High Biomass Indicates Importance of Small Phytoplankton Cells

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Study Site

- The Northern Gulf of Alaska (NGA) is a highly productive subarctic marine ecosystem characterized by:
  - Strong seasonality [3]
  - Cross-shelf gradients
  - High freshwater input [3,4]
  - Downwelling [3,4]
  - Highly variable phytoplankton stocks [3]
  - Long-term warming trends
- The GAK transect line spans 250km encompassing nearshore, shelf, and offshore stations.

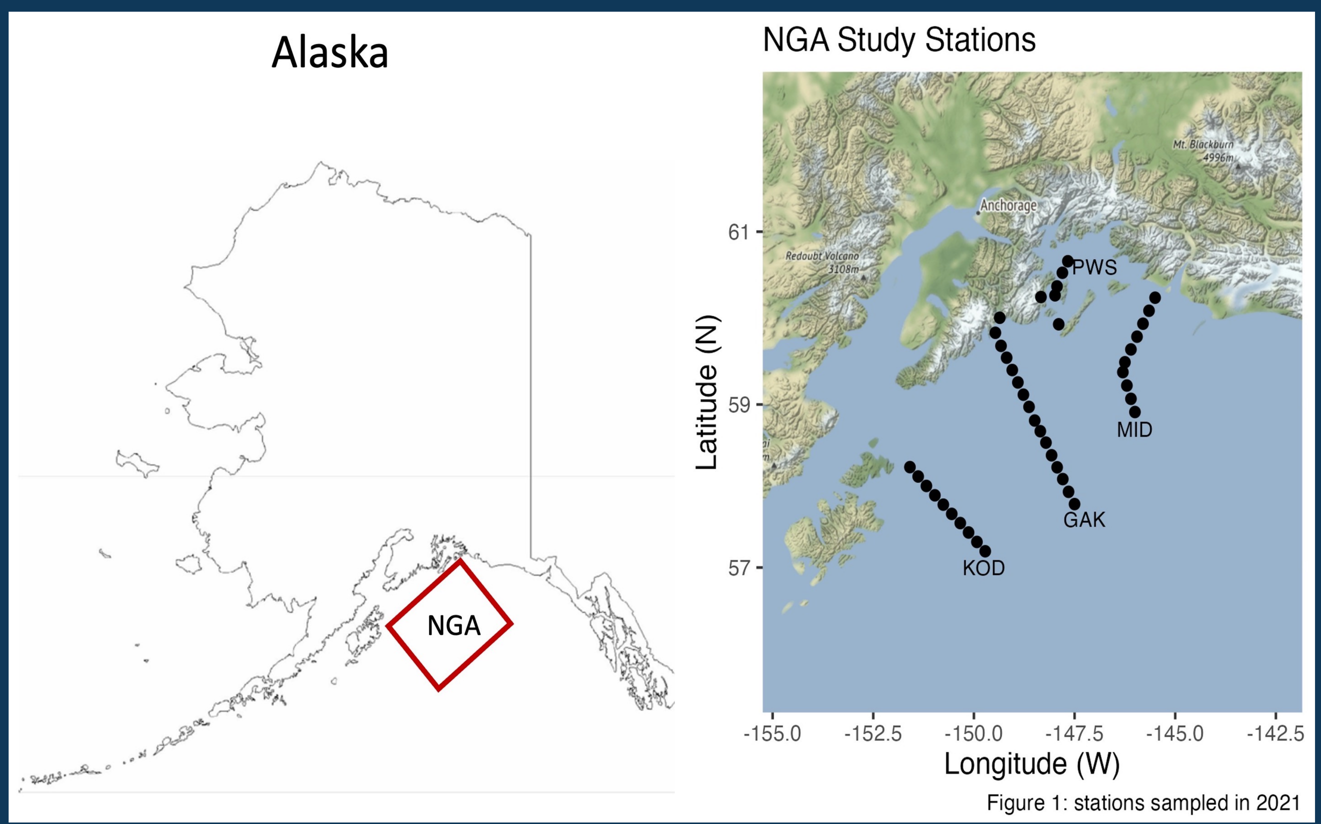

Figure 1: stations sampled in 2021

Methods

Sample Collection

- -Seawater samples were collected from CTD Niskin bottles at 10m along the GAK line in summer 2021.
- -Fixed, flash-frozen samples were later analyzed on a Guava EasyCyte flow cytometer.

