Elucidating coastal oceanic processes in the Canadian Arctic Archipelago using oxygen, carbon, and nitrogen isotopes

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The Canadian Arctic Archipelago (CAA), a significant portion of the Northwest Passage, and a principal conduit of Arctic Ocean water from the Pacific Ocean to the North Atlantic have been relatively understudied due to harsh weather conditions and presence of year-round ice coverage. As the region warms, and the contributions from and interactions between the ocean, cryosphere, land and meteoric exports change, so will the region's productivity and biogeochemical cycling.

Characterizing C, N, and O isotopic composition of suspended particulate organic matter (POM) and seawater can provide a baseline of source and inventory data for biogeochemical and freshwater budgets in this important and relatively undersampled region.

Objective:

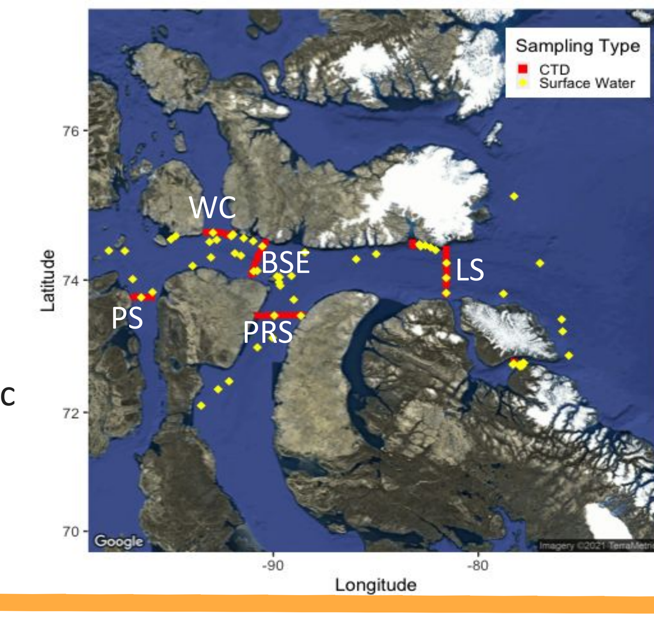
Assess what the oceanic isotopes (POC/N and H_2O) and nutrient concentrations reveal about summer biogeochemical cycling and productivity within the CAA and provide a baseline of source and inventory data for biogeochemical and freshwater budgets

Questions

i) From the O-18/Deuterium, can we determine if there are freshwater inputs of land/glacial ice melt or SIM?

ii) Can we indicate if there are signatures of terrestrial, sympagic, and marine carbon and nitrogen sources in pelagic POM using C-13/N-15?

