Colloidal trace metals in the Northern Gulf of Alaska: The contrasting size partitioning of iron, nickel, and copper

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Background

- The Northern Gulf of Alaska (NGA) is a productive subarctic biome where glacier rivers provide large input of freshwater, sediment, and trace elements (e.g., Fe, Ni, Cu) to shelf waters.
- The NGA domain borders the High Nutrient, Low Chlorophyll (HNLC) waters of the offshore Gulf of Alaska, where the availability of dissolved Fe limits primary production.
- Downwelling conditions in the NGA are relaxed during summer, allowing for subsurface offshore water to flow over the shelf, bringing with it dissolved trace elements (e.g., Ni, Zn).
- The MID Line is influenced inshore by the Copper River plume, at the shelf edge by Middleton Island, and offshore by mesoscale eddies that are advected along the continental margin.
- The Seward Line extends further offshore, and is also impacted by mesoscale eddies. It is influenced inshore by the Alaska Coastal Current and the outflow from Prince William Sound. Its convoluted topography influences cross-shelf gradients.

Methods

Samples collected from a trace metal CTD rosette, were sequentially filtered first through a 0.2µm membrane cartridge (Acropak 200) and then pumped through 0.02 µm syringe filter (Anotop) to remove particles and colloids. Filter cartridges and syringe filters were cleaned following the "GEOTRACES Cookbook" and Fitzsimmons and Boyle (2014), respectively. Acidified samples (pH 1.7; ultra clean hydrochloric acid) were analyzed using isotope dilution with ICP-MS detection.

Hydrography for GAK and MID stations

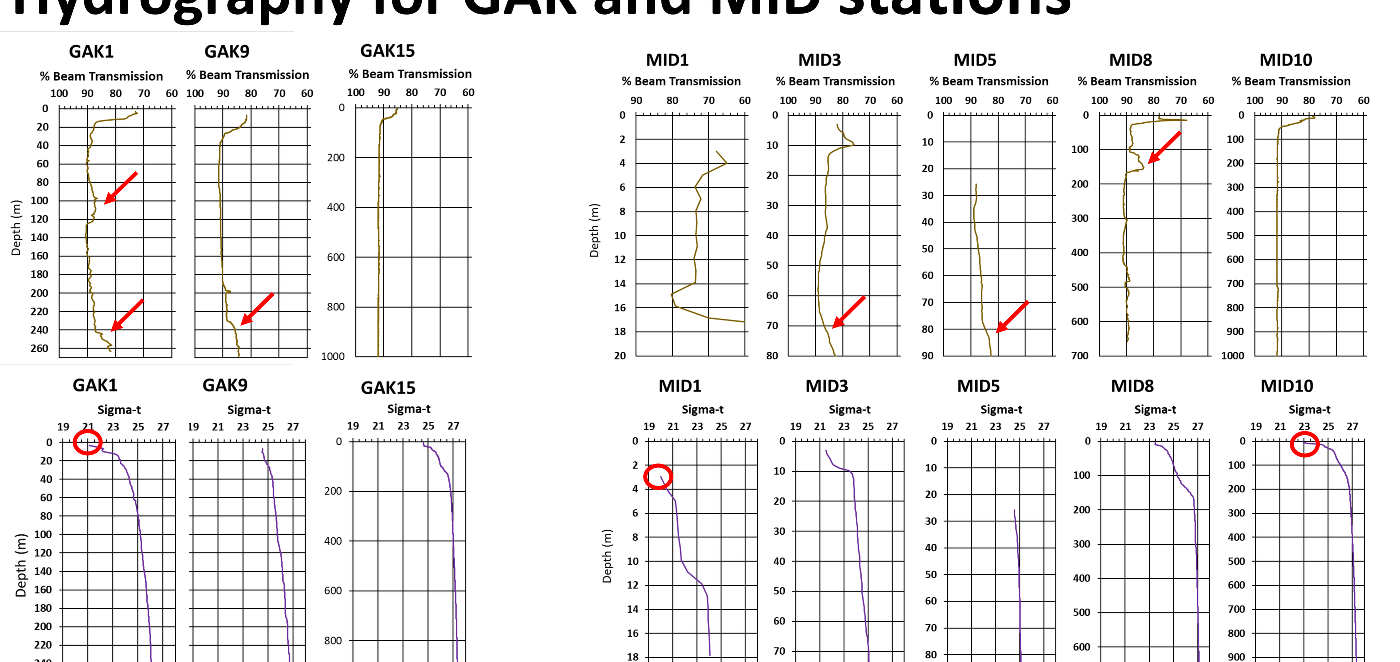

Figure 2. Vertical distribution of % beam transmission and sigma-t on the Seward Line (left) and the Middleton Island Line (right)

References: Fitzsimmons, J.N., E.A. Boyle, 2014. Assessment and comparison of Anopore and cross flow filtration methods for the determination of dissolved iron size fractionation into soluble and colloidal phases in seawater. *Limnology and Oceanography: Methods*,12, 246-263.

