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

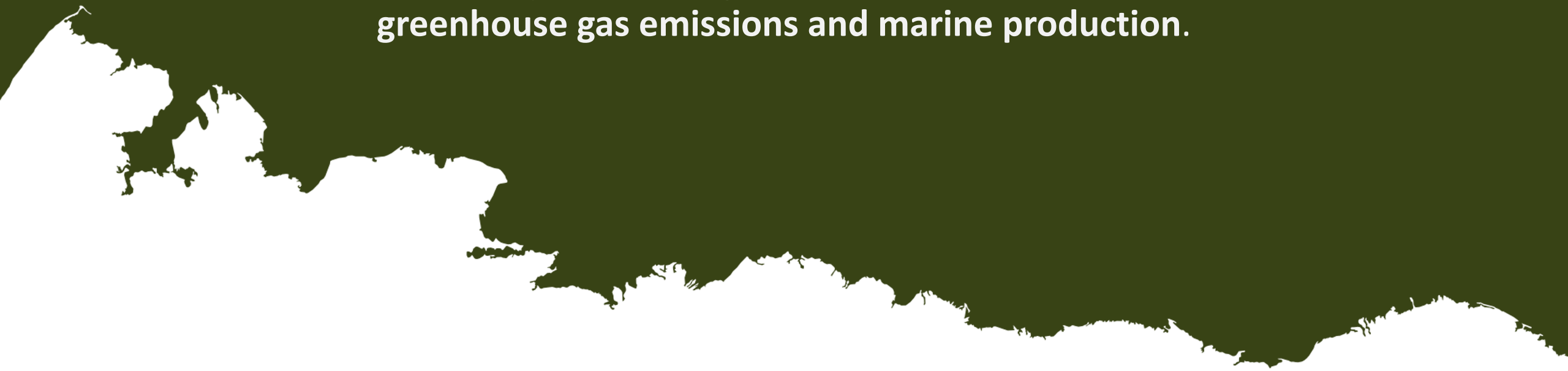
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BEAUFORT LAGOON ECOSYSTEMS LTER

Why do we care about the characteristics and quantity of organic matter eroding into the ocean?

Terrestrially-derived organic matter and nutrients fuel **greenhouse gas emissions and marine production**.

