Cruise ship-based ocean observations in the Canadian Arctic

OT44C-1642

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1. Utilization of Passenger Cruise Ships for Data Collection

The Canadian Arctic's vital climate-and carbon (C) regulating role hinges on ice and freshwater exports, alongside high productivity rates. Variability in freshwater inputs from the Canadian Arctic Archipelago (CAA) may disrupt water stability, phytoplankton function, and ocean productivity. **Currently, there is limited in situ data on the spatial and temporal variability of freshwater inputs and phytoplankton productivity in the CAA.**

Observations and experiments carried out in the CAA aboard passenger cruise ships with fixed routes and yearly trips can improve our understanding of the physical, biological, and chemical properties in this historically understudied and difficult-to-access region.

Recently, research and commercial vessels have been adopting **underway seawater flow-through observations**, using autonomous instruments for continuous measurement of ocean properties. This approach can enhance our understanding of physical, chemical, and biological aspects in a historically understudied region, such as CAA, complementing traditional depth profiles.

Main Objectives

1.Determine how inputs of freshwater alter water column physical and chemical composition throughout Canadian Arctic coastal waters and the North Atlantic

2.Determine how freshwater inputs influence photosynthesis, C uptake, and nutrient utilization of phytoplankton communities in the region

2. Methods

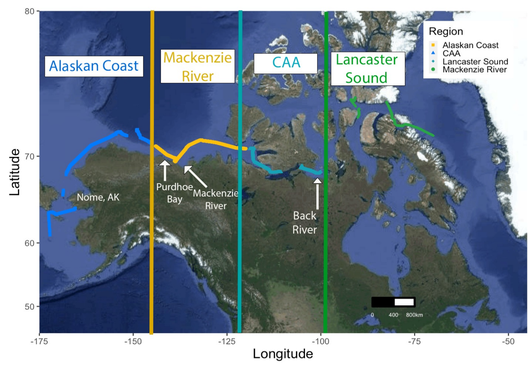
MS Roald Amundsen

The MS Roald Amundsen is a science-focused passenger cruise ship, equipped with underway sensors and a "science center" where guests can engage in research, data collection, and science lectures.

Research Area & Measurements

Data was collected during summer 2022 and 2023 (23 August to 17 September 2022 and 19 August to 12 September 2023) from Nome, Alaska to Pond Inlet, Nunavut