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Results

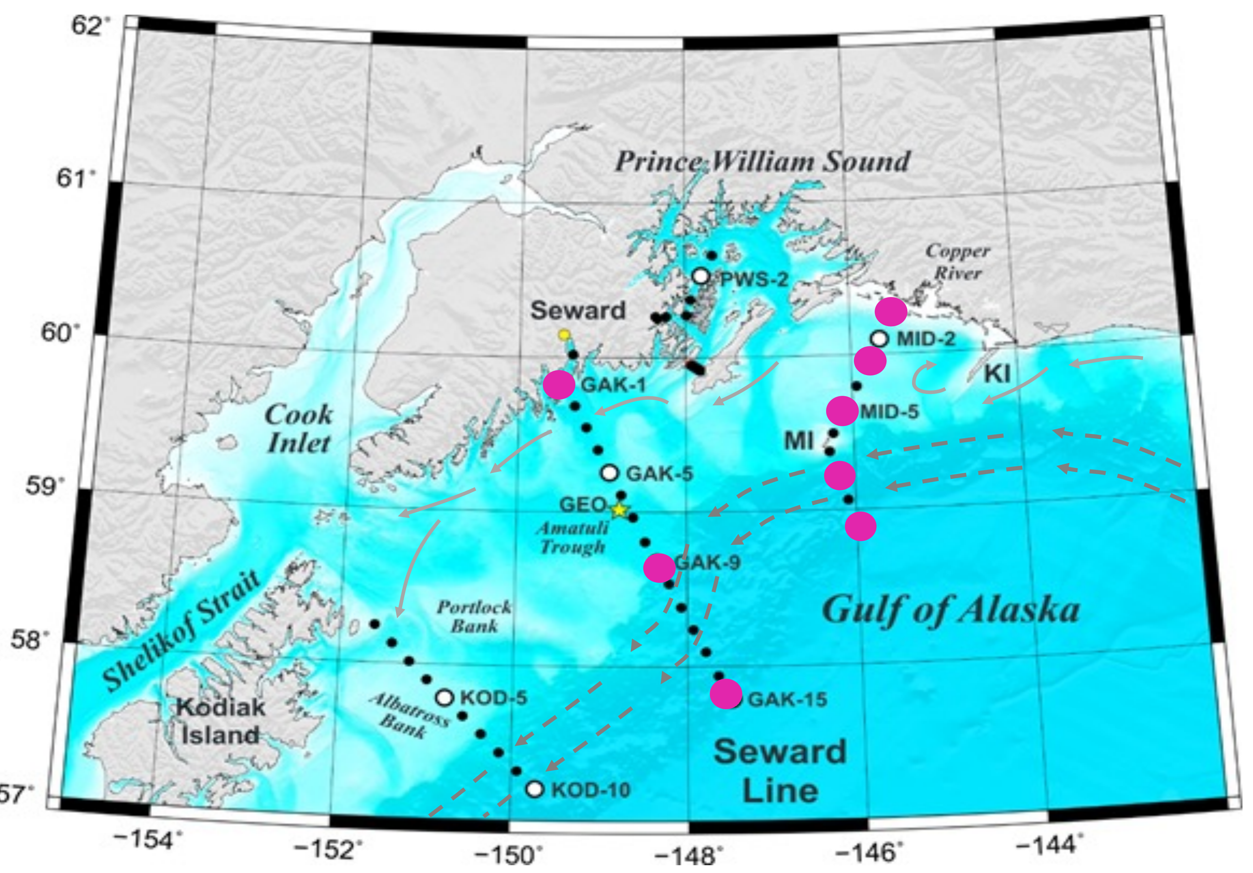

Figure 1. The domain of the Northern Gulf of Alaska. Sampled stations along the Seward (GAK) and Middleton Island (MID) lines are shown in pink. Solid grey arrows denote the Alaska Coastal Current, and dashed grey arrows the Alaska Current/Stream.

