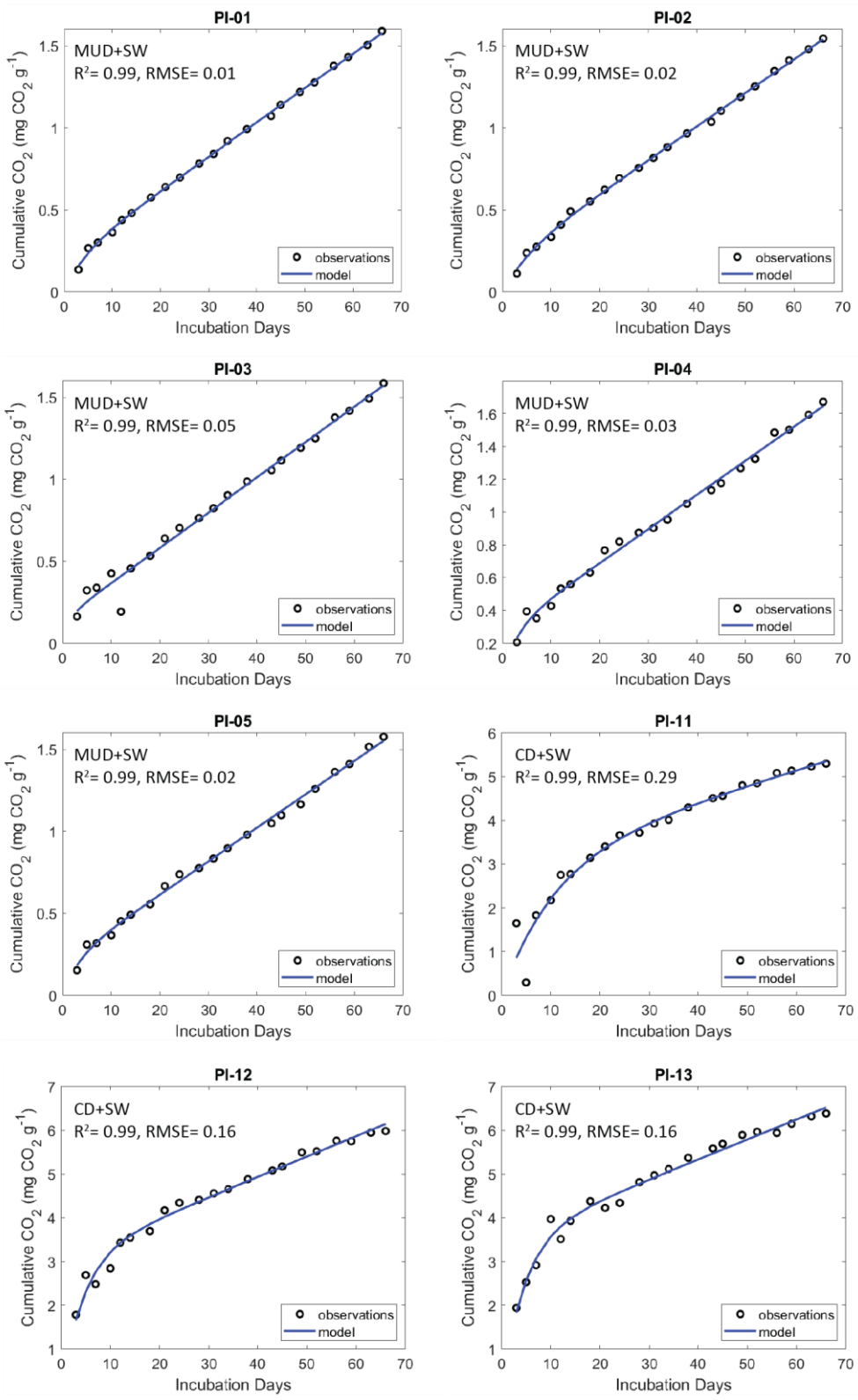

Figure S4. Observed and modelled cumulative CO_2 production for incubation set-ups with *mud debris* (MUD) and *cliff debris* (CD) mixed with *seawater* (SW). Model curve is a logarithmic fit reported with correlation coefficient (R^2) and root-mean-square error (RSME) given in mg CO_2 per gram dry weight (g^{-1}).