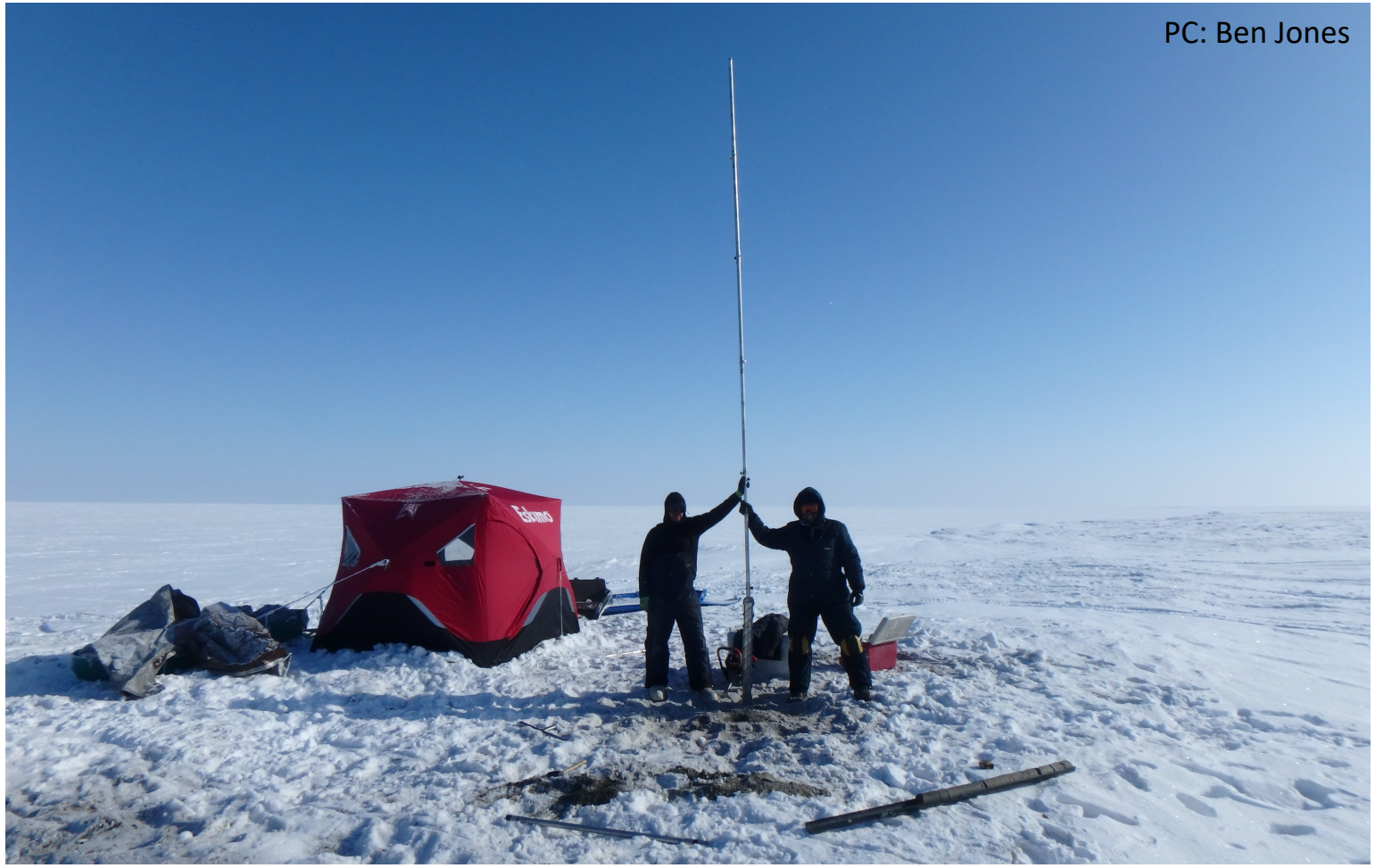


Study Site: Drew Point, Alaska

- Alaskan Beaufort Sea coast
- Tall permafrost bluffs
- Recent erosion rates average 17.2 m yr^{-1} (Jones et al. 2018).





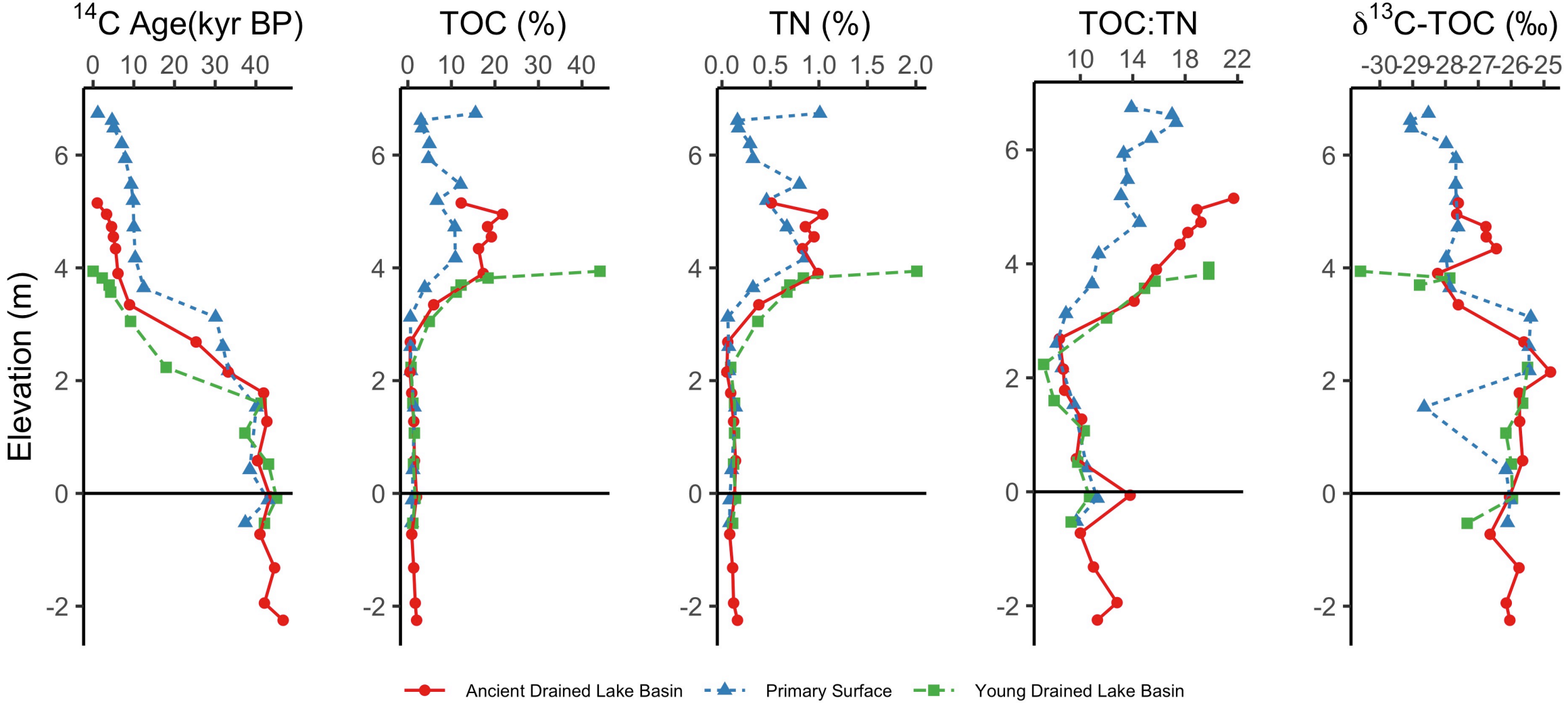


Coring Methods

3 permafrost cores near spanning from tundra surface to below sea level (~4-7 m long).

