New high resolution trace metal measurements in the Bering Strait and their implications for tracking Pacific Water circulation in the Western Arctic

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Seattle, WA

CICOES

NSF

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School of Oceanography
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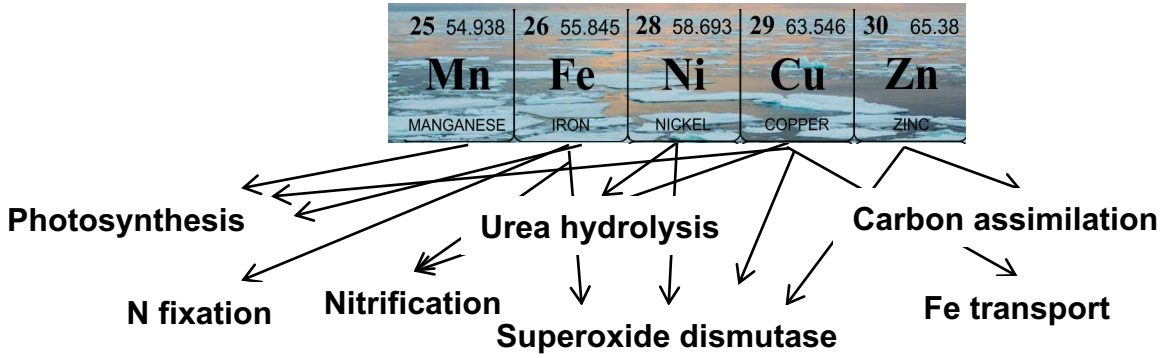
Trace metals

Why do we care about trace metals?

- Trace metals (~10^{-9} M) represent **essential micronutrients for phytoplankton** in the ocean