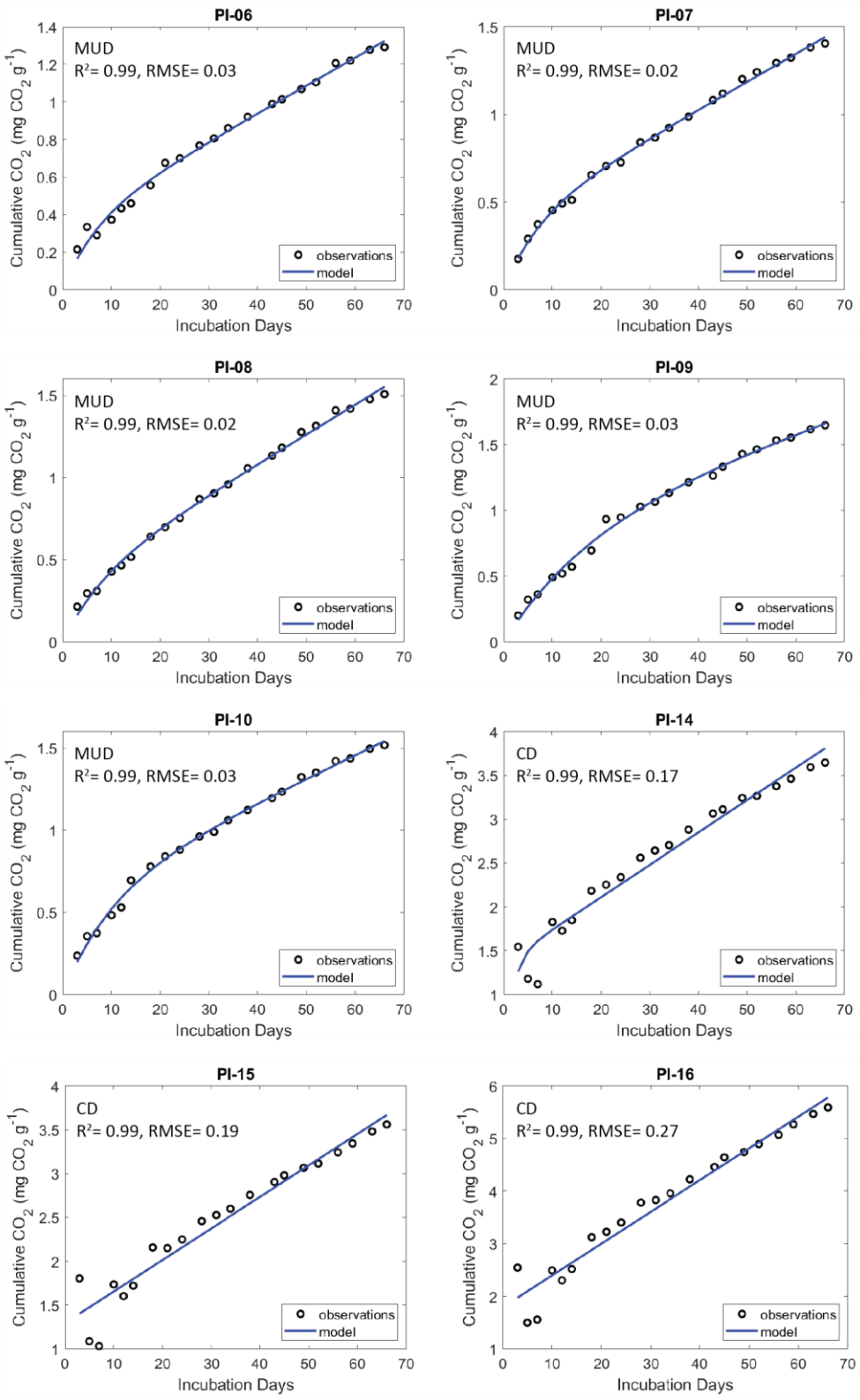

Figure S5. Observed and modelled cumulative CO_2 production for incubation set-ups with *mud debris* (MUD) and *cliff debris* (CD). Model curve is a logarithmic fit reported with correlation coefficient (R^2) and root-mean-square error (RSME) given in mg CO_2 per gram dry weight (g^{-1}).