Processing and Analysis

- --Statistical gates were determined based on known photosynthetic properties and cell size of each phytoplankton group (see Fig. 2)
- -Phytoplankton groups were differentiated based on their optical properties including fluorescence (red: chlorophyll-a; yellow: phycoerythrin) and forward scatter, a proxy for size.
- -Epifluorescence microscopy-based cryptophyte concentration estimates were deemed more accurate than flow cytometry estimates, so the former are presented here.

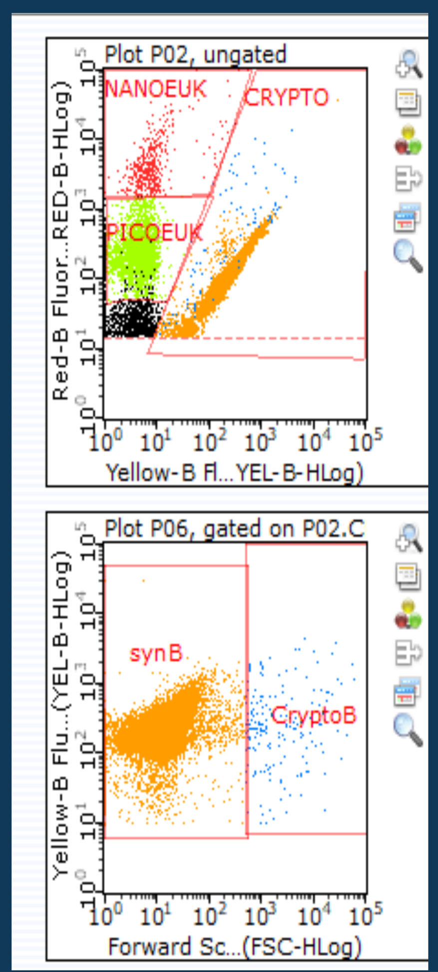

Figure 2: Cytogram on Guava software showing how phytoplankton groups were distinguished using statistical gates.

Acknowledgements

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References:
1. Olson, R. J., S. W. Chisholm, E. R. Zettler, and E. V. Armbrust. 1990. *Limnology and Oceanography* 35:45–58; **2.** O'Neill, K., N. Aghaeepour, J. Špidlen, and R. Brinkman. 2013. PLoS Computational Biology 9:e1003365; **3.** Strom, S.L. et al., 2006. *Marine Ecology Progress Series* 328; **4.** Waite, J. N., and F. J. Mueter. 2013. *Progress in Oceanography* 116.

