Land-to-ocean fluxes and biolability of organic matter eroding along the Beaufort Sea coast near Drew Point, Alaska

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Coastal erosion rates are increasing along the Alaskan Beaufort Sea coast due to increases in wave action, the increasing length of the ice-free season, and warming permafrost. These eroding permafrost coastlines transport organic matter and inorganic nutrients to the Arctic Ocean, likely fueling biological production and CO₂ emissions. To assess the impacts of Arctic coastal erosion on nearshore carbon and nitrogen cycling, we examined geochemical profiles from eroding coastal bluffs and estimated annual organic matter fluxes from 1955 to 2018 for a 9 km stretch of coastline near Drew Point, Alaska. Additionally, we conducted a laboratory incubation experiment to examine dissolved organic carbon (DOC) leaching and biolability from coastal soils/sediments added to seawater.

Three permafrost cores (4.5 – 7.5 m long) revealed that two distinct horizons compose eroding bluffs near Drew Point: Holocene age, organic-rich (~12-45% total organic carbon; TOC) terrestrial soils and lacustrine sediments, and below, Late Pleistocene age marine sediments with lower organic matter content (~1% TOC), lower carbon to nitrogen ratios, and higher δ¹³C-TOC values. Organic matter stock estimates from the cores, paired with remote sensing time-series data, show that erosional TOC fluxes from this study coastline averaged 1,369 kg C m⁻¹ yr⁻¹ during the 21st century, nearly double the average flux of the previous half century. Annual TOC flux from this 9 km coastline is now similar to the annual TOC flux from the Kuparuk River, the third largest river draining the North Slope of Alaska.

Experimental work demonstrates that there are distinct differences in DOC leaching yields and the fraction of biodegradable DOC across soil/sediment horizons. When core samples were submerged in seawater for 24 hours, the Holocene age organic-rich permafrost leached the most DOC in seawater (~6.3 mg DOC g⁻¹ TOC), compared to active layer soils and Late-Pleistocene marine-derived permafrost (~2.5 mg DOC g⁻¹ TOC). Filtered leachates were then incubated
aerobically in the dark for 26 and 90 days at 20°C to examine biodegradable DOC (i.e. the proportion of DOC lost due to microbial uptake or remineralization). Of this leached DOC, Late Pleistocene permafrost was the most biolabile over 90 days (31 ± 7%), followed by DOC from active layer soils (24 ± 5%) and Holocene-age permafrost (14% ± 3%). If we scale these results to a typical 4 m tall eroding bluff at Drew Point, we expect that ~341 g DOC m⁻² will rapidly leach, of which ~25% is biodegradable. These results demonstrate that eroding permafrost bluffs are an increasingly important source of biolabile DOC, likely contributing to greenhouse gas emissions and marine production in the coastal environment.