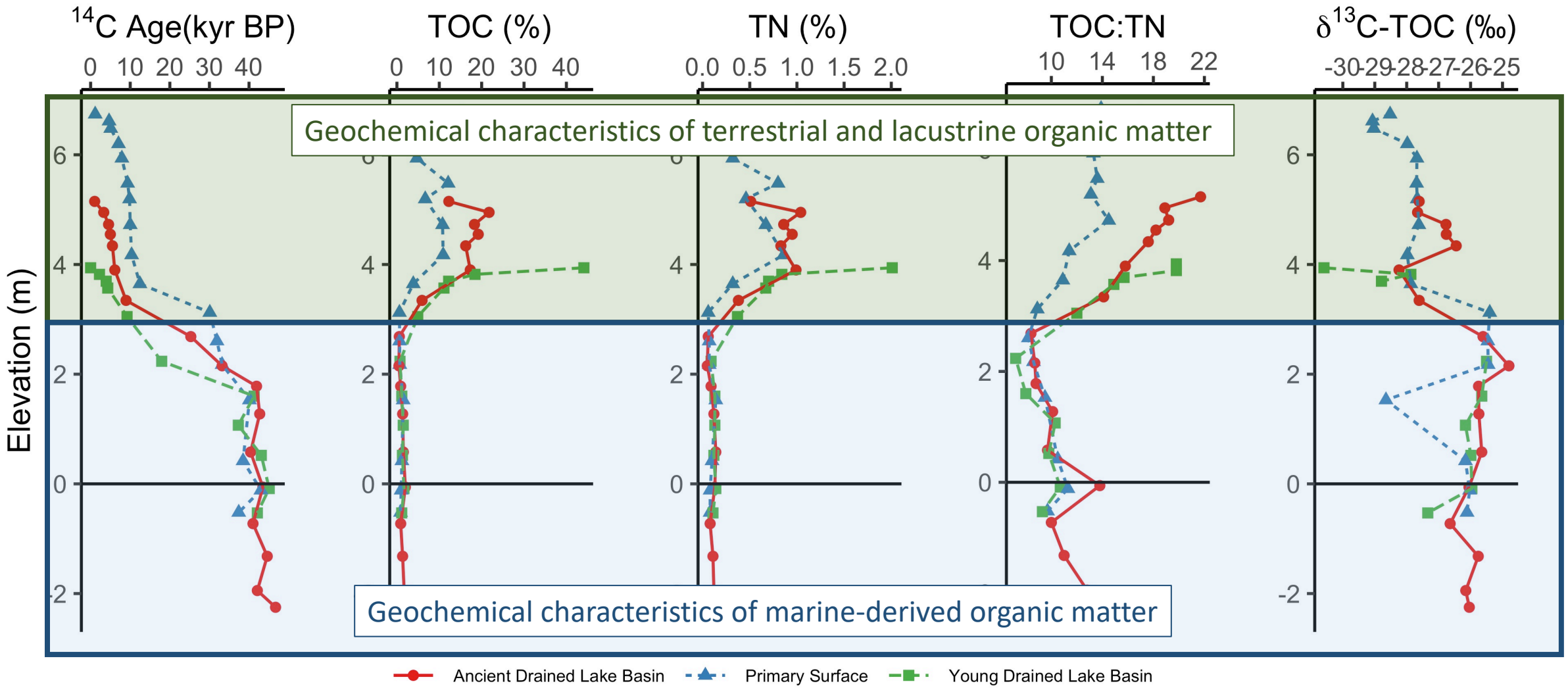
Sampled from:

- Ancient drained lake basin
- Young drained lake basin
- Primary surface (never reworked by thaw lake cycles)



