Tidal straits as hotspots for ice algal production: A case study in the Kitikmeot Sea

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Background

- Ice algae inhabit the bottommost centimeters of the sea ice, known as the skeletal layer, at the ice-water interface
- This habitat provides access to the nutrients in the water column below and light from above for photosynthesis
- Ice algae represent an important component of the Arctic marine ecosystem, providing a springtime pulse of primary production when other sources are at a minimum, however, climate induced change in ice cover is expected to greatly affect their role (Leu *et al.*, 2015)

Objectives

1. Investigate the influence of sub-ice current velocities on sea ice thickness across the tidal strait
2. Examine how the current gradient influences the nutrient flux to ice algal communities in relation to the influence on nutrient access/ocean-ice heat flux
3. Examine whether gradients in ice algal taxonomy and photophysiology exist along the tidal strait gradient investigated in objective 1

Methods

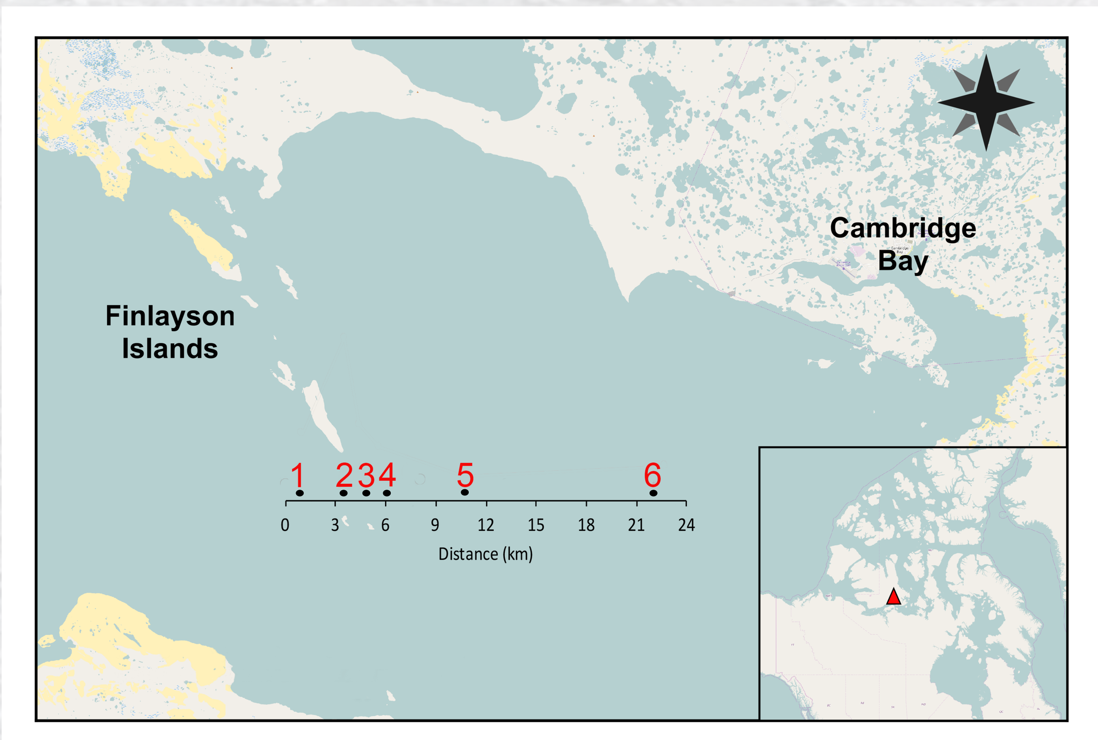
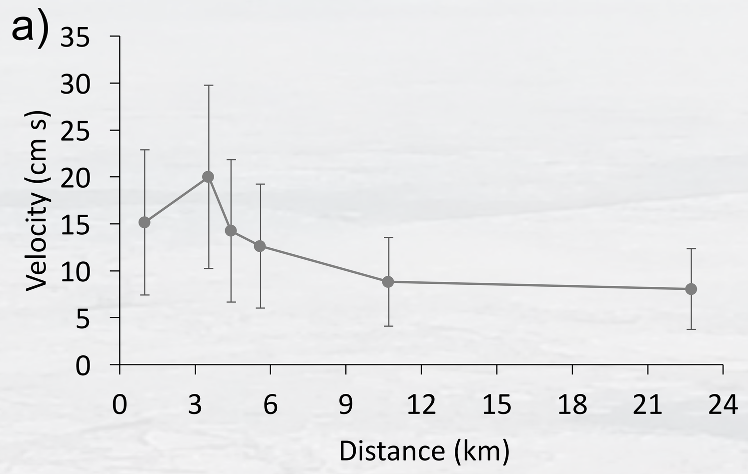