Conclusions

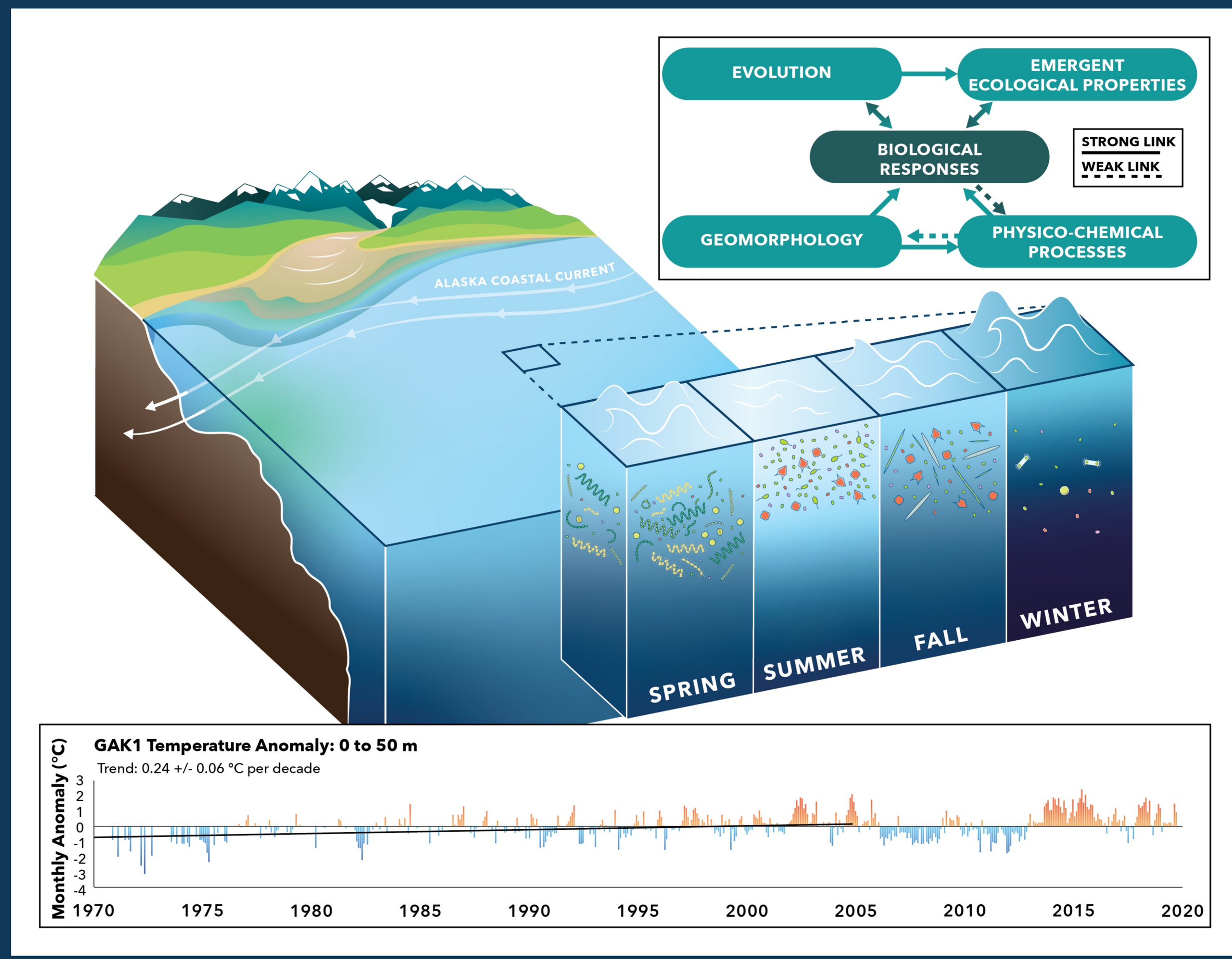

Figure 3: NGA LTER Conceptual Model

The Northern Gulf of Alaska is a highly productive ecosystem in summer and fall, despite low chlorophyll levels. Nanoeukaryotes and cryptophytes are crucial components of the NGA. There is a strong link between the biological needs of small-celled phytoplankton groups and their environment, particularly nutrient availability. While short- and long-term variability impact the biomass of phytoplankton, this research suggests that small cells have the capacity for high trophic transfer efficiency to fuel the NGA ecosystem.