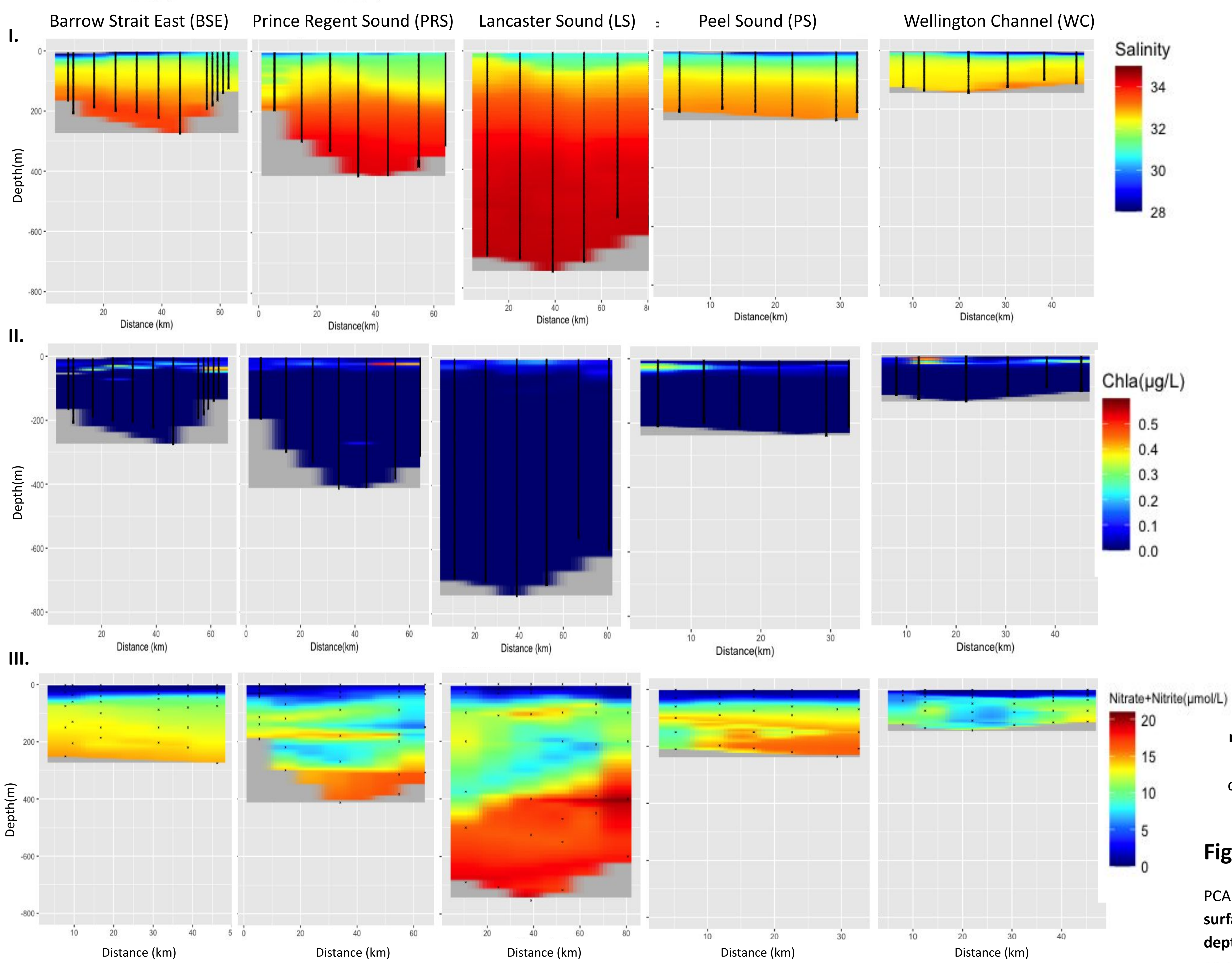
iii) Are freshwater inputs contributing nutrients/upwelling? Are the summer conditions in the CAA promoting or preventing high rates of productivity? (Nutrient and CTD fluorescence data)



Research Area:

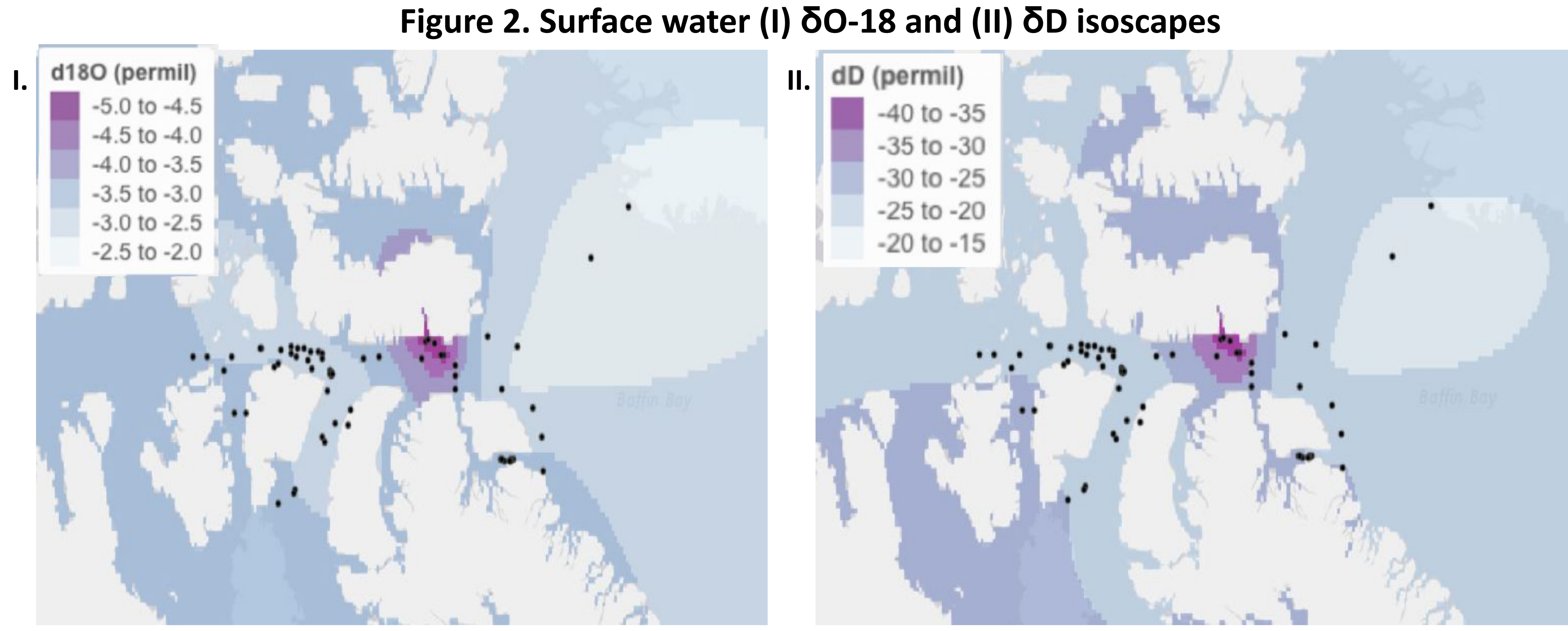
Fieldwork took place from July 17th, 2019 to August 5th, 2019. The cruise traveled west into Lancaster Sound towards Barrow Strait and back, conducting sampling transects across significant regional passages: Lancaster Sound (LS), Barrow Strait East (BSE), Wellington Channel (WC), Peel Sound (PS), Prince Regent Sound (PSR), with some additional sampling in Jones Sound, Pond Inlet, and Croker Bay

Figure 1. Water Column (I) Salinity, (II) Chl-a, and (III) Nitrate/Nitrite Profiles from Channel Transects



Stratification and nutrient limitation has led to low nitrogen-limited production. In ice free/minimal ice cover conditions (Barrow Strait, Prince Regent, Wellington), mixing in shallow channels with high flow rates are able to support pockets of low phytoplankton biomass during this end of summer season due to increase of nutrients to the surface. While in regions of high ice cover (Peel Sound) productivity is limited by both light and nitrogen. Additionally, In the most eastern transect (Lancaster Sound) the the mixing of Polar, Pacific, and Atlantic water masses is present, shown by unique layering of nitrate-nitrite concentrations

Figure 2. Surface water (I) δO-18 and (II) δD isoscapes



Depletion of O-18 in the Croker Bay region signifies the input of glacial water out of the North and South Croker Bay glaciers. The lack of nutrient input from the Croker Bay glaciers suggests low glacial flow out of Croker Bay and little to no input from subglacial sediments. Therefore, the glacial outflow does not enhance primary productivity in the NWP. West of Barrow Strait East, surface waters became colder, fresher, and more depleted in O-18, signifying the presence of sea ice.