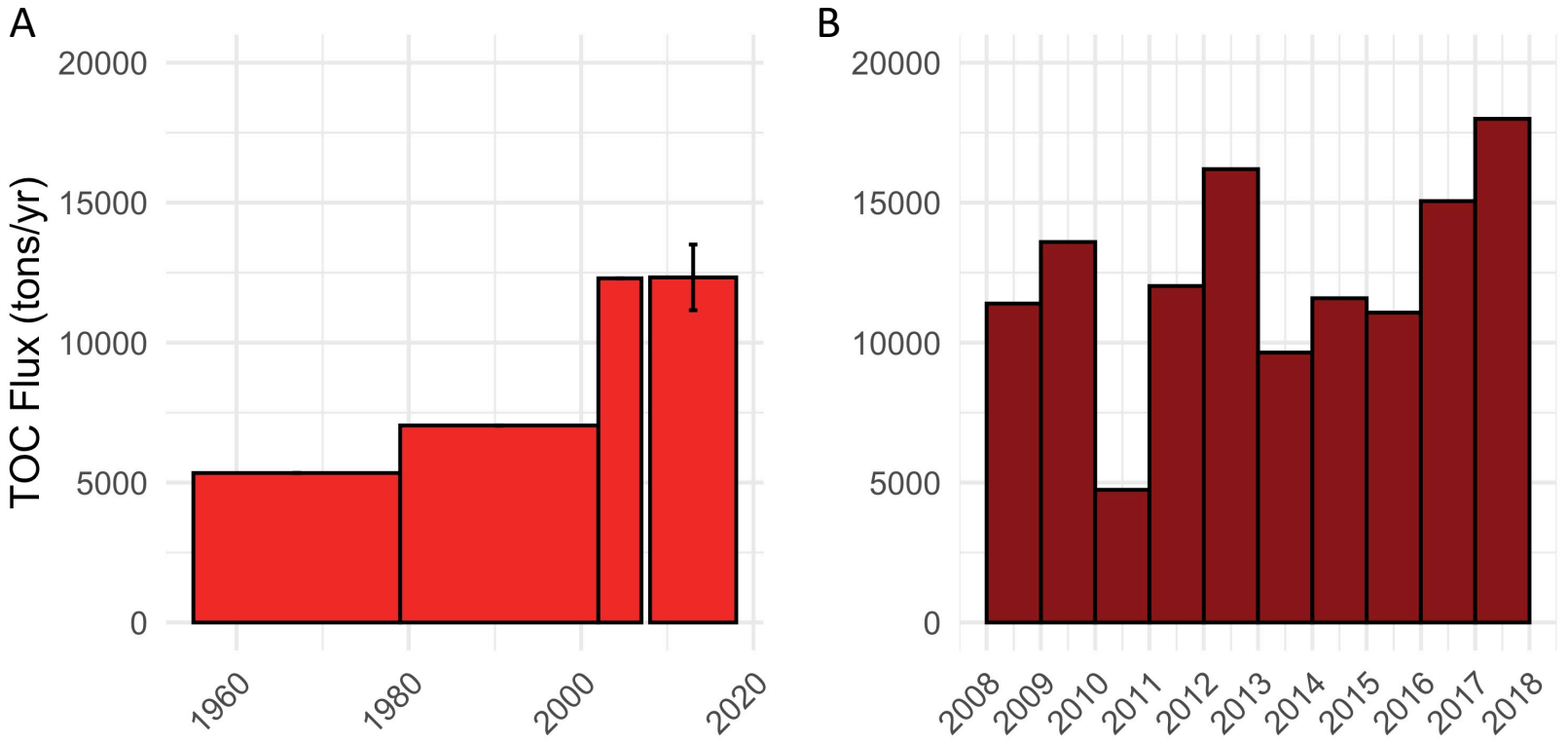
Geochemical profiles from permafrost cores