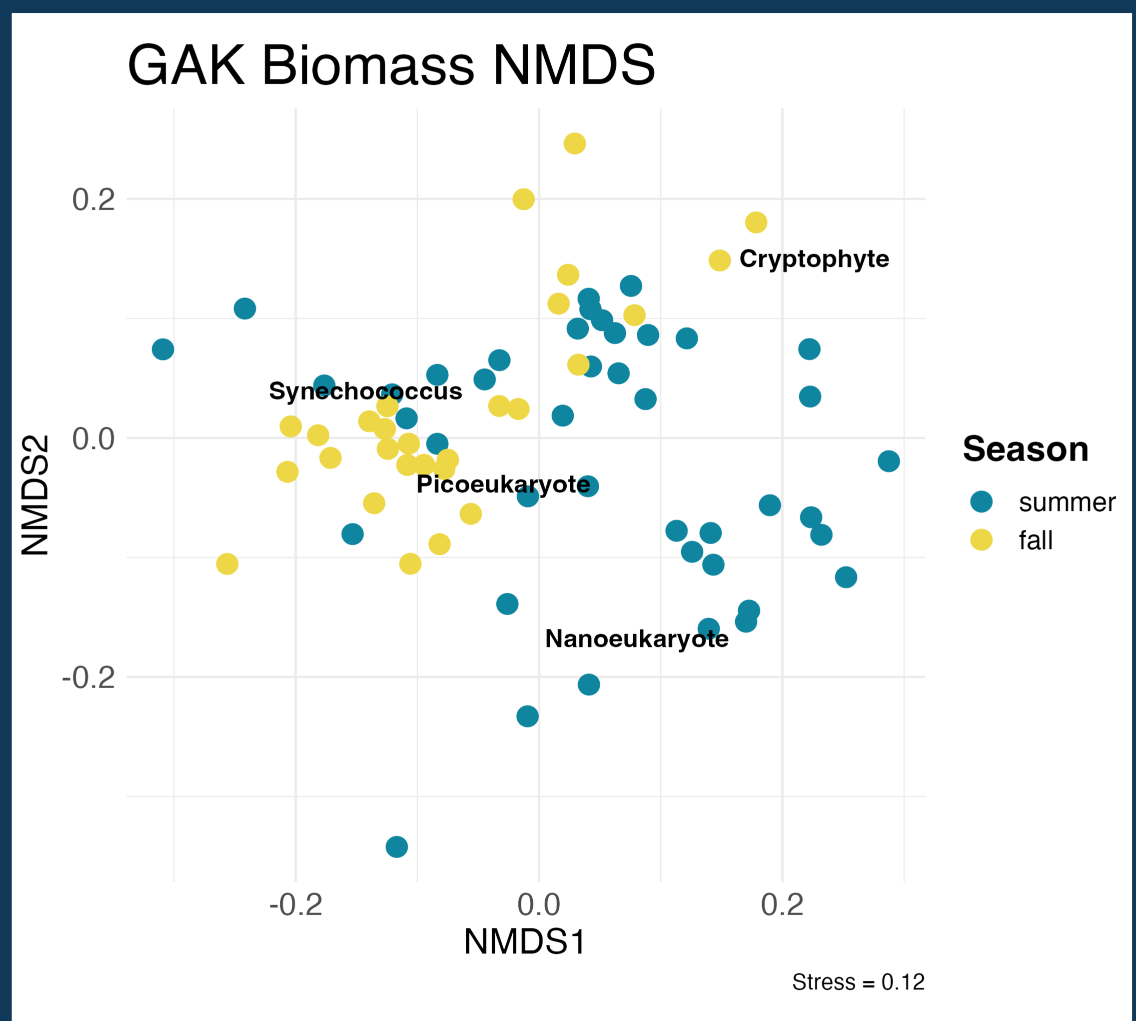

Figure 4: NMDS ordination plot of GAK summer and fall 2021 phytoplankton biomass. (includes data from 0-30m, depth was not a significant factor). Points represent the NMDS separation of seasons and distinct phytoplankton groups are mapped in their specific ordination space on top. Bray-Curtis dissimilarity measure was used.