Figure 3. Surface water (I) δ^{13}C-POM and (II) δ^{15}N-POM isoscapes

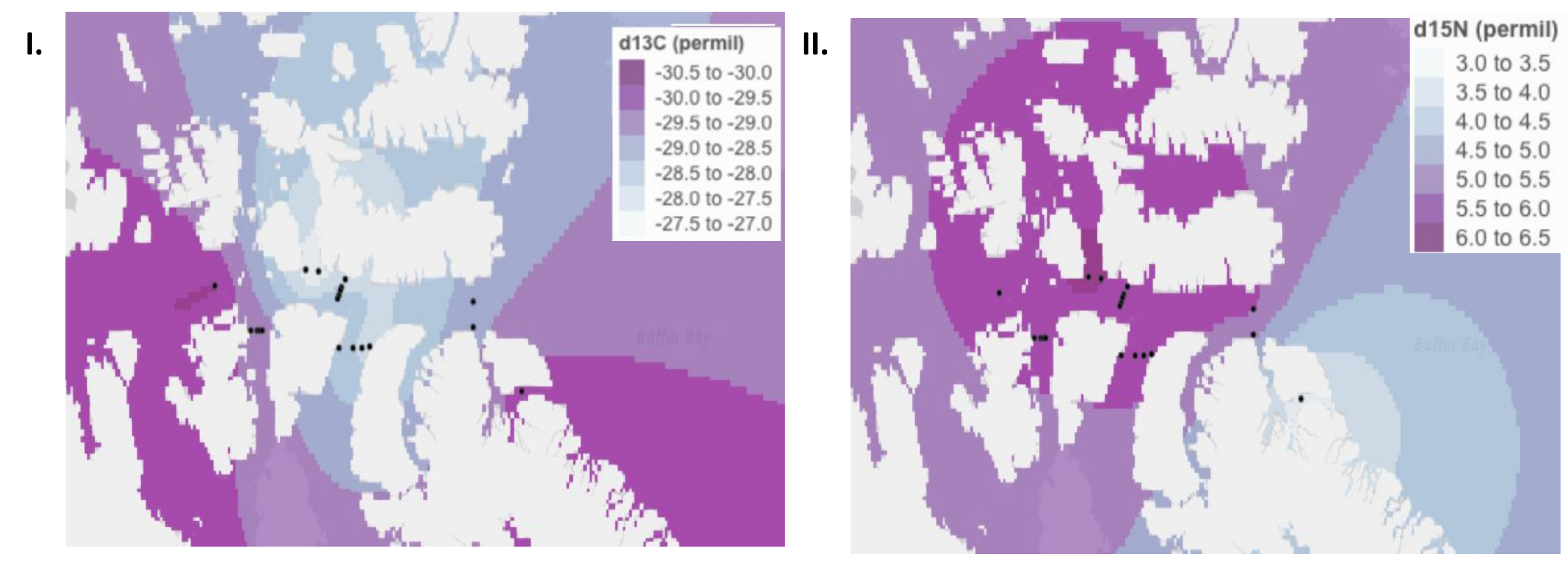
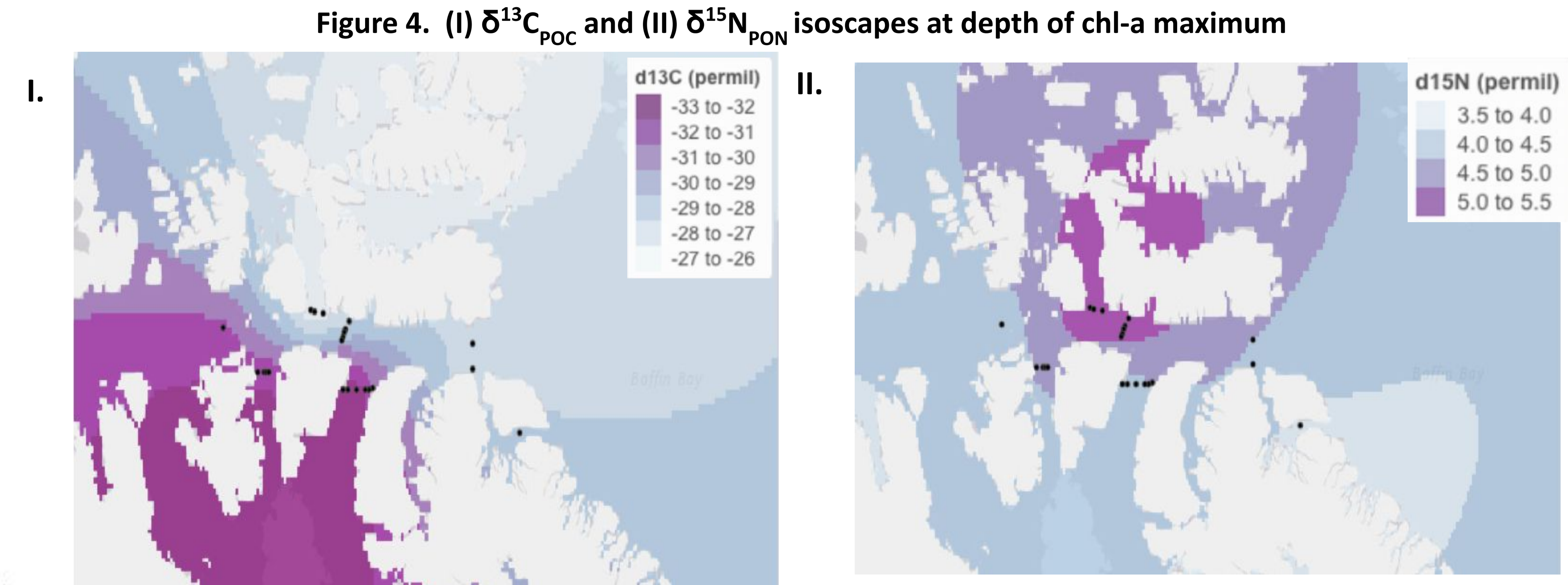


