Temporal Variability of Dissolved Aluminum and Manganese in the Northern Gulf of Alaska (NGA)

Annie Kandel (akandel@alaska.edu) and Ana Aguilar-Islas; University of Alaska Fairbanks

Abstract

Dissolved aluminum (dAl) and manganese (dMn) are lithogenic elements that can be used to trace river plumes. Large freshwater input from glacial and non-glacial rivers to the Northern Gulf of Alaska (NGA) has been shown to result in elevated dAl along coastal waters in late summer, but concentrations of dMn have not been reported in this region. Tracing the spatial and temporal variability of freshwater input to the Gulf of Alaska and its influence over the shelf ecosystem will help advance understanding of the newly established NGA-LTER Site. Here we present dAl and dMn distributions obtained during the 2018 and 2019 field seasons. Highly elevated dAl (uM range) and dMn (~ 100 nM range) in the Copper River plume decreased rapidly with increasing salinity and distance from the river delta. Spring concentrations of dAl and dMn were two orders of magnitude lower compared to summer. Ratios of dAl:dMn varied seasonally as well as with location. Samples were analyzed via inductively coupled plasma mass spectrometry (ICP-MS).

Background

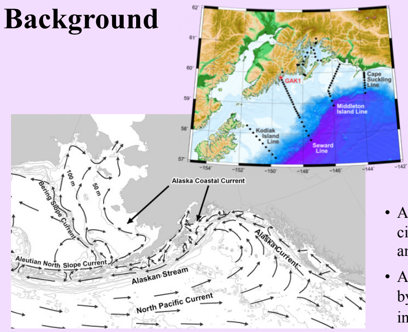

Figure 1: Maps showing major circulation patterns in the NGA (above) and sampling stations (inset)[2].

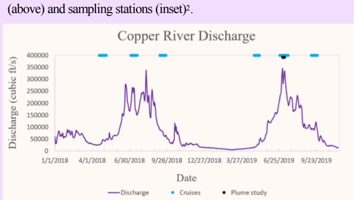

Figure 2: Copper River discharge throughout 2018 and 2019, measured at Million Dollar Bridge (Data from the USGS[3]).

- The NGA LTER site is sampled seasonally (spring, summer, fall) along cross-shelf transects: KOD, GAK, MID, CS lines (Fig. 1)
- Alaska Gyre: large-scale, offshore circulation including Alaska Current and Alaskan Stream
- Alaska Coastal Current (ACC): driven by freshwater input and confined to the inner shelf.
- Freshwater input to NGA surface waters reaches a maximum in late summer due to increased precipitation and glacial melt.
- Copper River flux varies interannually and is the largest point source of freshwater to the NGA coast.
- Previous work[1] in the NGA has shown highly elevated [dAl] nearshore in low-salinity plumes.

Sample Collection and Processing

- Copper River Plume study summer 2019
- Towed "iron fish" pump system to obtain clean surface water samples while underway with inline filtration (0.2 um)
- Sample preparation:
  - High [dMetal] samples diluted 1:30 with acidified MQ water
  - Low [dMetal] samples preconcentrated offline onto a resin column (Fig. 4)
- Analysis via ICP-MS at UAF (Thermo Element 2)

Table 1. Vessels and dates for NGA LTER cruises in this study.

Cruise	Vessel	Dates
Spring 2018	R/V Sikuliaq	4/18-5/5
Summer 2018	M/V Wolstad	7/3-7/18
Fall 2018	**M/V Tiglax**	**9/11-9/25**
Spring 2019	**M/V Tiglax**	**4/26-5/9**
Summer 2019	**R/V Sikuliaq**	**6/27-7/17**
Fall 2019	M/V Tiglax	9/11-9/25

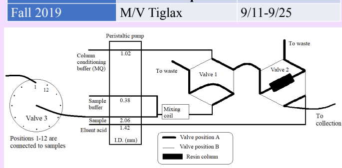

Figure 3: Offline preconcentration system of seawater onto Nobias Chelate- PA1 resin.