macronutrients

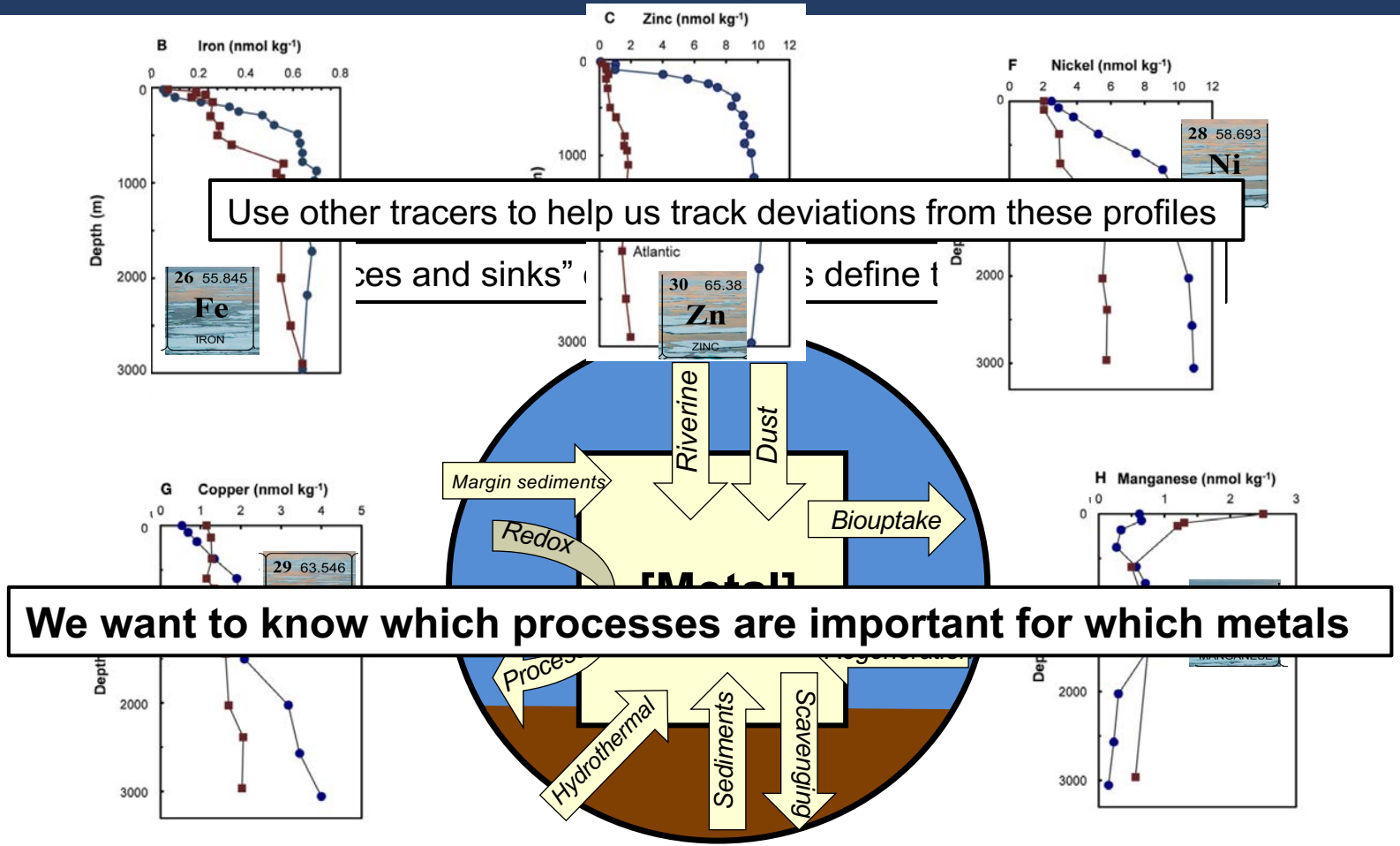
micronutrients

$$(C_{124}N_{16}P_{1}S_{1.3}K_{1.7}Mg_{0.56}Ca_{0.5})_{1000}Sr_{5.0}Fe_{7.5}Zn_{0.80}Cu_{0.38}Co_{0.19}Cd_{0.21}Mo_{0.03}$$

In fact, phytoplankton have a cellular requirement for many trace metals, which can lead to limits on productivity or community composition