Figure 4. (I) $\delta^{13}C_{POC}$ and (II) $\delta^{15}N_{PON}$ isoscapes at depth of chl-a maximum



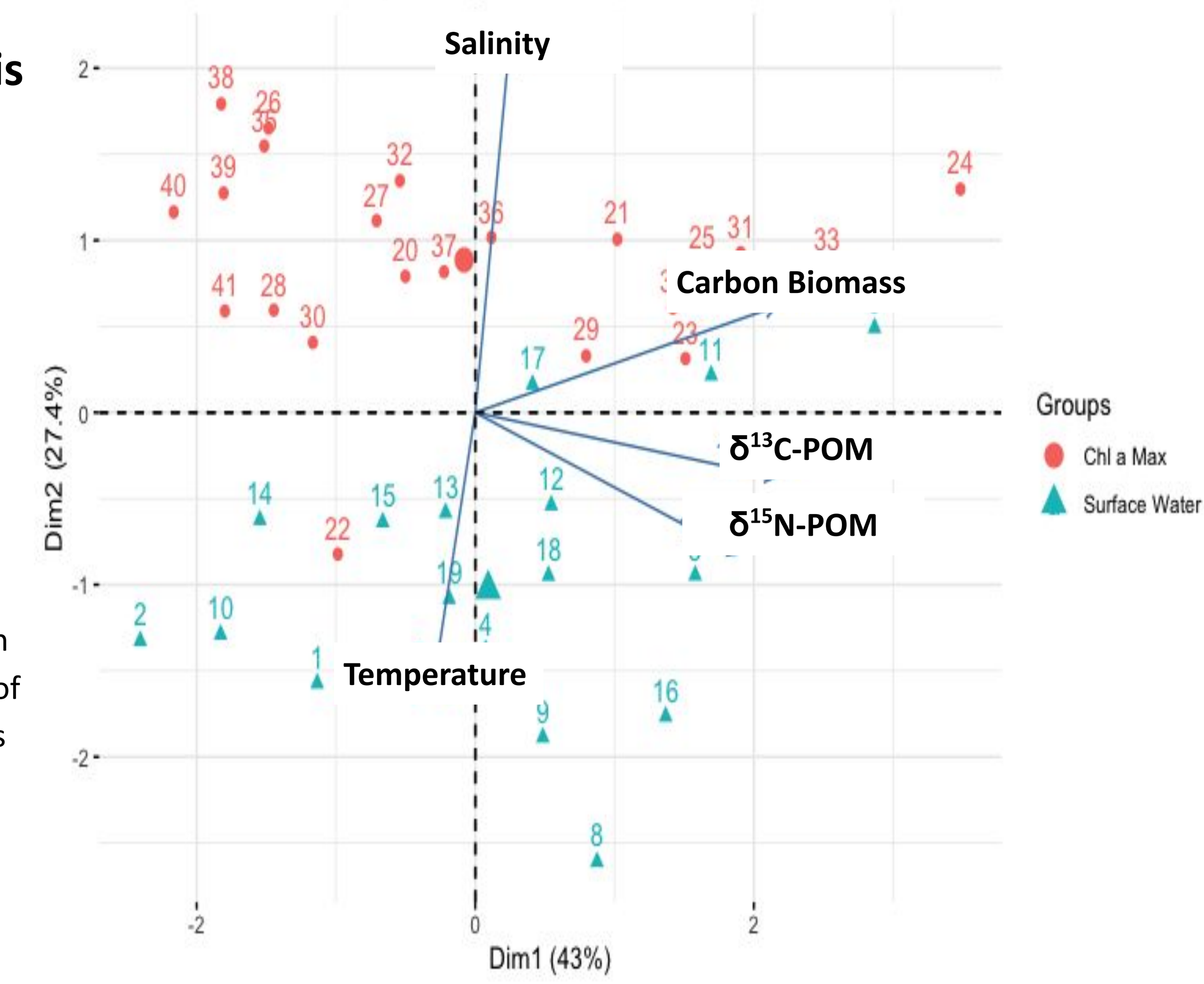
The typical range for C-13 of pelagic POM is –22 to –28 ‰ (Peterson and Fry,1987). **Our ^{13}C-POM measurements reached a minimum value of -34.2 ‰, seen in western portion of ship track.** Low values are usually seen as a sign of low/limited terrigenous imports, although our observations are depleted past terrigenous signatures. Additionally, they do not spatially correlate with depleted O-18 observations of Croker Bay, as would be expected if low signatures were terrigenous. **δ^{15}N-POM values were typical of marine derived nitrogen.**

Figure 4. Principal component analysis

PCA shows a **clear distinction between differences in surface water samples and samples from chl-a max depth.** Salinity and C biomass had a stronger influence on samples at chl-a max, while temperature more heavily affects samples at surface.

Surface: High DIC and slow algae growth are likely the causing factor of low δ^{13}C-POM as a result of low temperatures and low light.

Chl-a max depth: low δ^{13}C-POM signatures, along with a correlation of increasing POC biomass and presence of sea ice are signs of potential input of sympagic diatoms into pelagic waters, as sympagic POM gets richer in C-13 as biomass increases (Tremblay et al.,2006; Gradinger,2009, Burkhardt 1999).



Conclusions

- Summertime waters of the NWP were strongly stratified, especially with regards to salinity. Productivity was low throughout the study region and likely limited by nitrogen availability
- O-18 depletion shows there is a clear input of glacial water at the mouth of Croker Bay. The input of glacial water does not result in an increase of nutrients into Lancaster Sound, nor does it support higher rates of productivity.
- Western transects observed heavily depleted δ^{13}C-POM. PCA analysis shows that δ^{13}C-POM depletion in surface waters is a result of low light and low temperature. In contrast, salinity and POC biomass had a strong influence on C-13 samples located at chl-a maximums, providing evidence for the input of sympagic diatoms into pelagic waters, originating from western sea ice melt.

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