Seward Line

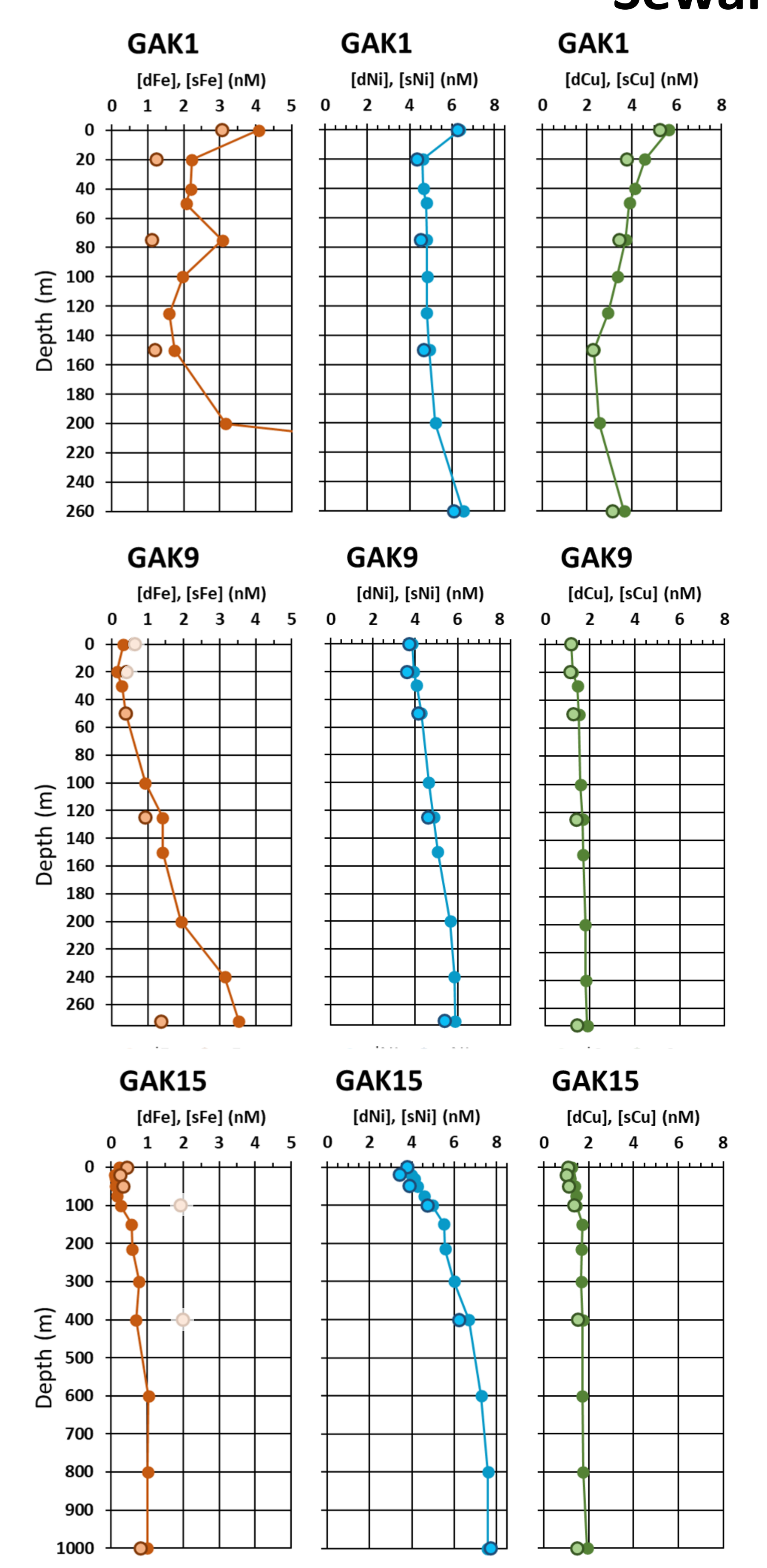

Figure 3. Vertical distribution of dissolved (<0.2 µm) and soluble (< 0.02 µm) metals along the Seward Line.

- **GAK1:** Higher [dMetal] at the surface shows the influence from the fresh Alaska Coastal Current and the outflow from Prince William Sound. Benthic input is also apparent for the 3 metals, with [dFe] = 25.21 nM and [sFe] 8.58 at the bottom most sample. (see hydrography graphs)
- **GAK9:** Diminished riverine influence is seen in the lower [dMetal] at the surface for this shelf edge station. Benthic input is apparent for dFe. Higher subsurface dNi and dCu reflect subsurface offshore waters moving onto the shelf. (see hydrography graphs)
- **GAK15:** Lower surface [dFe], but similar [dNi] and [dCu] as seen at station GAK 9 shows the influence of HNLC waters. Subsurface [dNi] (> 6 nM), [dCu] (~ 2nM) and [dFe] (~ 1 nM) show the characteristics of subsurface offshore waters that can flow onto the shelf during summer.
- Contamination during ultra filtration at subnanomolar [dFe]