Bristol et al. 2021



Organic matter profiles from permafrost cores

Bristol et al. 2021

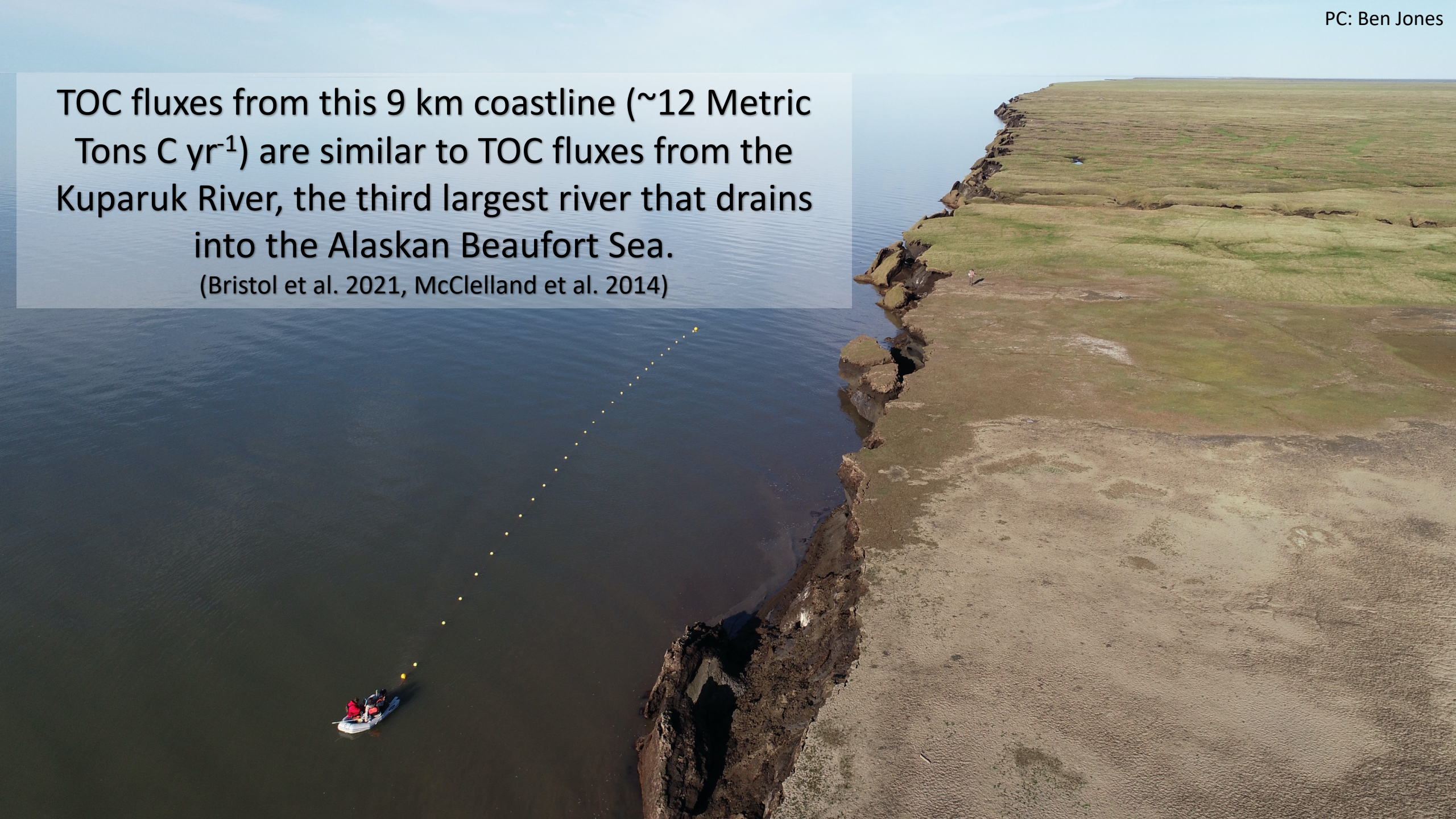


Estimation of total organic carbon fluxes to the ocean (metric tons TOC year^{-1}) from the 9 km study section **(A)** over four time steps from 1955 to 2018 and **(B)** over annual time steps from 2008 to 2018. The error bar shows standard error.

Annual TOC Fluxes

Total organic carbon (TOC) fluxes from coastal erosion at Drew Point have approximately doubled in the 21st century (2002-2018) compared to the previous half century (1955-2002).

Bristol et al. 2021



PC: Ben Jones

TOC fluxes from this 9 km coastline (~12 Metric Tons C yr^{-1}) are similar to TOC fluxes from the Kuparuk River, the third largest river that drains into the Alaskan Beaufort Sea.

(Bristol et al. 2021, McClelland et al. 2014)

Leaching: How much dissolved organic carbon (DOC) is produced when permafrost bluffs erode into the ocean?

Lability: How much DOC is incorporated into microbial biomass and/or decomposed?





Active layer (n=5)

TOC: 11.1 ± 0.02 %

Holocene age terrestrial soils and lacustrine sediments (n=3)

TOC: 11.1 ± 0.4%

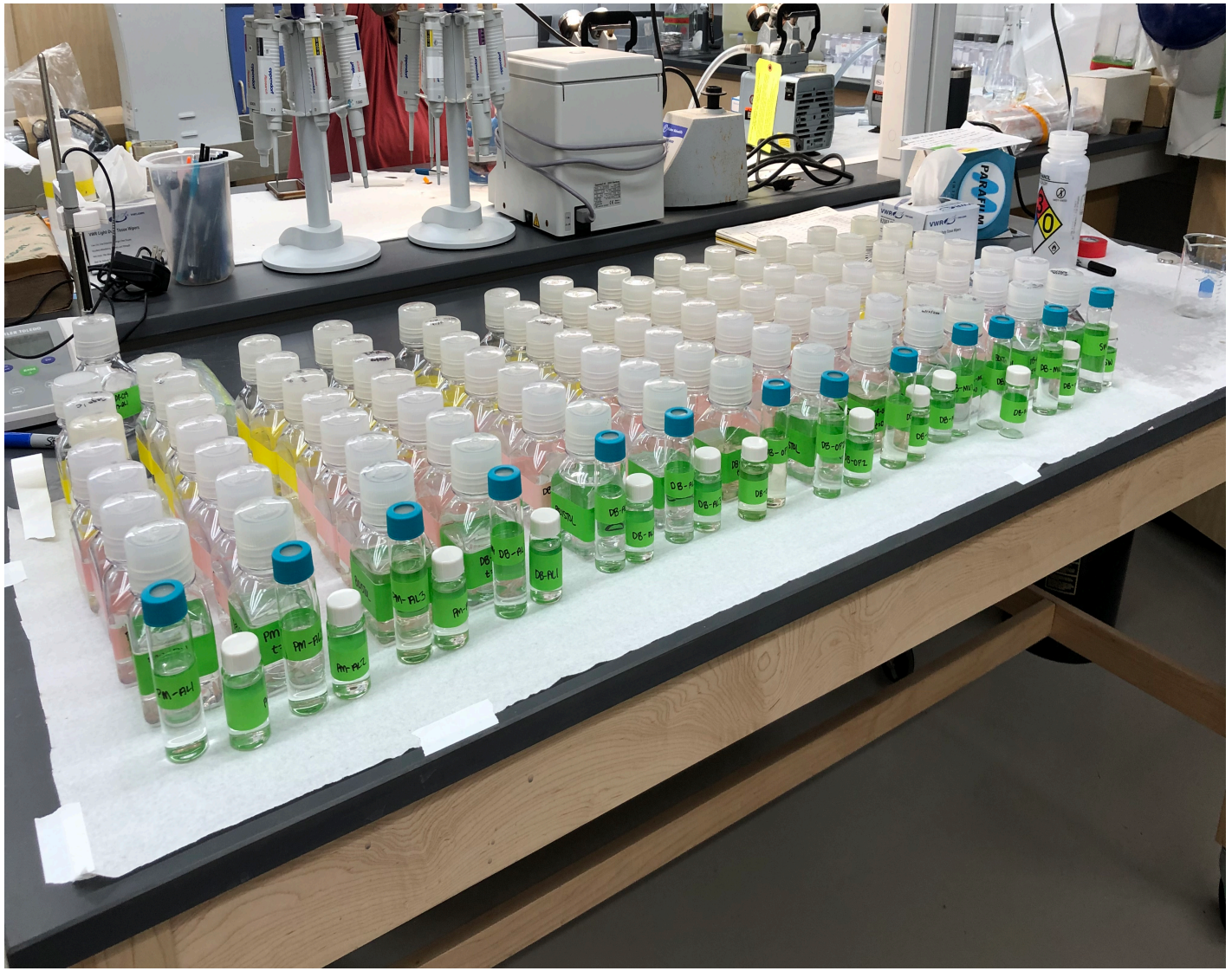
Late Pleistocene age marine sediment (n=3)

