The impact of wastewater outflow on local primary production in Cambridge Bay, Nunavut

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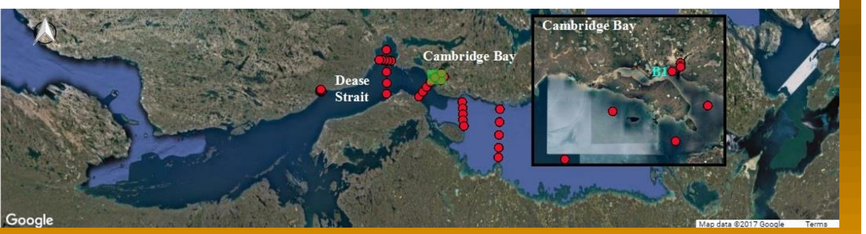
Abstract

Cambridge Bay is being heavily influenced by anthropogenic stressors, including indirect impacts associated with climate change and direct through local human activities. In the current study, we will examine the impact of wastewater effluent on local primary production through a comparison of regional versus local variability in phytoplankton production and biomass in Dease Strait. Data from annual summer cruises aboard the *R/V Martin Bergmann*, spanning 2013-2017, are presented in support of the analysis.

Research Field



Objectives & Methods

Objectives

1) Quantify regional versus local wastewater outflow nutrient budgets of Cambridge Bay; and
2) Assess the impact of wastewater associated with nutrient enrichment on primary production and taxonomic composition relative the regional observations.

Methods

- A 5-year dataset of nutrient concentrations and phytoplankton standing stocks in Dease Strait near Cambridge Bay is being compiled and analyzed.
- Nutrient concentrations, phytoplankton biomass and composition, and primary production in the Bay will be determined.

Analysis Tools	Measurements
Nutrient AutoAnalyzer	PO_4, NO_3+NO_2, $Si(OH)_4$ and NH_4
High Performance Liquid Chromatography (HPLC)	The concentrations of photosynthetic pigments
CHEMTAX Program	The contribution of phytoplankton groups to total chlorophyll *a*
The ^{13}C method	Local primary production

Table 1. Analysis methods for nutrients, phytoplankton biomass and composition, and local primary production

- Elevated NO_3+NO_2 within Cambridge Bay (a),
- N:P (b) and N:Si (c) ratios averaged 1.29 and 0.21, respectively (does not include Cambridge Bay stations).

→ Suggests N-depleted system.

- N:P (b) and N:Si (c) ratios were an average 7 times greater within Cambridge Bay.

→ Suggests N-enhanced system.

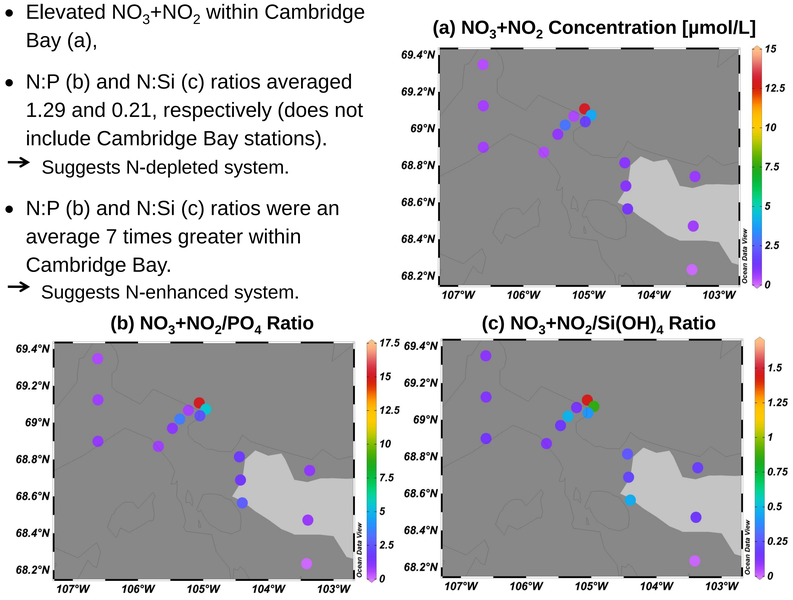


Figure 1. Map of water column averaged (2013-2015): (a) NO_3+NO_2 concentration [µmol/L]; (b) NO_3+NO_2/PO_4 ratio; (c) NO_3+NO_2/$Si(OH)_4$ ratio

- **<u>NO_3+NO_2 concentration was more than 10 times higher in 2014 than in 2013 or 2015 and spread out into surface waters outside of the Bay, but $Si(OH)_4$ and PO_4 did not show an increase.</u>**

  Chaves-Barquero (2016) shows wastewater effluent to be enhanced in nitrogen, but not phosphate.