- Figure 4 shows obvious distinction in the NMDS ordination of phytoplankton groups. *Synechococcus* spp. and picoeukaryotes, both small cells, group more closely together suggesting that size is an important factor in variability of phytoplankton community composition. The separation of season on NMDS 1 suggests that summer and fall have different trends in community composition.
- Environmental factors that significantly influence phytoplankton community composition include station sampled, season, distance offshore, bottom depth, salinity, nitrogen, ammonium, silicate, phosphate, oxygen, & Chl-a. (env.fit statistical test, $p < 0.05$).
  - These variables and cross-shelf trends in salinity, nitrogen, and chlorophyll-a presented in figures 7 & 8 suggest that phytoplankton may be nutrient limited offshore.

Results

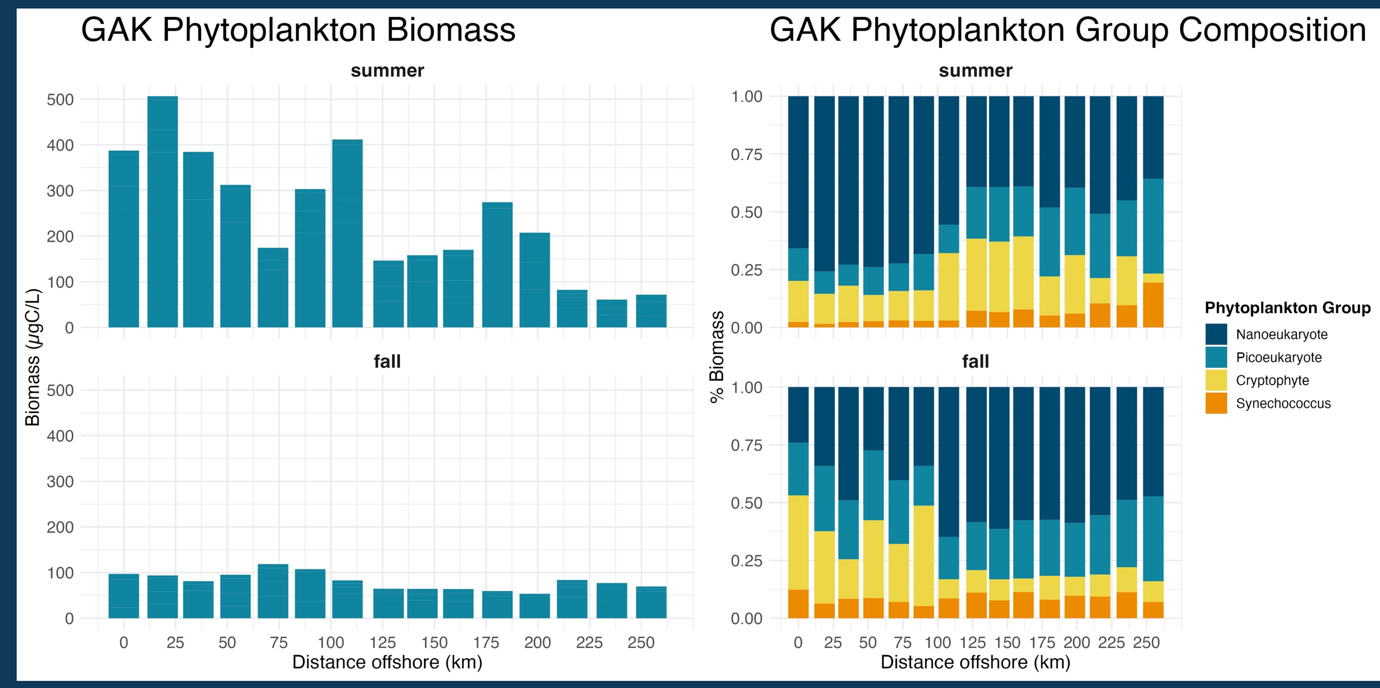

Figure 5: Biomass of small cell (~<25μm) phytoplankton from 10m along the GAK line in summer and fall 2021.