Figure 1. Location of sample sites in Dease Strait, NU.

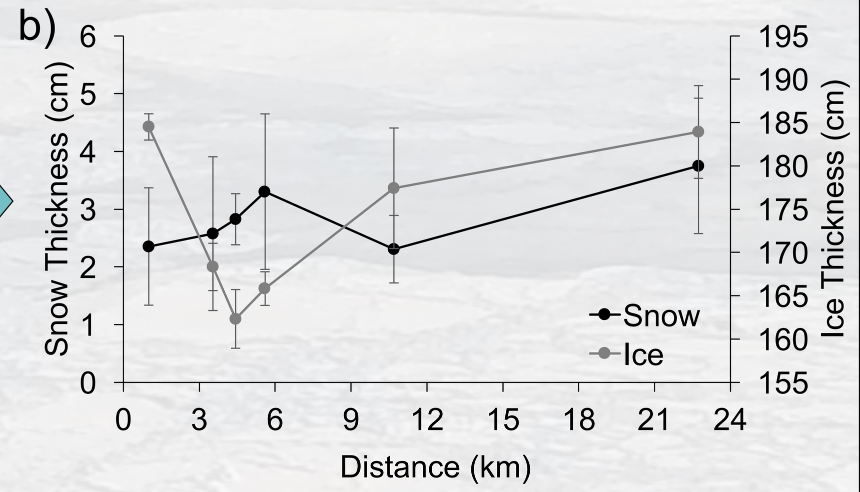
- Fieldwork executed during the spring bloom in Dease Strait, NU from 27 April to 20 May, 2016 during ICE-CAMPS (**Fig. 1**)
- Sea ice and water column samples were collected under thin snow cover (< 5 cm) at six sites (**Fig. 1**)
- Two ice-tethered ADCP's were used to determine current velocities at the ice-water interface (just below the sea ice) over a 48 hr period
- Variables analyzed: current velocities, snow depth, ice thickness, chlorophyll *a* (via fluorescence), nutrients, particulate organic carbon/nitrogen (POC/PON), and taxonomy

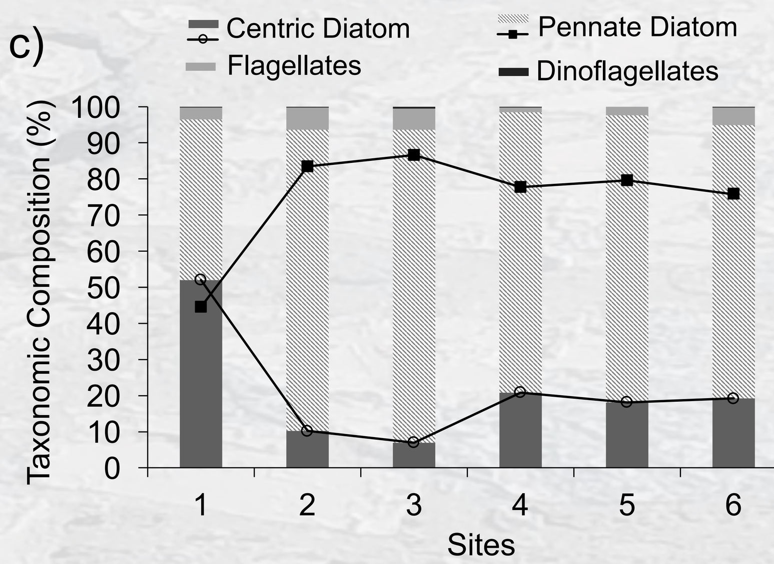
Results



Current velocities increased in the center of the tidal strait due to flow constriction between the islands, decreasing outside of the strait (**Fig. 2a**)