Twining&Baines, 2013; Sunda, 2013; Ho et al., 2003

Elemental personalities

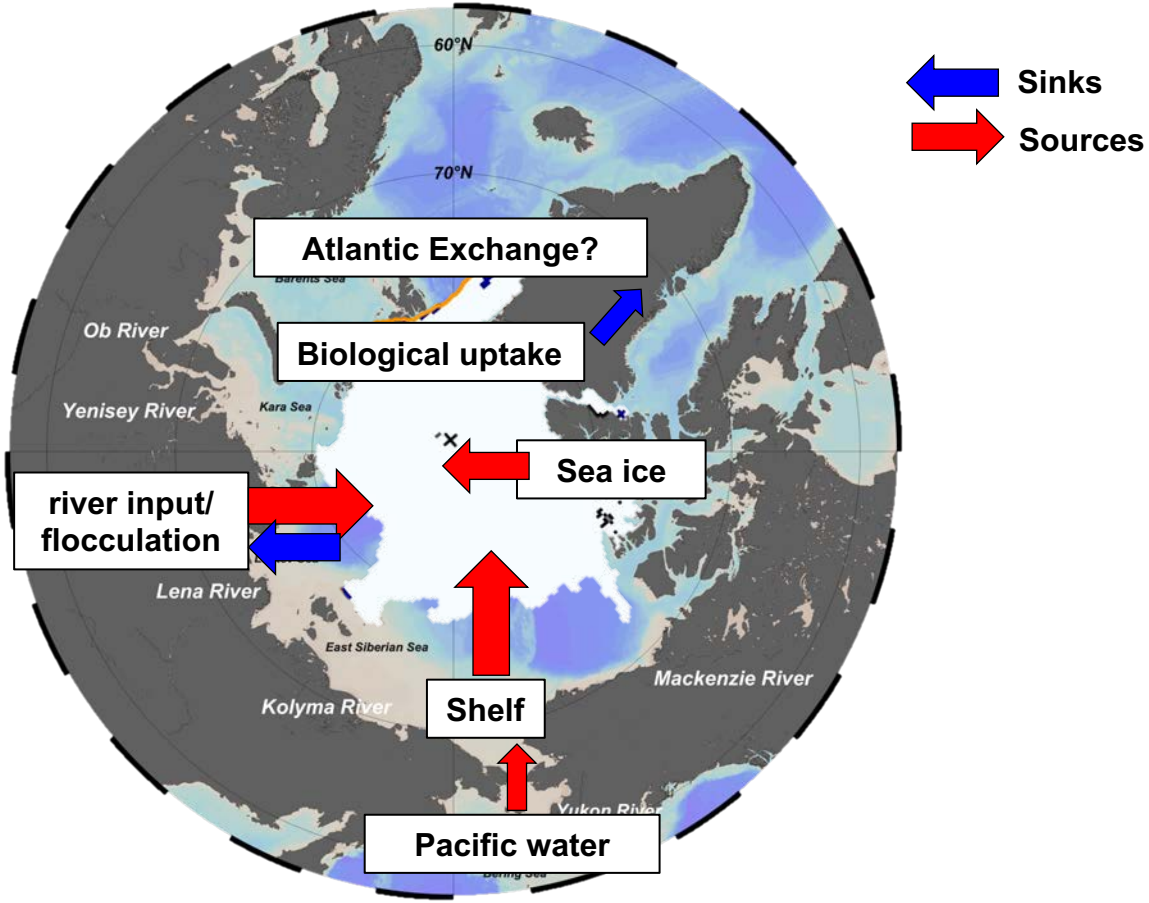


Use other tracers to help us track