Using $\delta^{18}O$-H_2O to Trace Freshwater from Rivers and Sea Ice Melt in the Kitikmeot Sea

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Abstract

- The Kitikmeot Sea is a hydrologically unique region of the Canadian Arctic Archipelago.
- Significant freshwater input is provided by river discharge and local sea ice melt.
- This large influx of freshwater affects the stratification of the water column, influencing nutrient cycling.
- The southern end of Bathurst Inlet is influenced by the Burnside and Western rivers, which lower salinity due to freshwater inflows.
- The northern end of Bathurst Inlet, connected to Dease Strait and Coronation Gulf, has a higher proportion of marine water and higher salinity.
- Understanding the origin and movement of freshwater entering Bathurst Inlet is crucial because it impacts stratification, nutrient cycling, and the distribution of biological communities.

The Kitikmeot Sea

Unique Hydrological Characteristics:

- Significant freshwater input from rivers.
- Key rivers: Coppermine, Burnside, Ellice, Western.
- Influencing water circulation, salinity, stratification, and nutrient cycling.

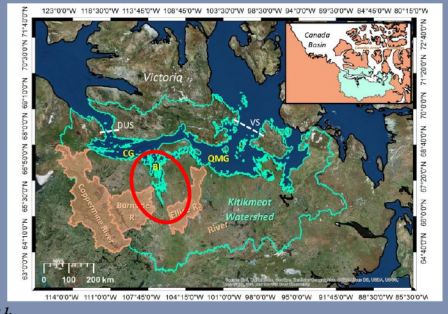


Figure 1.
Map of the Canadian Arctic Archipelago highlighting the Kitikmeot Sea, key watersheds and geographic features such as Bathurst Inlet circled in red (Williams et al., 2018).

Shallow Sills and Estuarine Circulation:

- Shallow sills in Dolphin Union Strait and Victoria Strait.
- Limit the movement of marine water flowing in.
- Creating an estuarine-like circulation.

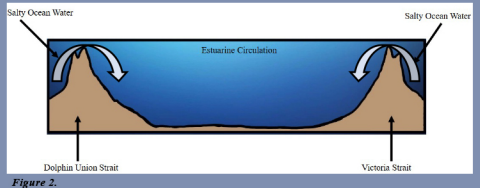


Figure 2.
An illustration of the sills from Dolphin Union and Victoria Strait in the Kitikmeot Sea.

Figure 3.
Taking δ18O samples during the Kitikmeot Sea Science Study aboard the CCG Louis St. Laurent (October 2024).

Scientific and Ecological Monitoring:

The Kitikmeot Sea Science Study (K3S, 2015-2024) is a Fisheries and Oceans led exploratory oceanographic study with three primary goals:

- Examine the Pacific-origin estuarine inflow.
- Trace the origin and movement of freshwater and its impact on stratification and mixing.
- Study biological community distributions and composition with respect to ecosystem variables (e.g., currents, salinity, nutrients).

Literature Cited

- *Williams, W., Brown, K. A., Bluhm, B., Carmack, E. C., Dalman, L., Danielson, S. L., ... & Schimnowski, A. (2018). Stratification in the Canadian Arctic Archipelago's Kitikmeot Sea: biological and geochemical consequences. Polar Knowledge, 1, 46-52*
- *Ostlund, H. G., & Hut, G. (1984). Arctic Ocean water mass balance from isotope data. Journal of Geophysical Research, 89(C4), 6373–6381. https://doi.org/10.1029/JC089iC04p06373 Popova, E. E., Yool, A., Coward, A. C., Aksenov, Y. K., Alderson, S. G., De Cuevas, B. A., & Anderson, T. R. (2010). Control of primary production in the Arctic by nutrients and light: insights from a high resolution ocean general circulation model. Biogeosciences, 7(11), 3569-3591*

Bathurst Inlet

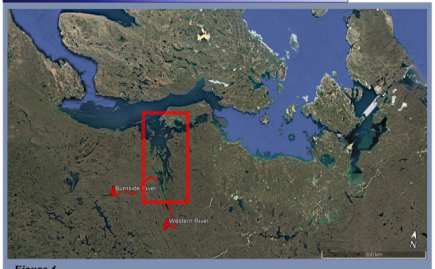


Figure 4.
Google Earth image of the Kitikmeot Sea, with Bathurst Inlet denoted with a box (shown in Figure 5). The Burnside and the Western rivers, the main sources of river water into the inlet.

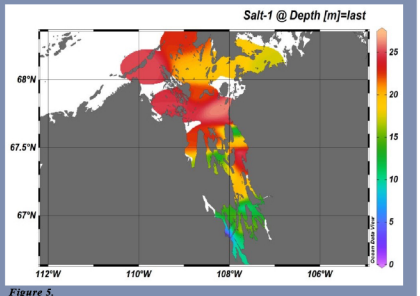


Figure 5.
Salinity (PSU) of the surface waters in Bathurst Inlet. The Burnside and Western rivers cause the southern end of the Inlet to have lower surface salinities than the northern end.