Research Area



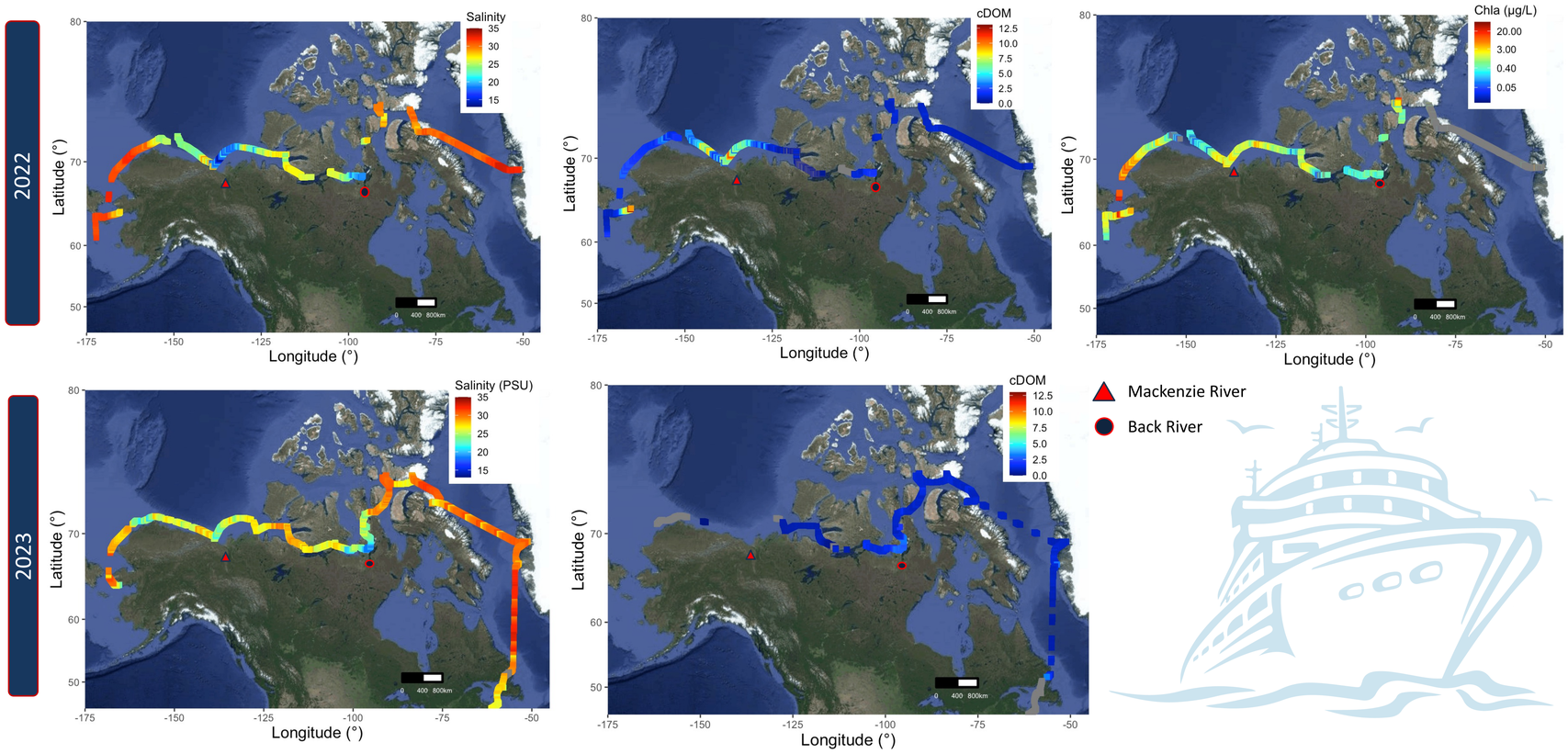
FerryBox Underway Sensors

- **FerryBox Continuous Measurements:** Temperature, salinity, oxygen concentration, oxygen saturation, chlorophyll *a* , cDOM fluorescence, turbidity, at a depth of ~4-7m
- **Chelsea LabSTAF:** Measures phytoplankton productivity using single turnover active fluorescence - light saturation index (Ek), photosynthetic stress (Fv/Fm), gross primary productivity per unit volume, and gross oxygen production (mol O_2 m^{-3} s^{-1})
- **Inorganic nutrients** (nitrate/nitrite, phosphate, silicate)
- **Stable isotopes** of water and particulate organic matter (δO^{18}_{H2O}, δC^{13}_{POM} & δN^{15}_{POM})

3. Results – Underway Sensor Observations

Figure 2: Salinity, cDOM, and Chla along ship track

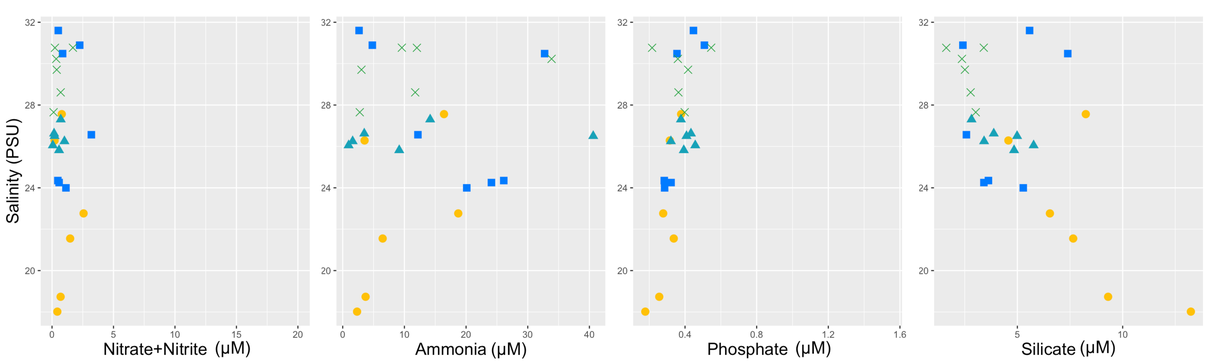
The lowest salinity and highest cDOM were observed near Mackenzie and Back Rivers. The highest chl-a was observed in Pacific Waters along the Alaskan coast and within the outflow of the Mackenzie River.