deviations from these profiles

ces and sinks" s define t

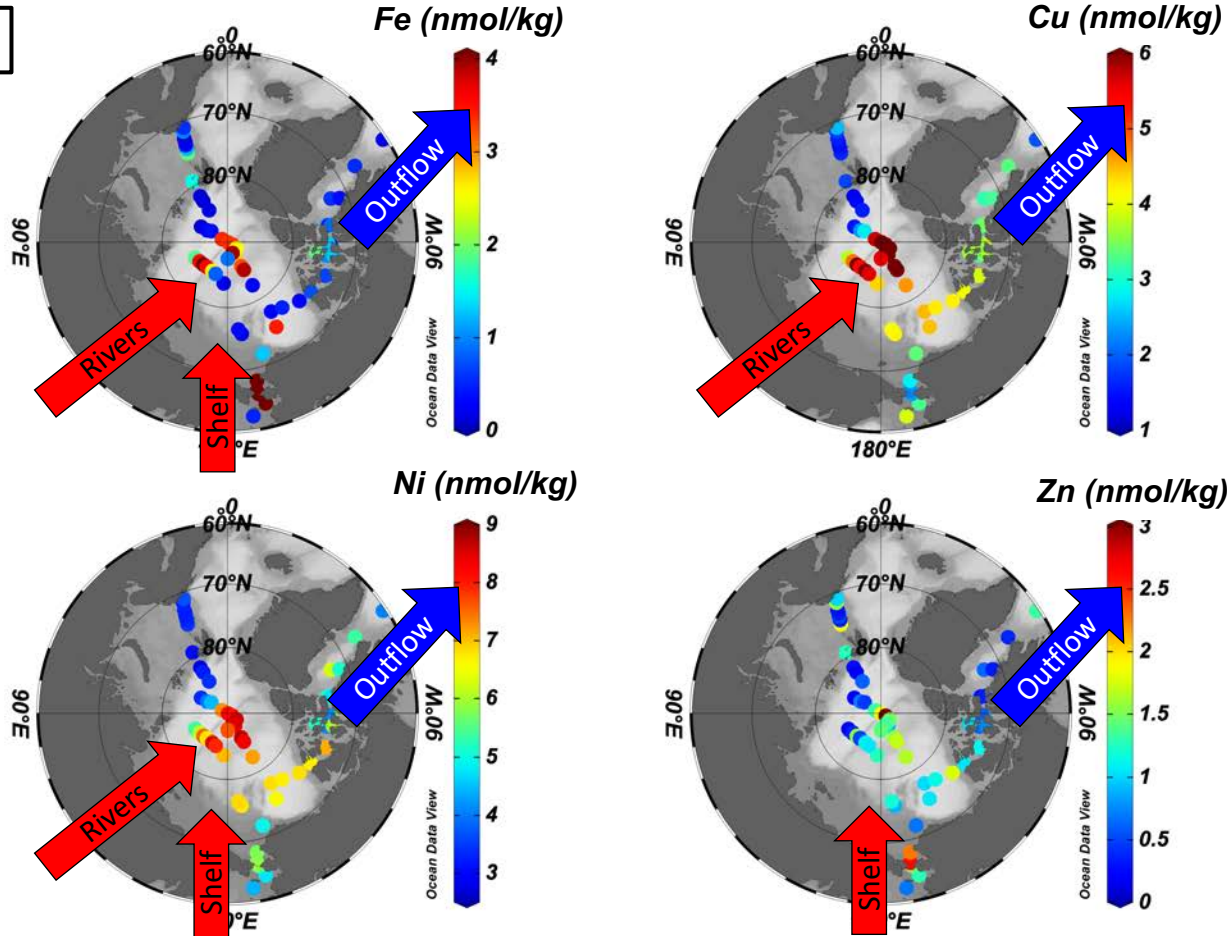
We want to know which processes are important for which metals