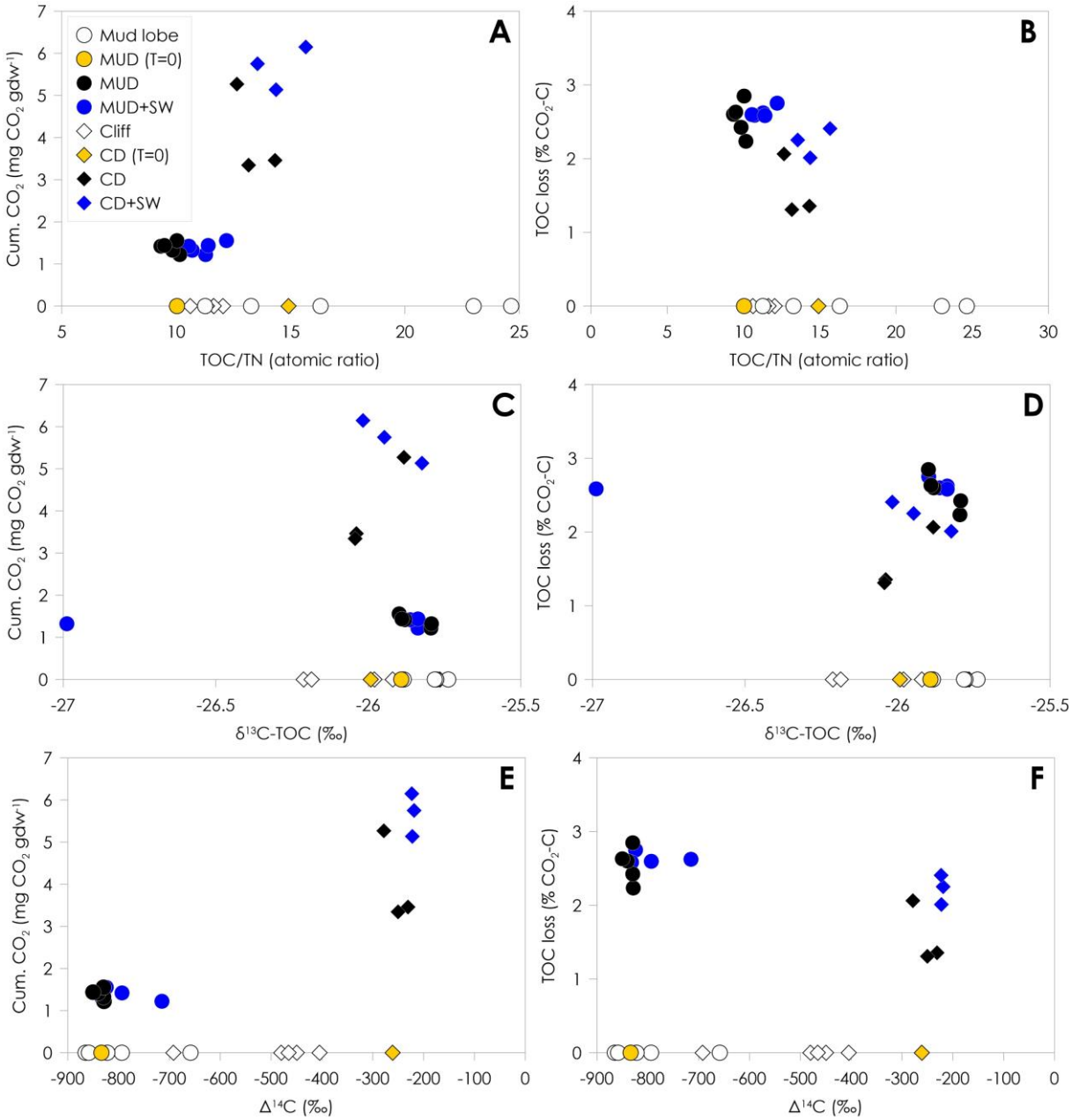

Figure S6. CO_2 production normalized to gram dry weight (gdw) and %TOC loss as CO_2-C plotted against TOC/TN-ratio (A, B), δ^{13}C-TOC (C, D) and Δ^{14}C (E, F) as indicators for organic matter degradation. Open symbols on the x-axis indicate samples from *mud lobe* and *cliff* that were not incubated to show the natural variability in the *mud lobe* and *cliff*. The *mud debris* (MUD) and *cliff debris* (CD) samples used for the incubation (T = 0) are indicated by the yellow symbols, incubated samples by the black symbols and incubated samples with seawater (SW) added by the blue symbols.