- **Elevated nutrient concentrations were consistently observed at depth within Cambridge Bay.**

  These nutrients reflect enhanced supply from anthropogenic sources in the Bay and were likely restricted from mixing into Dease Strait by strong surface stratification and a 25 m shoal at the mouth of the Bay.

Year	2013	2014	2015
Ice break-up	16 July	26 July	21 July
Sampling	22 July	28 July	6 August

Table 2. The date of ice break-up and of sampling from 2013 to 2015

- **Heavy rainfall during the sea ice and the wetland melt in 2014 may have led to the large pulse of nutrient concentration observed in the Bay in late July.**

  The total rainfall in July: 48.6 mm (2013), 85.6 mm (2014), 59.4 mm (2015)
  2013, 2014, 2015 were sampled 6 days, 2 days, 16 days after ice break-ups, respectively.

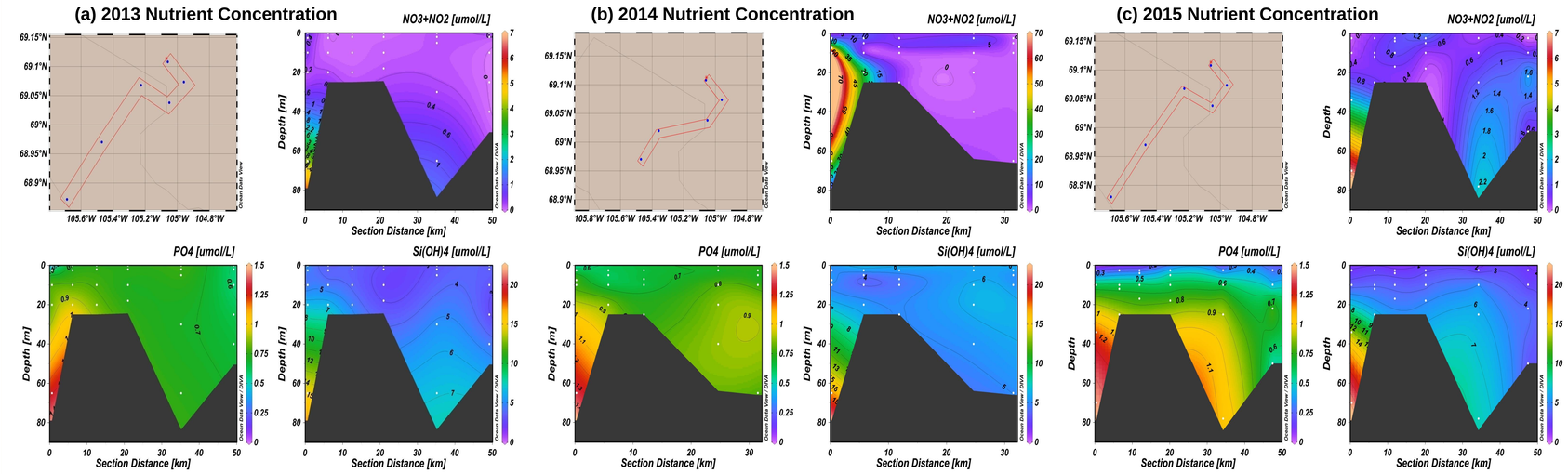


Figure 2. Nutrient Concentrations (Cambridge Bay - Dease Strait): (a) 2013 PO_4, NO_3+NO_2 and $Si(OH)_4$ concentrations; (b) 2014 PO_4, NO_3+NO_2 and $Si(OH)_4$ concentrations; (c) 2015 PO_4, NO_3+NO_2 and $Si(OH)_4$ concentrations