Mixing End Members: f1, f2, and f3

Methods: We follow Östlund and Hut's (1984) approach for a three-end member mixing model to determine the fraction of marine water, meteoric water, and sea ice melt in each water sample based on the observed δ18O and salinity values (Table 1).

End Member	Salinity (PSU)	$\delta^{18}O$-H_2O (‰)
f1: Marine Water	28.6*	-3.83*
f2: Meteoric Water	0	-19.5
f3: Sea Ice Melt	4	-2

Table 1.
Salinity (PSU) and $\delta^{18}O$-H_2O (‰) values for marine water (f1), meteoric water (f2), and sea ice melt (f3) end members in Bathurst Inlet.

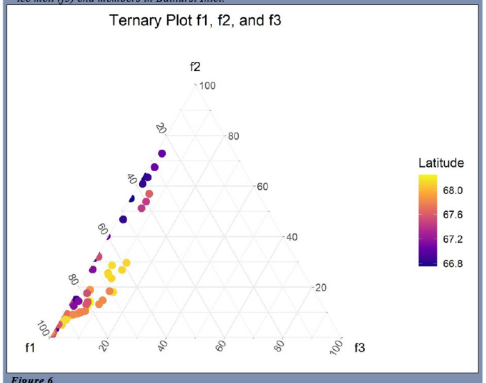


Figure 6.
Ternary plot showing the results of the mixing model, illustrating the proportions of marine water (f1), meteoric water (f2), and sea ice melt (f3) colored by latitude for profile samples from Bathurst Inlet.

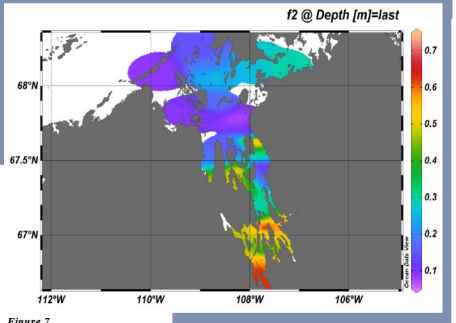
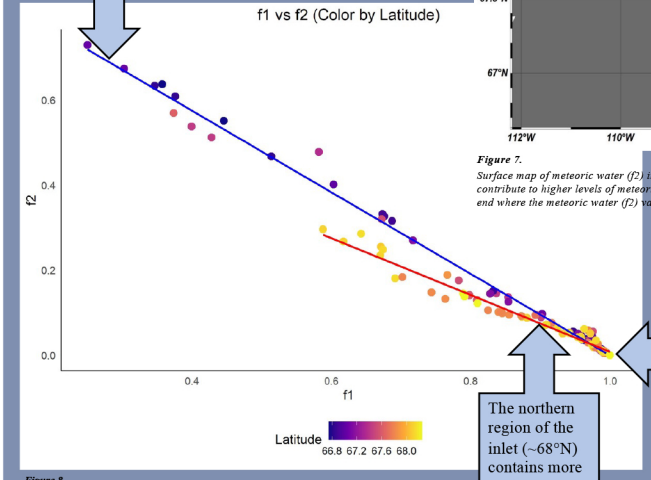


Figure 7.
Surface map of meteoric water (f2) in Bathurst Inlet. The Burnside and Western rivers contribute to higher levels of meteoric water (f2) in the south end, compared to the northern end where the meteoric water (f2) values are lower.

The southern region of the inlet (~67°N) contains more meteoric water (f2).

- The water in Bathurst Inlet is composed primarily of marine water (f1) and meteoric water (f2).
- Sea ice melt (f3) is negligible.



The data starting in the same corner indicates that the marine water (f1) originates from a similar source.

The northern region of the inlet (~68°N) contains more marine water (f1).

Figure 8.
Scatter plot displaying the mixing model results of marine water (f1) versus meteoric water (f2), colored by latitude, for profile samples from the Bathurst Inlet dataset. A clear latitude-based deviation is observed, with lighter yellow/orange colors representing higher latitudes (~68°N), marked by a red linear regression line, and darker blue/purple colors representing lower latitudes (~67°N), marked by a blue linear regression line.

Next Steps

- Compare the data with marine end members from the Canadian Basin to assess how fresh the Bathurst Inlet dataset truly is.
- Investigate potential pathways of water movement within Bathurst Inlet, examining how it enters with higher salinity and exits with lower salinity. Could this process be modeled?
- Explore whether Bathurst Inlet could be classified as an estuary to better understand its ecological characteristics.
- Quantify the volume of freshwater entering Bathurst Inlet: We have confirmed the sources of freshwater, but how much is entering the inlet.
- Examine alkalinity and ion concentrations in the dataset to further characterize water quality and potential movement pathways.

Acknowledgements

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