TOC: 1.7 ± 0.3 %

Soil/sediment horizons sampled for leaching and lability study

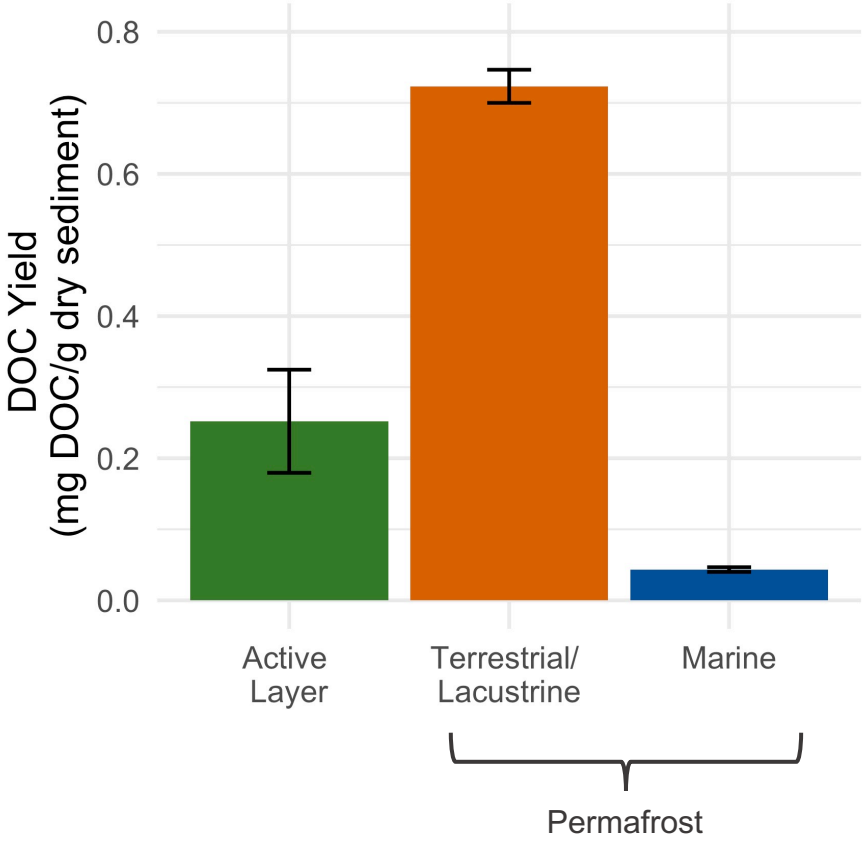
Experimental Methods

- Leach bulk soil/sediment samples in seawater for 24 hours
- GF/F filter the leachates and incubate in aerobic conditions in the dark at 20°C
- At 0, 26, 90 days, GF/F filter and measure DOC concentrations