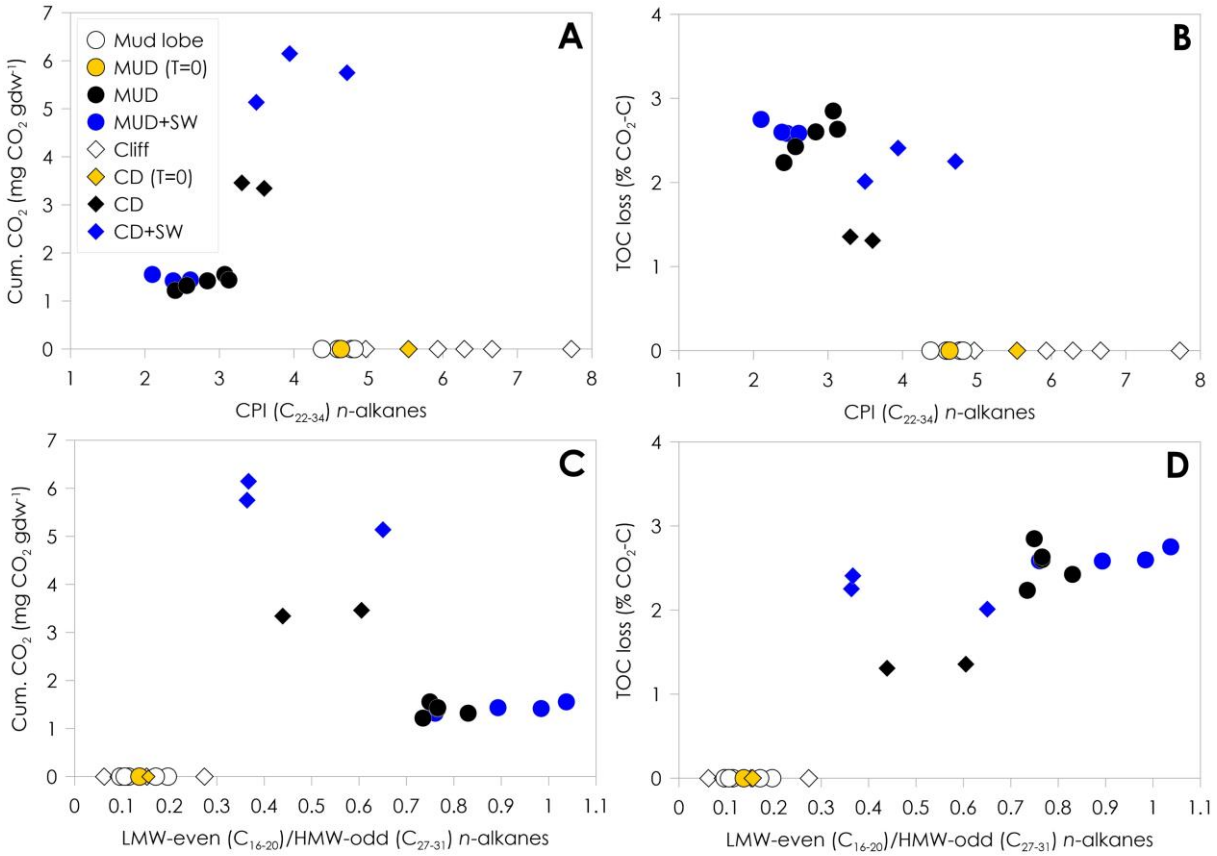

Figure S7. CO_2 production normalized to gram dry weight (gdw) and %TOC loss as CO_2-C plotted against CPI *n*-alkanes (A, B) and LMW-even to HMW-odd n-alkane ratios (C, D). Open symbols on the x-axis indicate samples from *mud lobe* and *cliff* that were not incubated to show the natural variability in the *mud lobe* and *cliff*. The *mud debris* (MUD) and *cliff debris* (CD) samples used for the incubation (T = 0) are indicated by the yellow symbols, incubated samples by the black symbols and incubated samples with seawater (SW) added by the blue symbols.

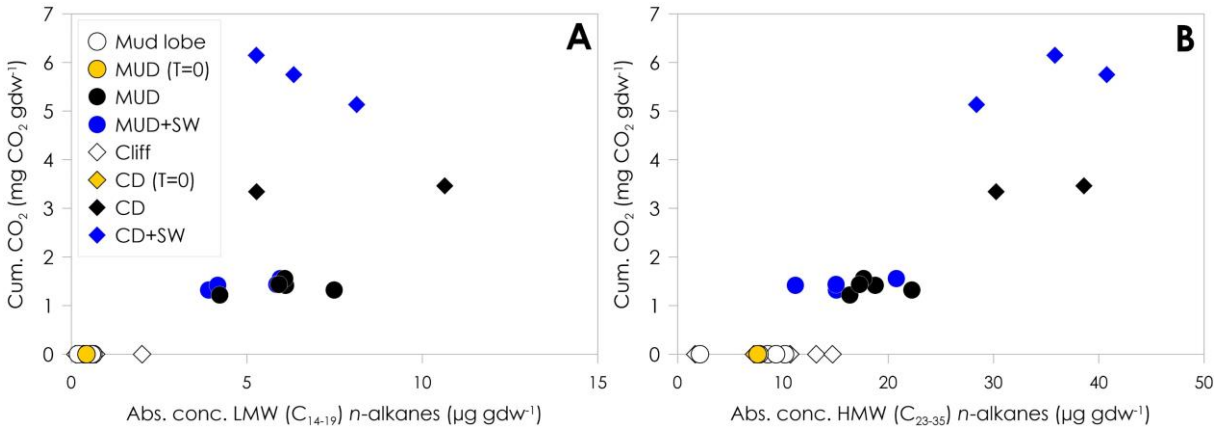

Figure S8. CO_2 production normalized to gram dry weight (gdw) plotted against absolute LMW *n*-alkane (A) and HMW *n*-alkane (B) concentrations. Open symbols on the x-axis indicate samples from *mud lobe* and *cliff* that were not incubated to show the natural variability in the *mud lobe* and *cliff*. The *mud debris* (MUD) and *cliff debris* (CD) samples used for the incubation (T = 0) are indicated by the yellow symbols, incubated samples by the black symbols and incubated samples with seawater (SW) added by the blue symbols.