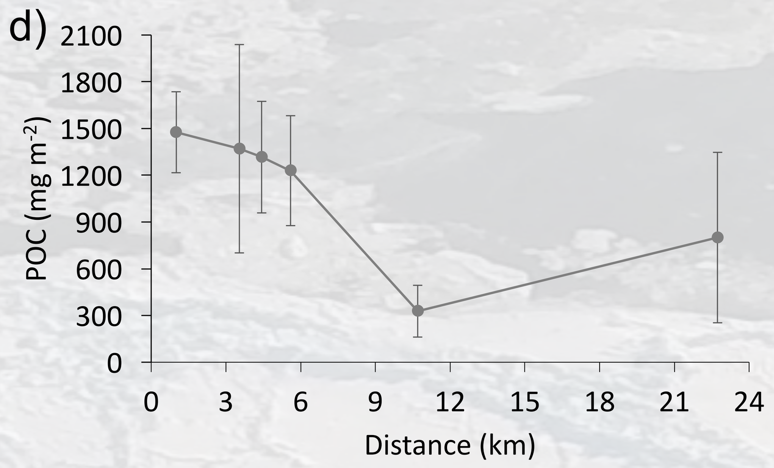
Ice thickness decreased near tidal strait and increases away from the tidal strait (**Fig. 2b**)

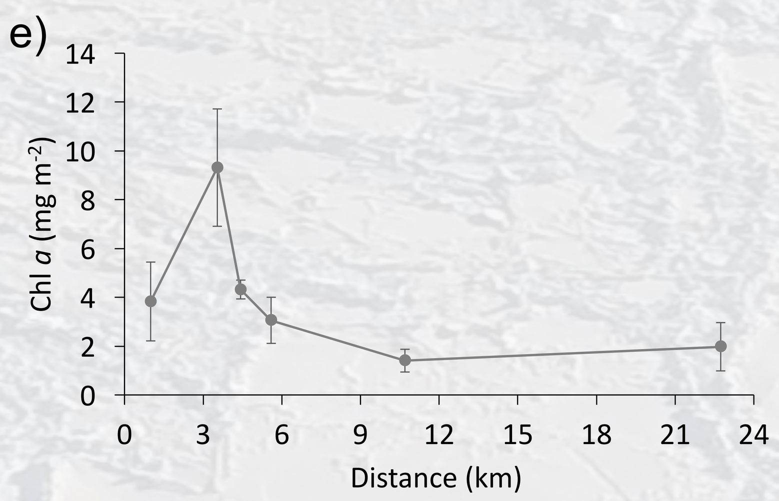




Pennate diatoms dominated at the majority of sites (**Fig. 2c**)

Particulate organic carbon decreased away from the tidal strait (**Fig. 2d**)





Chlorophyll *a* concentrations followed a similar trend and increased towards site 2, peaking, and decreased westward (**Fig. 2e**)

POC:chlorophyll *a* ratio was lowest at the second site (**Fig. 2f**)