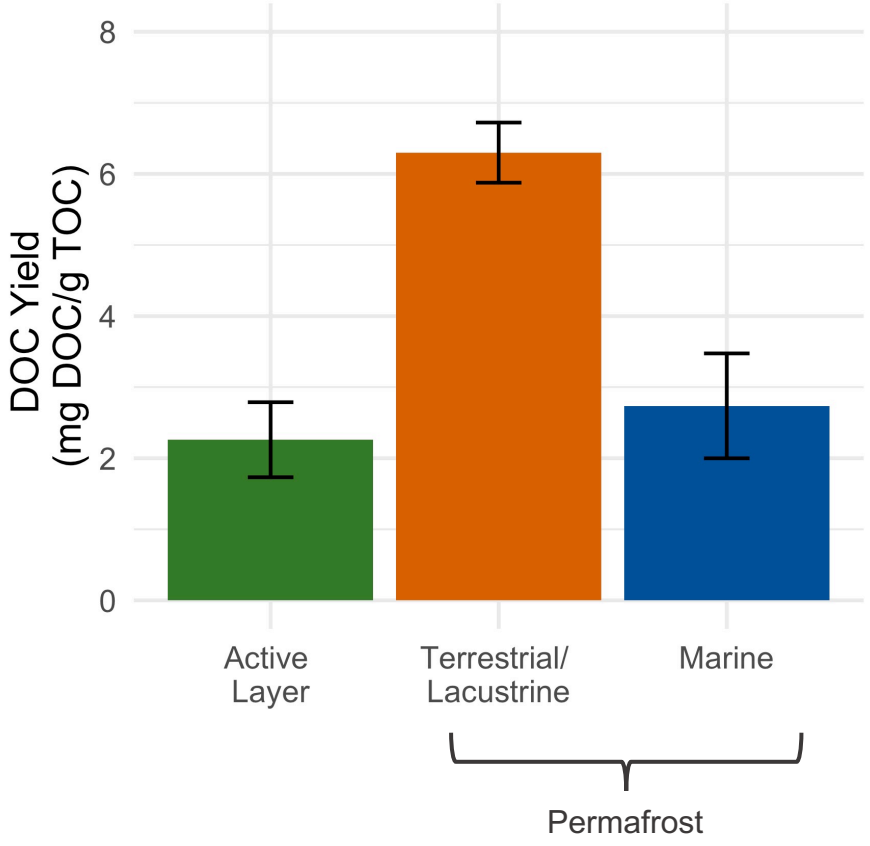


Similar to methods proposed by Vonk et al. 2015

DOC yield normalized to dry sediment

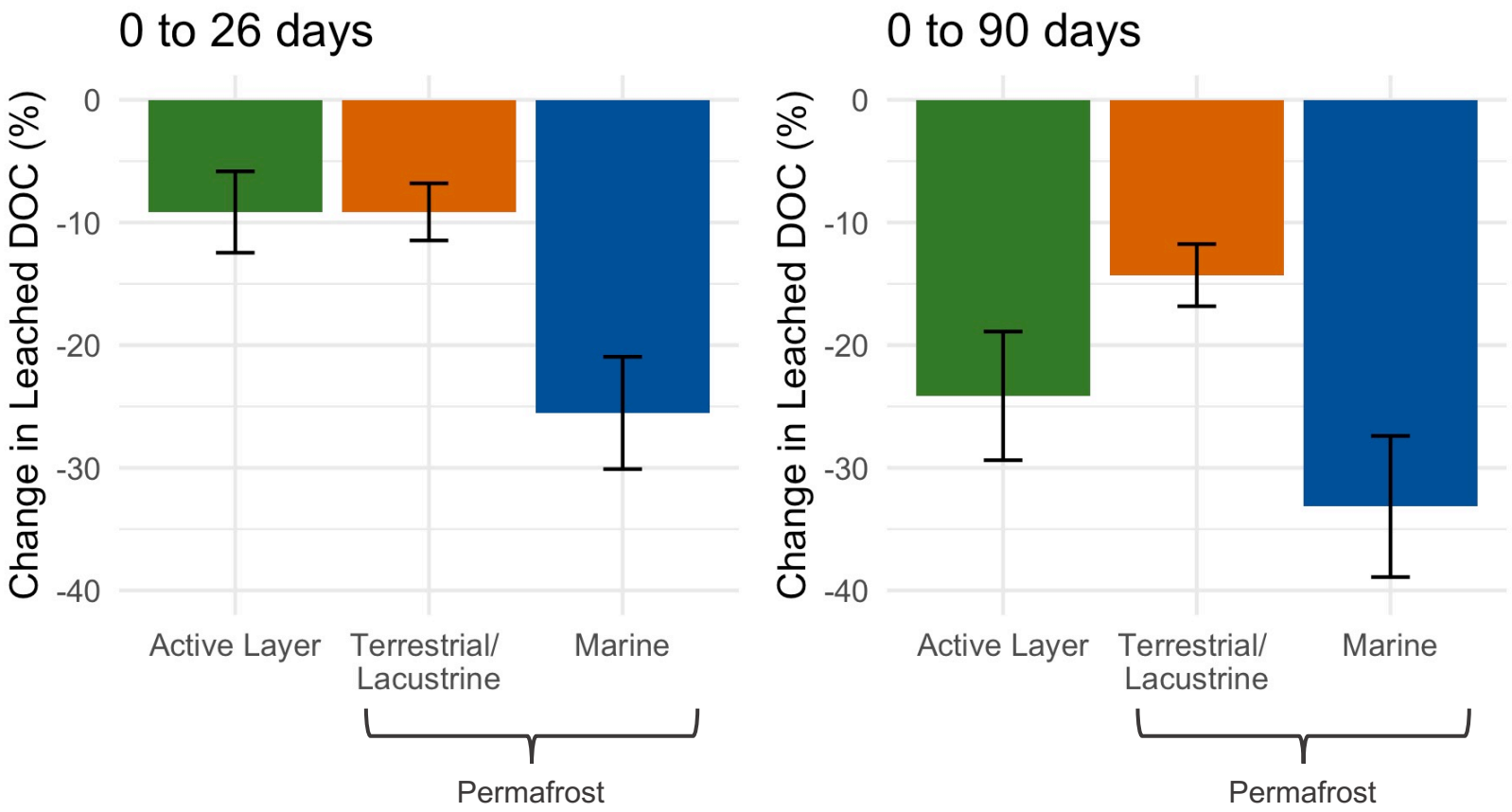


DOC yield normalized to organic carbon



DOC Leaching

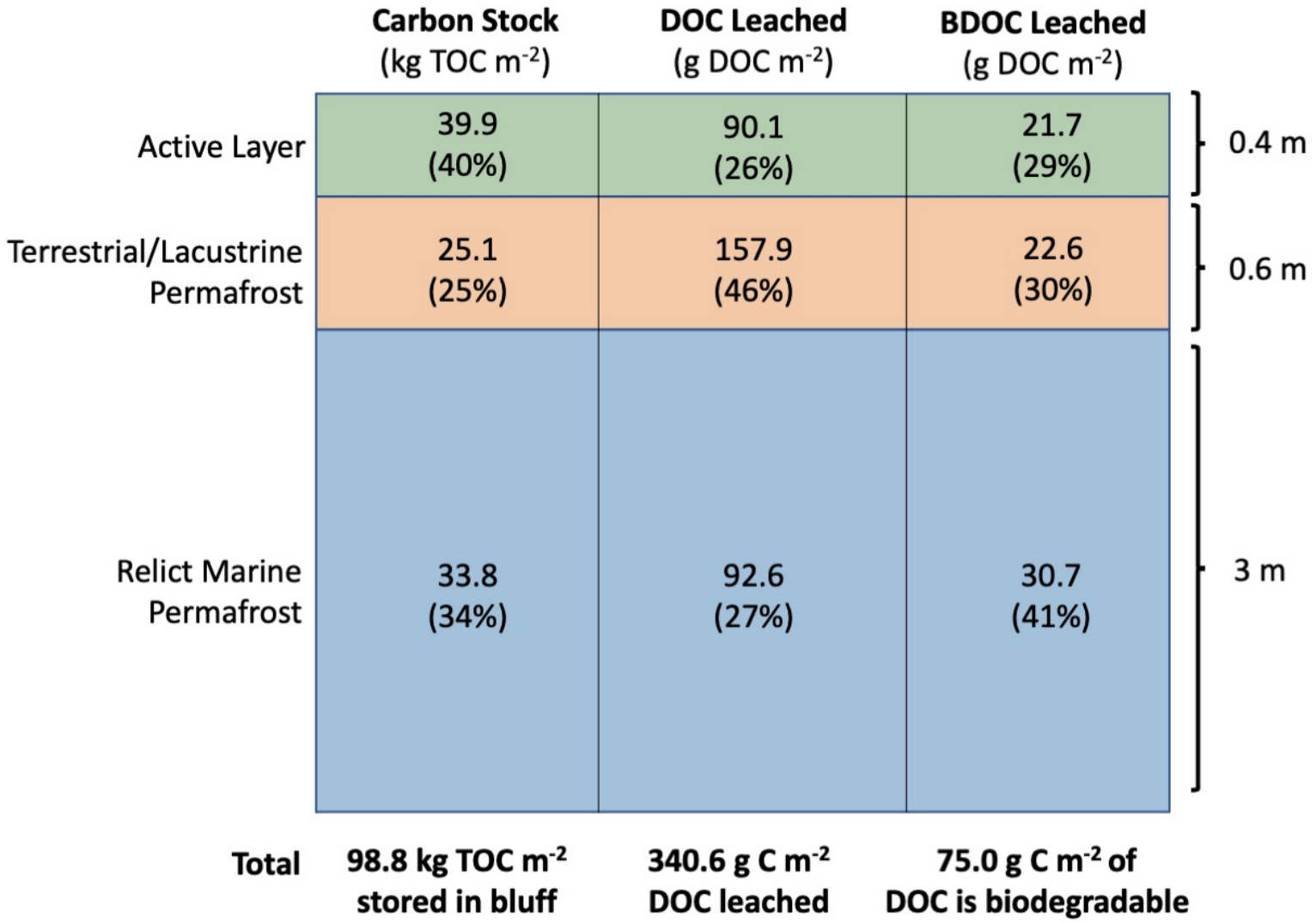
- Dissolved organic carbon (DOC) is the form of organic carbon that is easily used by microbes.
- Active layer soils leached the most DOC when normalized to dry sediment or to total organic carbon content.



Biodegradable DOC

- DOC loss represents biodegradable DOC; i.e. the DOC lost to microbial uptake or remineralization
- Late Pleistocene, marine derived permafrost contained the most labile DOC.

Scaling experimental results to a typical 4 m bluff at Drew Point



To adequately assess the amount of labile DOC produced by eroding bluffs, carbon stocks, leaching yield, and the biodegradable fraction of DOC must be considered for each soil/sediment horizon.

PC: Ben Jones

Take home messages

- Permafrost coasts are an increasingly important source of terrestrial organic matter and nutrients to the Arctic Ocean.
- Not all permafrost is the same! Source of organic matter influences geochemical characteristics.
  - Total organic carbon and nitrogen content varies greatly with depth.
  - Highest DOC leaching yields from terrestrial/lacustrine layer of permafrost
  - Highest fraction of biodegradable DOC leached from relict marine layer of permafrost
- Must consider increasing erosion rates, landscape geomorphology, organic matter stocks at depth, and organic matter leaching and lability across horizons to accurately assess the quantity and fate of organic matter entering the Beaufort Sea.



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