Sources 1. Brown, M. T., Lippiatt, S. M., and Bruland, K. W. (2010). Dissolved aluminum, particulate aluminum, and silicic acid in northern Gulf of Alaska coastal waters: Glacial/riverine inputs and extreme reactivity. *Marine Chemistry*, 122, 160-175.
2. https://nga.lternet.edu/
3. https://waterdata.usgs.gov/ak/nwis/dvstat/?search_site_no=15214000&agency_cd=USGS&referred_module=sw&format=sites_selection_links
4. https://oceanview.pfeg.noaa.gov/products/upwelling/dnld

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Conclusions

- **Large input of dAl and dMn from the Copper River in summer remains nearshore, confined by the Alaska Coastal Current (ACC)**
- **Seasonality and location influences the dMn:dAl ratio as well as their absolute concentrations**
- **Bathymetric features (e.g., Albatross Bank) enhance surface [dAl] and [dMn]**

Preliminary Results

Copper River Plume (Summer 2019)

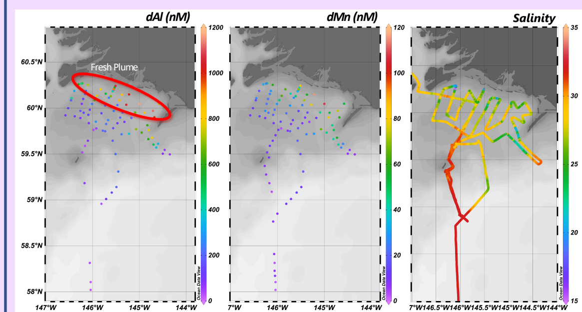

Figure 4: Surface distributions of dAl (left), dMn (center) and salinity (right) during the Summer 2019 Copper River plume study

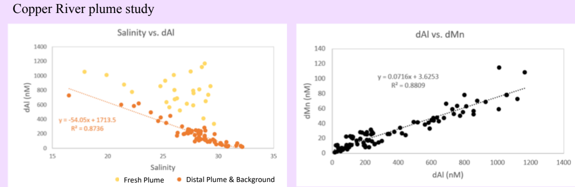

Figure 5: Relationship of surface [dAl] to salinity (left), and the ratio of dMn:dAl in summer 2019 (right)

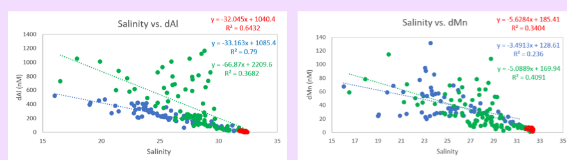

Figure 6: Seasonal relationships of surface [dAl] (L) and [dMn] (R) to salinity in the NGA

- The Copper River Plume input of dAl and dMn is constrained mainly within the ACC
- Non-conservative input of dAl in the fresh plume is apparent in summer at mid salinities in samples taken near the Copper River delta
- The ratio of dMn to dAl varies with season and location

Spring 2019

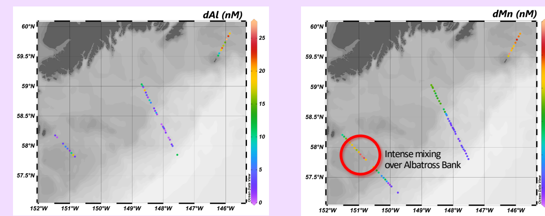

Figure 7: Spring distributions of surface dAl (L) and dMn (R).

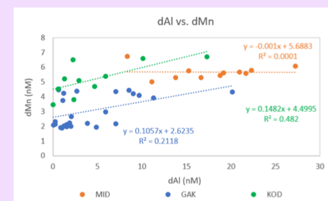

Figure 8. Ratio of surface dMn:dAl in Spring 2019

- Less robust dAl:dMn relationship during spring, prior to the influx of freshwater
- [dAl] and [dMn] 2 orders of magnitude lower along the MID line in spring vs. summer

Fall 2018

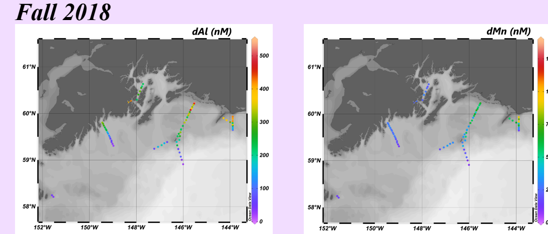

Figure 9. Fall distributions of surface dAl (left) and dMn (right).

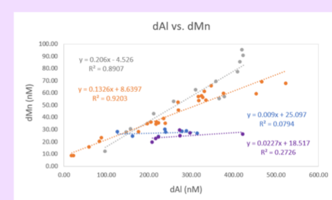

Figure 10. Ratio of surface dMn:dAl in Fall 2018

- In fall, cross-shelf gradients apparent: dAl and dMn higher in lines with greater glacier river influence (CS, MID)
- Surface dAl was more variable than dMn in PWS and the inner GAK line