Middleton Island Line

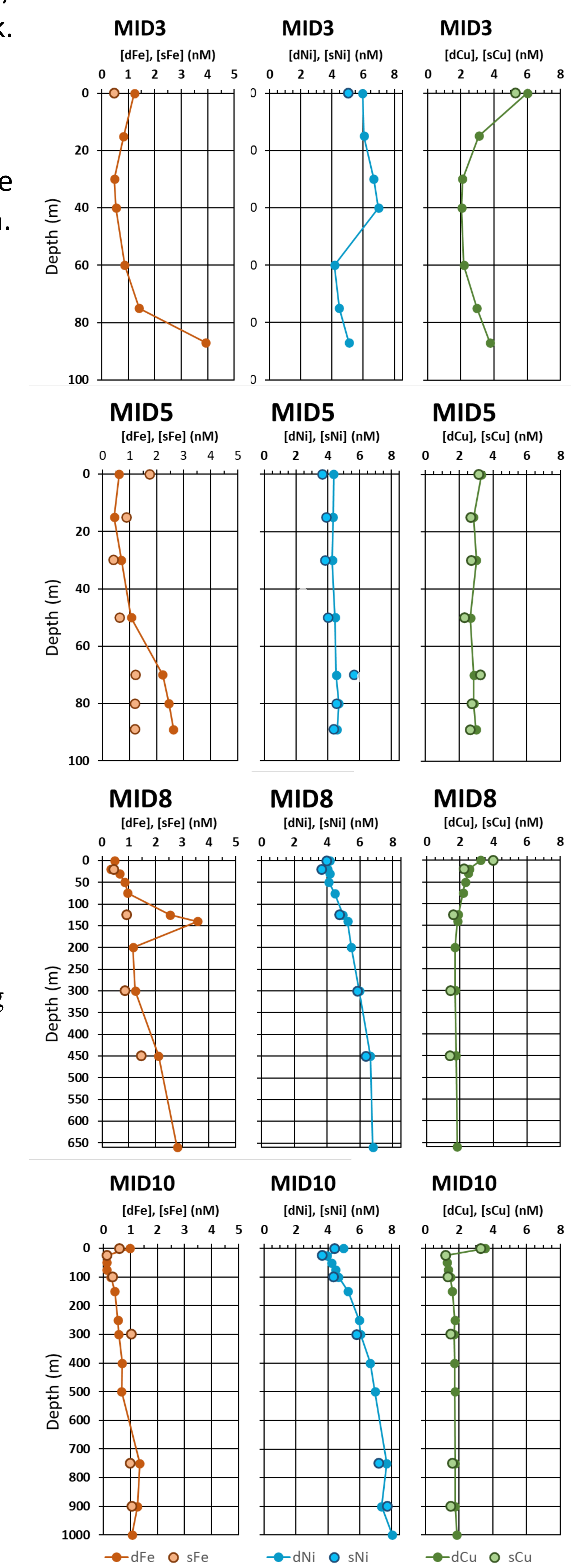

Figure 4. Vertical distribution of dissolved (<0.2 µm) and soluble (< 0.02 µm) metals along the Middleton Line

MID1	Fe	Ni	Cu
Dissolved [nM]	2.22	5.64	7.80
Soluble [nM]	0.55	5.02	7.02

- **MID 1:** This shallow station (~ 20 m) is directly influenced by the outflow of the Copper River (CR), yet surface [dFe] is lower than at GAK1, suggesting enhanced scavenging and/or lower Fe-binding organic ligands. The highest [dCu] was measure at this station, indicating high riverine input of dCu.
- **MID 3:** Higher surface [dMetal] show the influence of the CR plume at this midshelf station. Benthic input is also apparent for the three metals.
- **MID 5:** A benthic source of dFe is mainly in the colloidal fraction. The riverine influence of dMetals is diminished at this midshelf station.
- **MID 8**: The influence from Middleton Island (100-200 m) and benthic input are apparent in the [dFe], while the influence of subsurface offshore water is apparent for [dNi] (enhanced) and [dCu] (diluted)
- **MID 10:** The influence of a lower density water at the surface is seen in the higher [dMetal]. Similar to GAK15, the characteristics of the subsurface offshore water are [dNi] approaching 8 nM, the [dCu] ~2 nM, and [dFe] ~ 1nM

CONCLUSIONS

- dNi and dCu were found in the < 0.02 µm size fraction throughout the water column.
- In general, surface dFe was mostly in the soluble fraction, while deep samples, influenced by sediment resuspension, exhibited a larger fraction of colloids
- Enhanced scavenging of dFe Copper River plume region results in lower dFe in surface and subsurface waters compared to GAK 1