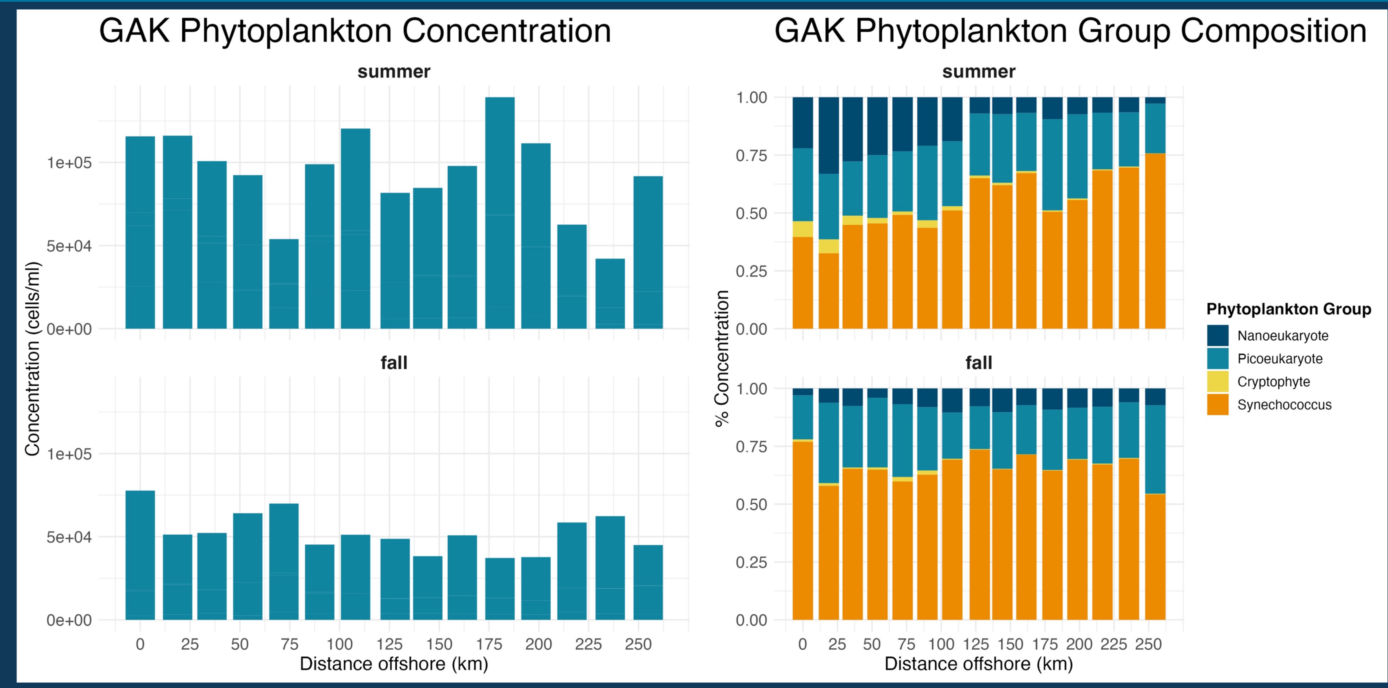

Figure 6: Concentration of small cell phytoplankton from 10m along the GAK line in summer and fall 2021.

- Nanoeukaryotes and cryptophytes contribute >50% of the total biomass in summer and fall. (Figure 5)
  - Indicates a potential for high trophic transfer efficiency from these groups despite low total Chl-a. (Figure 8)
- Small cells (<20μm) make up over >80% of the total chlorophyll-a measured in summer, and >60% in fall. (Figure 8)
  - Suggests our data are representative of the phytoplankton community in the NGA in these seasons.
- There are distinct seasonal trends in phytoplankton community composition and total biomass. (Figures 4, 5, & 6)
  - Summer has ~5x the maximum biomass of fall.
  - Summer shows distinct cross-shelf trends in total biomass.
  - Nanoeukaryotes are more abundant nearshore in summer and offshore in fall. In contrast, cryptophytes are more abundant offshore in summer and nearshore in fall.
- Low offshore biomass in summer suggests that cells are smaller and phytoplankton growth is limited. (Figure 5)
  - Small cells increase in their % contribution to total biomass with increasing distance offshore.