Trace metals in the Arctic Ocean

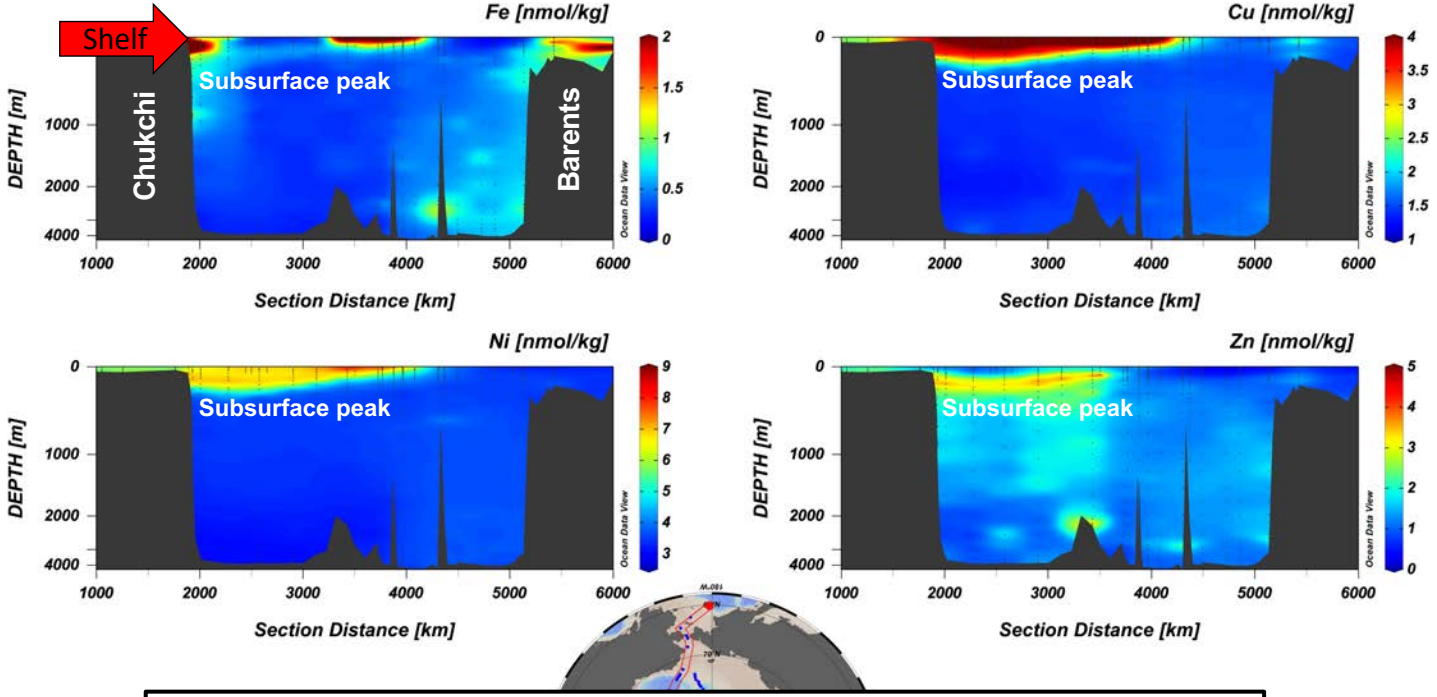


Trace metals in the Arctic Ocean: GEOTRACES

2015 (surface):



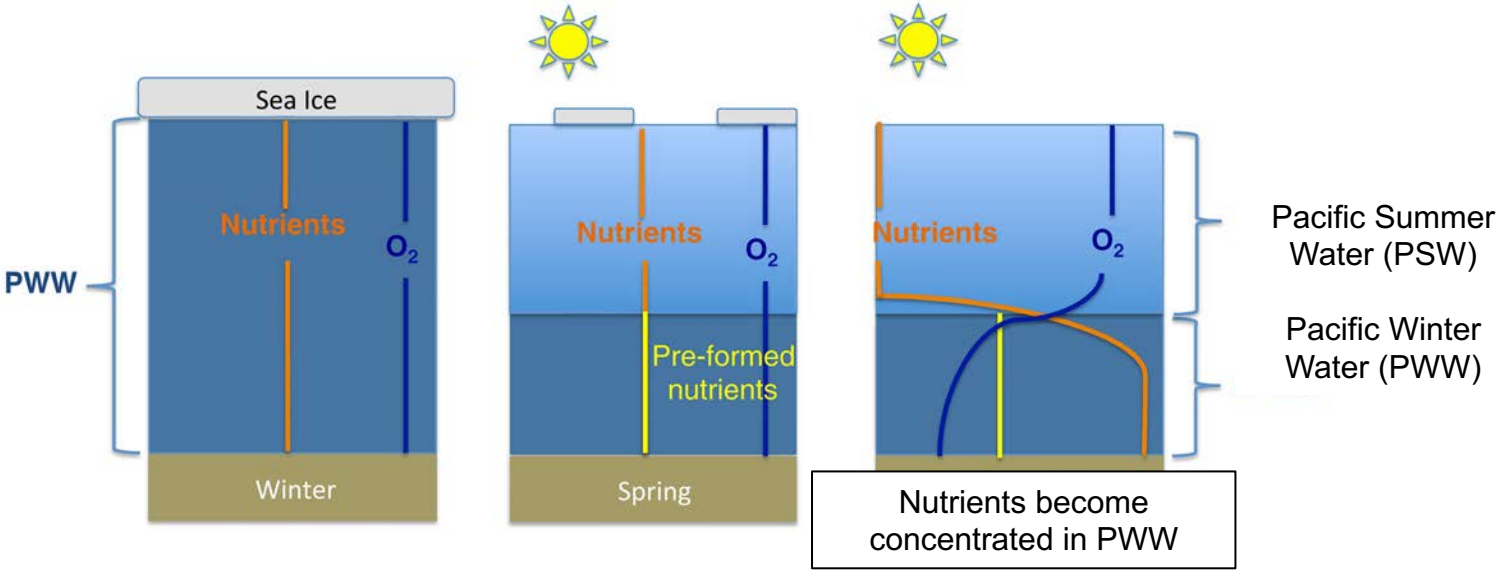
Trace metals in the Arctic Ocean



Distribution is shaped by cycling on the Chukchi Shelf and subsequent entrainment into the halocline