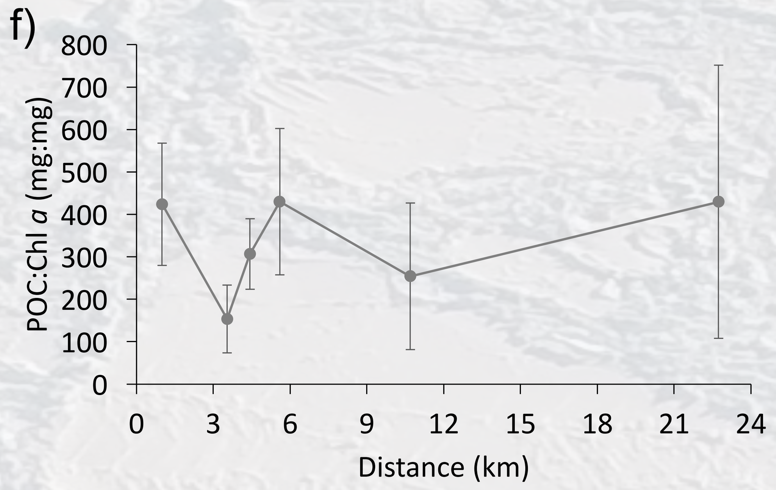


Figure 2. Current velocities (a) over a 48 hr period and snow and ice thickness (b) at the six sample sites. Bottom-ice taxonomic composition (c), average particulate organic carbon concentration (d), chlorophyll *a* (chl *a*) (e) concentration and the ratio of particulate organic carbon to chl *a* (f).

Results

- Positive relationships of phosphate and silicate vs. chl *a* and no relationship with nitrate plus nitrite

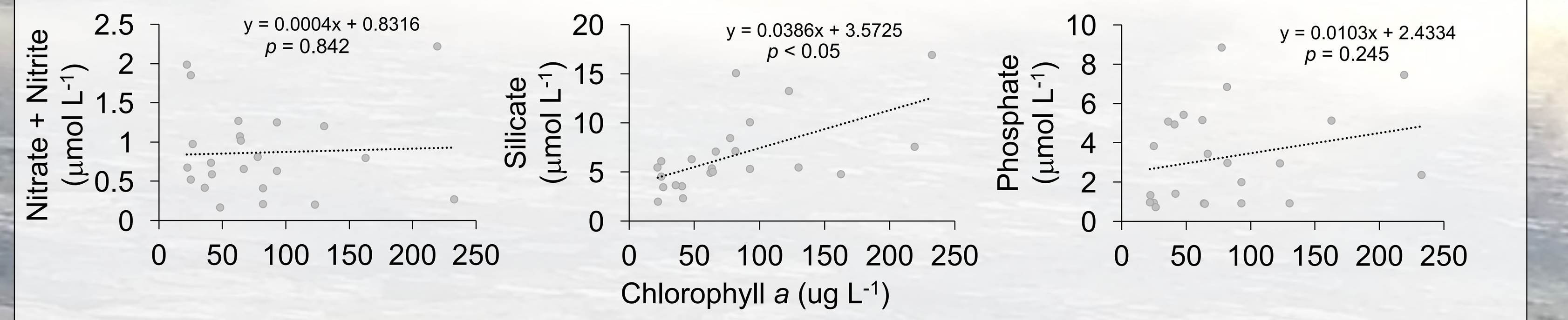


Figure 4. Nitrate (a), silicate (b), and phosphate (c) concentrations versus chlorophyll *a* concentrations in bottom ice for all samples collected.

Discussion

- Stronger currents are associated with decreased ice thickness and greater nutrient access, leading to enhanced ice algal chl *a* with evidence of less nutrient stress
- Positive relationships of phosphate and silicate concentration vs. chl *a* and no relationship with nitrate plus nitrite → potential nitrogen limitation
- An increase in chl *a*, currents and pennate diatoms with decreased POC:chl *a* suggests less nutrient stress while an increase in POC, POC:chl *a* ratio, and centric diatoms suggests potential nitrogen limitation (Campbell et al., 2017)

There are three mechanisms of nutrient supply that potentially explain the positive influence of sub-ice current velocities on sea ice algae in this study:

1. Water column mixing – greater mixing from depth to the ice bottom
2. Ocean-ice molecular diffusion – smaller viscous layer enhances a greater exchange of nutrients into the skeletal layer
3. Within ice convection – nutrients penetrate further into the skeletal layer