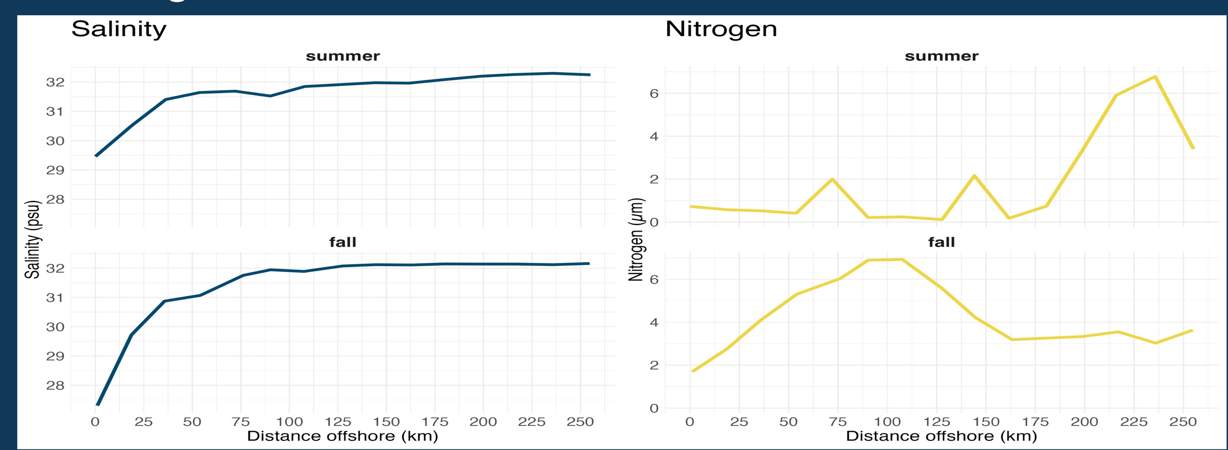

Figure 7: Mean upper 10m salinity and nitrogen (nitrite & nitrate) across the GAK line in summer and fall 2021.

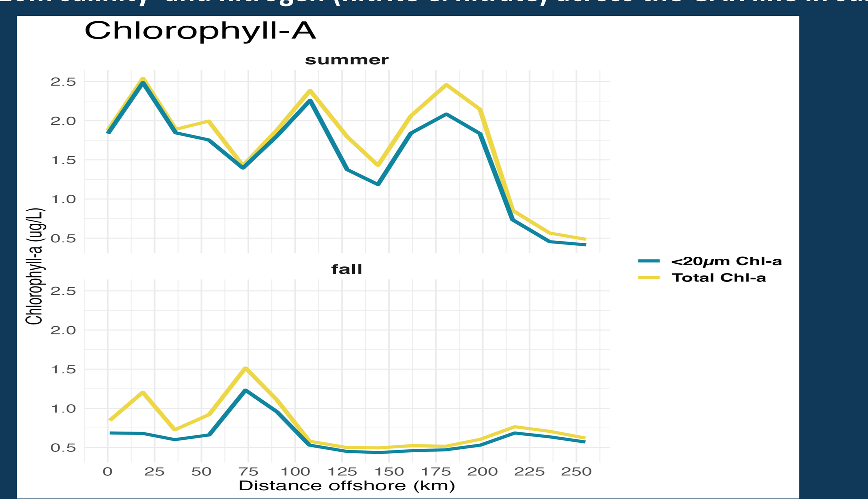

Figure 8: Mean upper 10m chlorophyll-a across the GAK line in summer and fall 2021. Yellow line depicts total Chl-a and blue line shows size fractionated Chl-a in cells <20μm.