Jensen et al., 2019; 2020; 2022; Gerringa et al., 2021

The halocline: Pacific Summer and Winter Water



Pacific water flows through Bering Strait and is modified

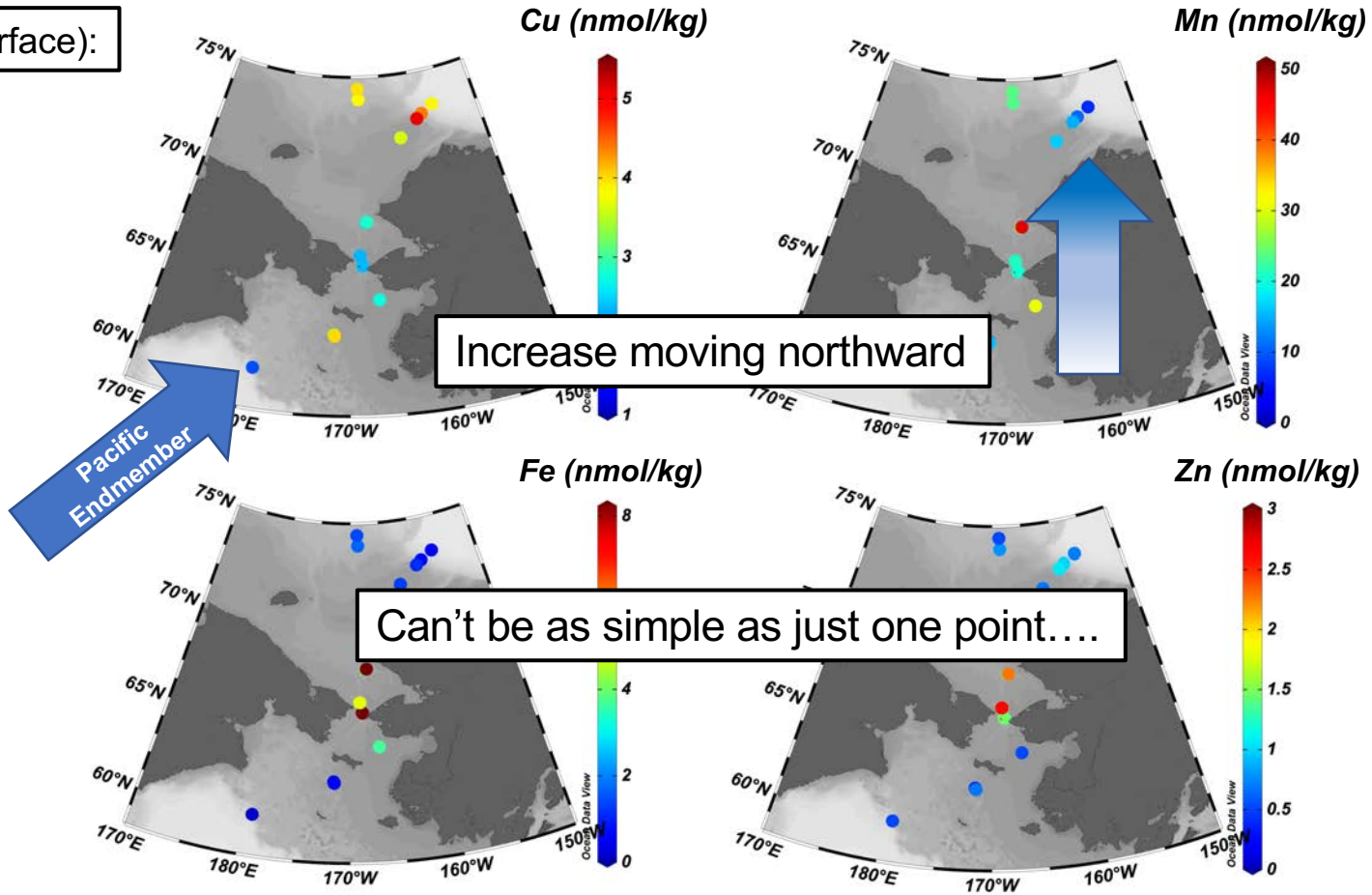
If we want to trace metals in the Arctic, we need to know the amount coming in from the Pacific

What is the Pacific "endmember" concentration for each trace metal?