Table S2. Summary of DOC concentrations and pH for incubation set-ups with *mud debris* (MUD) (n = 5), MUD with seawater (SW) (n = 5), *cliff debris* (CD) (n = 3) and CD with SW (n = 3) after two months of incubation (T = 1). DOC concentration and pH are given from mineral (PF_{MIN}) and organic-rich (PF_{ORG}) permafrost mixed with seawater after four months (T = 1*) are displayed to give a reference to local *in situ* permafrost and taken from Tanski et al. (2019). All values are given as mean ± standard deviation.

	SW (T=0)	**SW** (T=1)	**MUD+SW** (T=1)	**CD+SW** (T=1)
This study				
DOC (mg L^{-1})	1.7 ±0.0	2.6 ±1.0	7.2 ±0.1	27.8 ±1.0
pH	8.2 -	8.2 ±0.1	7.0 ±0.1	7.0 ±0.0
	SW (T=0)	**SW** (T=1*)	**PF_{MIN}+SW** (T=1*)	**PF_{ORG}+SW** (T=1*)
Tanski et al. (2019)				
DOC (mg L^{-1})	1.3 ±0.0	2.2 ±0.2	11.6 ±3.9	52.7 ±6.5
pH	8.2 ±0.0	8.5 ±0.1	7.6 ±0.1	5.2 ±0.2