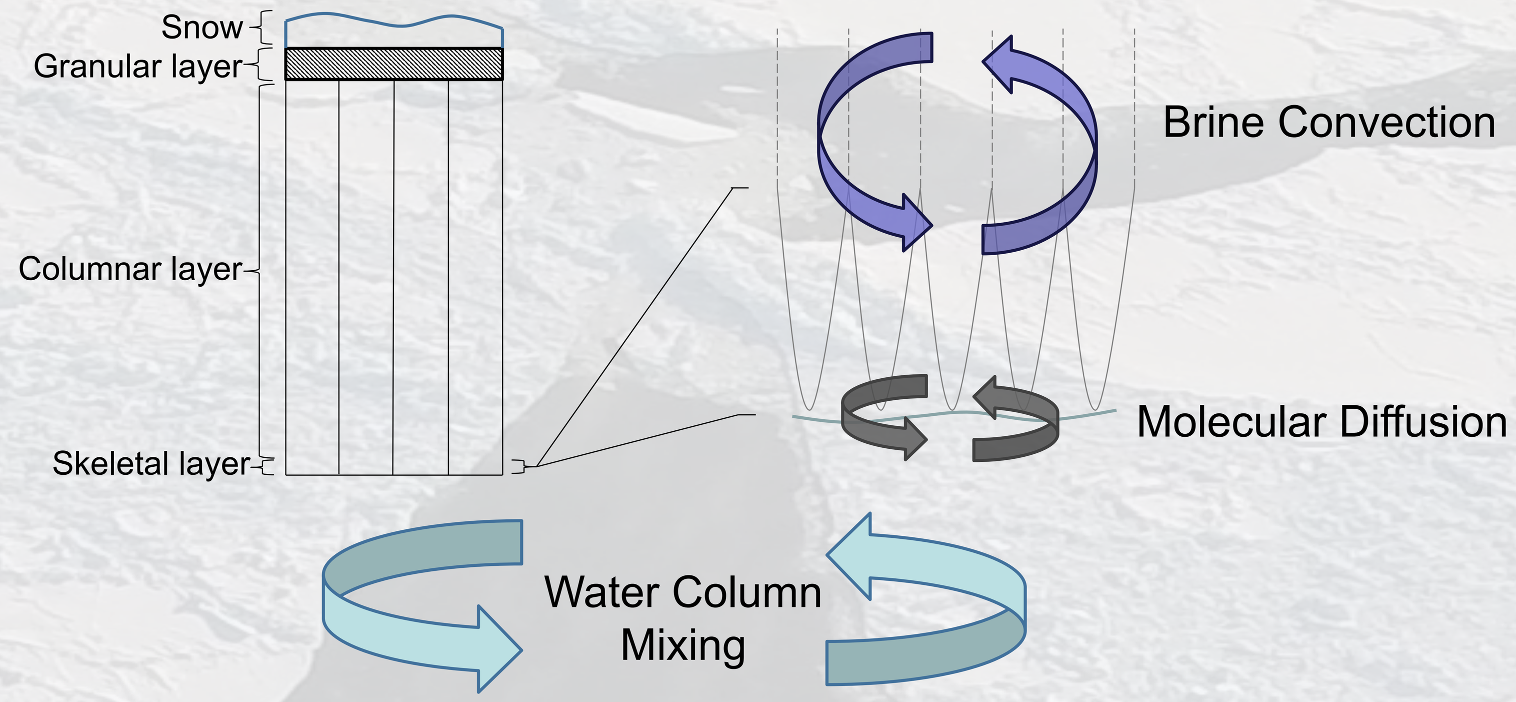


Figure 5. Schematic of the ocean-ice nutrient flux mechanisms.

Significance

Tidal currents enhance nutrient supply to sea ice algae, making areas like tidal straits with greater sub-velocities potential biological hotspots.

Acknowledgements

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References

1. Leu, E., Mundy, C., Assmy, P., Campbell, K., Gabrielsen, T., Gosslin, M., ... Gradinger, R. (2015). Arctic spring awakening – Steering principles behind the phenology of vernal ice algae blooms. *Progress in Oceanography, 139*, 151–170.
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