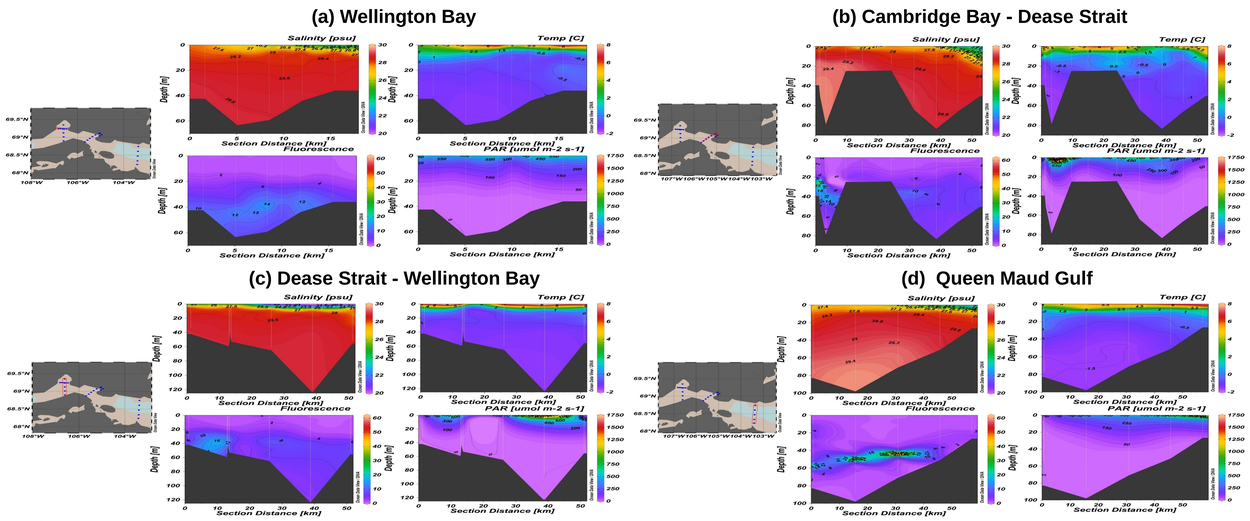


Figure 3. Regional ocean conditions (salinity, temperature, fluorescence and photosynthetically active radiation (PAR) from 2013 CTD data): (a) Wellington Bay; (b) Cambridge Bay - Dease Strait; (c) Dease Strait – Wellington Bay; (d) Queen Maud Gulf

- The region is characterized by low salinity, strong surface stratification, and a deep chlorophyll maximum (DCM).
- Salinities reached their highest values within Queen Maud Gulf and Cambridge Bay.
- High chlorophyll fluorescence between 20 and 50 m within Cambridge Bay; however most chlorophyll fluorescence below euphotic zone (b)

  → Suggests a post bloom settling of organic matter within the Bay.

- Highest chlorophyll fluorescence observed in DCM in Queen Maud Gulf. (d)

Conclusion

- **A strong nitrogen source is apparent within Cambridge Bay relative to the surrounding region.**

  → Evidence supports anthropogenic sources.

- **Enhanced production is likely trapped within the Bay, which could exacerbate the anthropogenic influence on the local system.**

Future Research

- Collect samples twice each year both before wastewater discharge and during wastewater discharge, from 2018 to 2019.
- Measure nutrient concentrations, phytoplankton biomass and composition, and primary production.
- Determine the impact of nitrogen effluent on microbial community composition and primary production.

References

Chaves-Barquero, L.G., Luong, K.H, Mundy, C.J., Knapp, C.W., Hanson, M.L., and Wong, C.S., 2016. The release of wastewater contaminants in the Arctic: A case study from Cambridge Bay, Nunavut, Canada. Environ. Pollut, 218, 542-550.

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Acknowledgements

Laura Dalman, Lisa Matthes, Dr. Aurelie Delaforge, Dr. Ha, Sun-Yong, The *R/V Martin Bergmann* crew, Nicole Pogorzelec, CEOS, and University of Manitoba