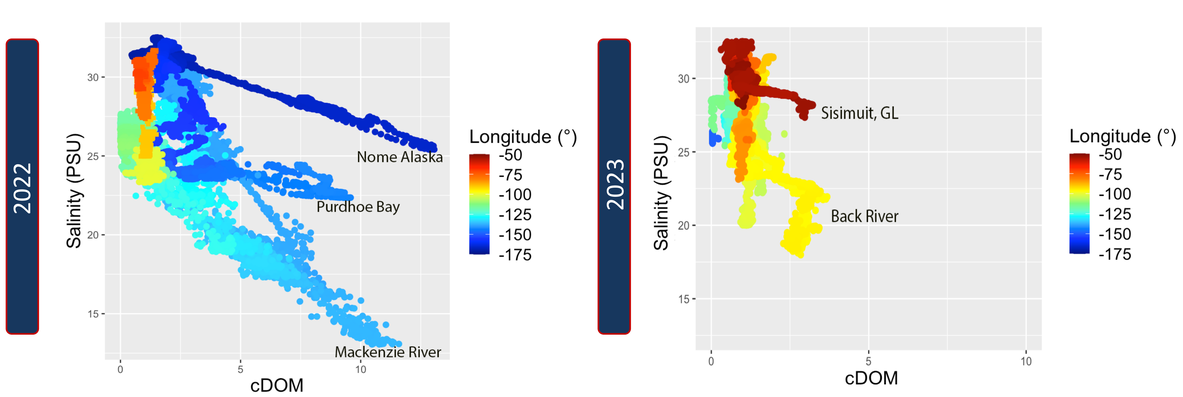


4. Results – Salinity and Nutrients

Figure 2: Salinity vs Nutrients and cDOM

During 2022, nitrate+nitrite and phosphate were depleted throughout the ship track. Silicate and cDOM increased with lower salinity, with the highest concentrations at Nome, Mackenzie River region, and Prudhoe Bay. These sites are known to have freshwater inputs from local rivers. Nitrate+nitrite and phosphate inputs were likely utilized closer to river drainage regions.





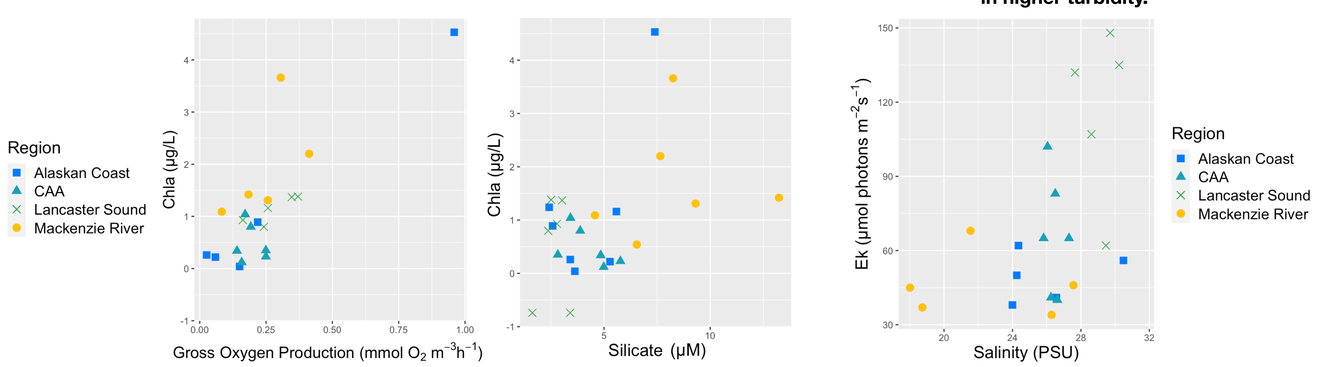
5. Results – Chla, Productivity, and Light Saturation

Figure 3: Chla vs Silicate, Gross Oxygen Production

Chla was positively correlated with gross oxygen, with the highest production along the Alaskan Coast and Mackenzie River. Chla was positively correlated with silicate, specifically in the Mackenzie River region. Nutrient input from river output is a likely driver of higher regional production.

Figure 4: Light Saturation vs Salinity

Phytoplankton within the Mackenzie River region is low light adapted compared to high light adaption within Lancaster Sound, likely due to higher turbidity and cDOM concentrations. However, low salinity did not always result in higher turbidity.



6. Conclusions and Future Directions

Productivity peaks in nutrient-rich Pacific waters along the coast of Alaska and within the Mackenzie River outflow. However, productivity remains low throughout the CAA, with slight increases due to nutrient inputs from Canadian mainland rivers. River inputs are likely supplying nutrients to the nutrient-depleted waters, which are being rapidly utilized before reaching open ocean waters.

Future work will use stable isotope analysis of surface water and particulate organic matter to quantify and distinguish freshwater and nutrient sources and assess how they affect water column stability. Additionally, underway ship data will be compared to satellite data to expand the temporal and spatial analysis.

Leveraging passenger cruise ships and underway systems offers accessible means to enhance data collection. Engaging passengers further amplifies opportunities for data acquisition, education, and outreach in the region.

Acknowledgements: Samira Umar, MS Roald Amundsen crew and technicians, The Inuit communities of Ikaluktutiak (Cambridge Bay), Uqsuqtuuk (Gjoa Haven)