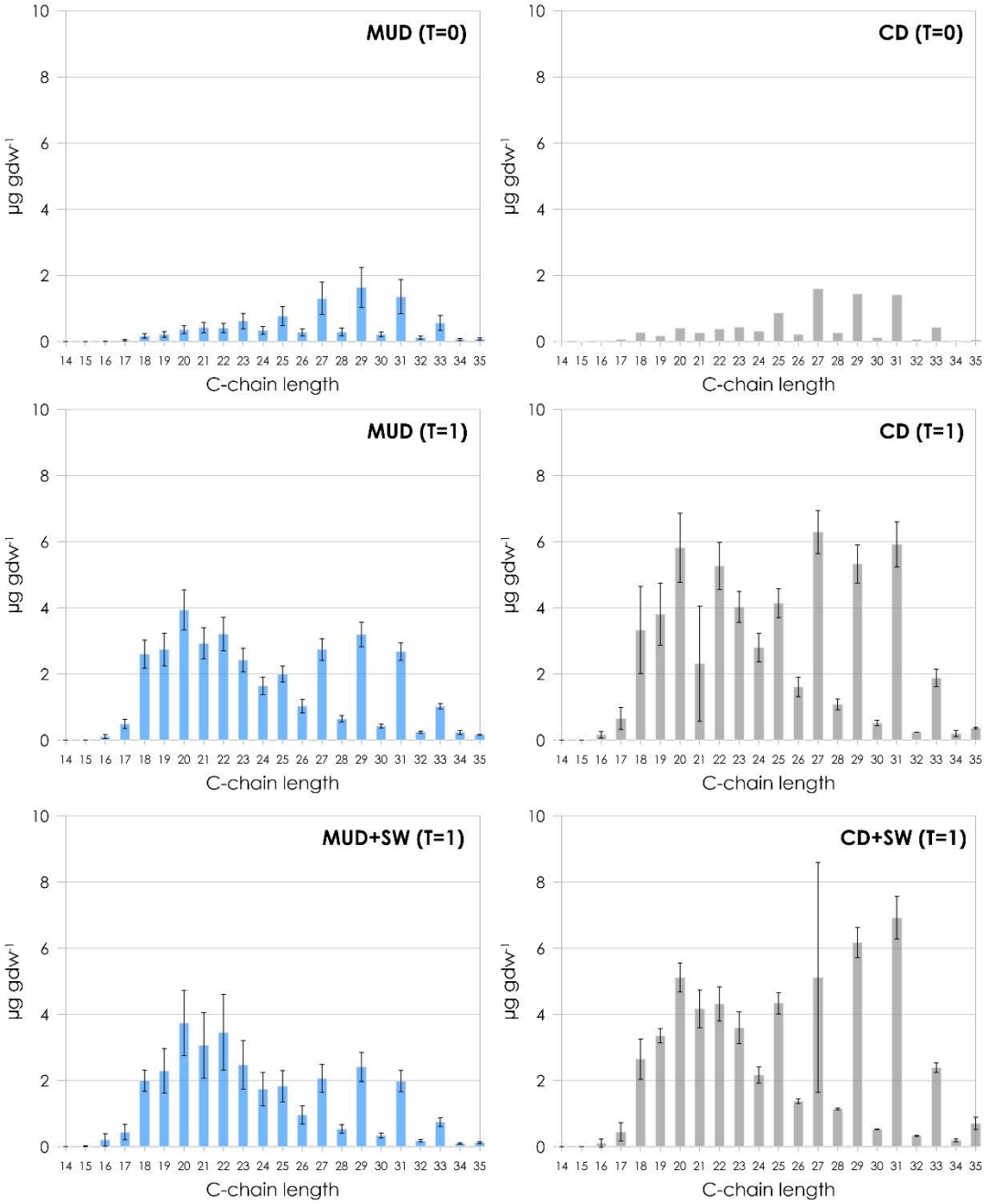

Figure S9. Bar graphs showing the distribution of *n*-alkane carbon chains in *mud debris* (MUD), *cliff debris* (CD) and set-ups incubated with seawater (SW). The upper panels show the *n*-alkane distribution before the incubation (T=0) and the middle and lower panels after the incubation (T=1).

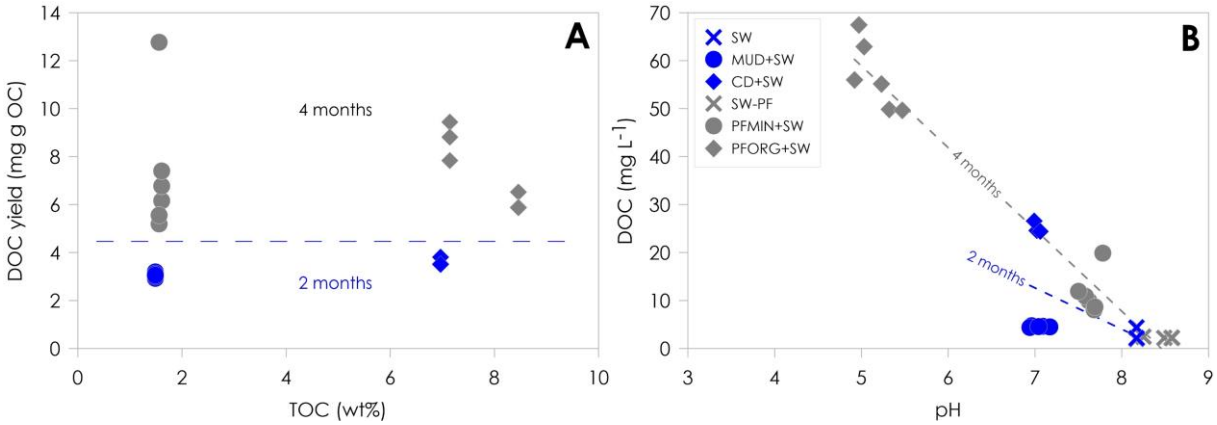

Figure S10. Scatter plots showing correlation between initial TOC contents and DOC yield (a) as well as pH and DOC concentration (b) of *mud debris* (MUD) and *cliff debris* (CD) in seawater (SW) after the incubation of two months. As reference for local permafrost, correlations are also displayed for mineral (PF_{MIN}) and organic-rich permafrost (PF_{ORG}) samples and seawater (SW-PF) incubated for four months (Tanski et al., 2019).