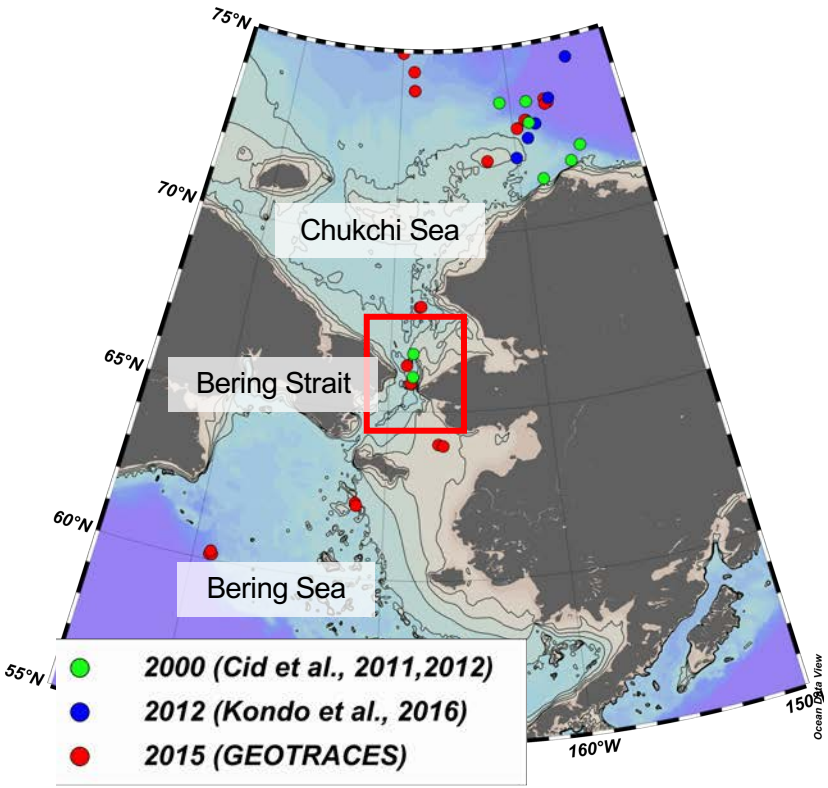
Granger et al. (2018)

Bering Strait trace metals: GEOTRACES

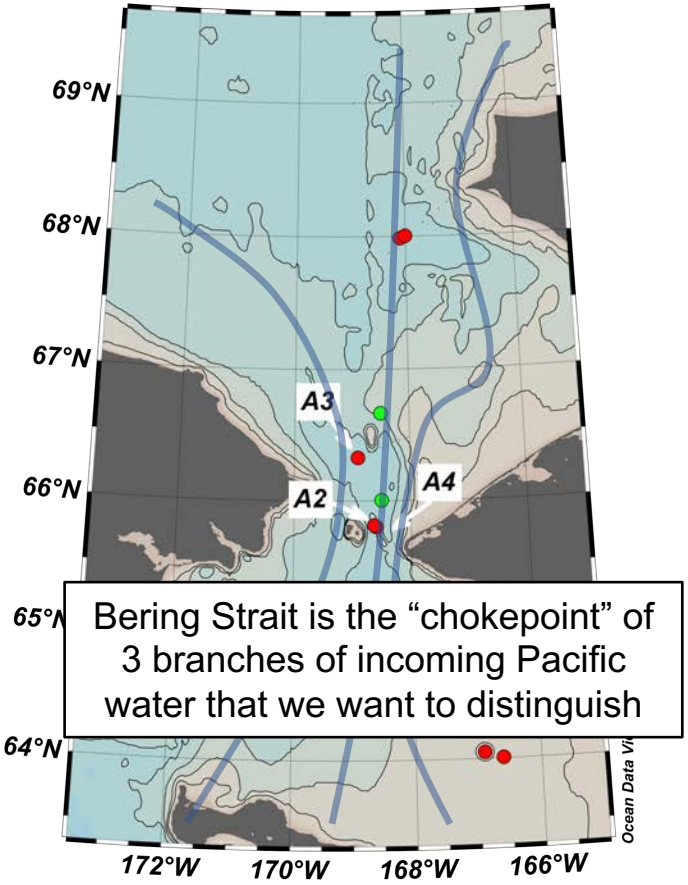
2015 (surface):



Trace metal data in the Bering Strait

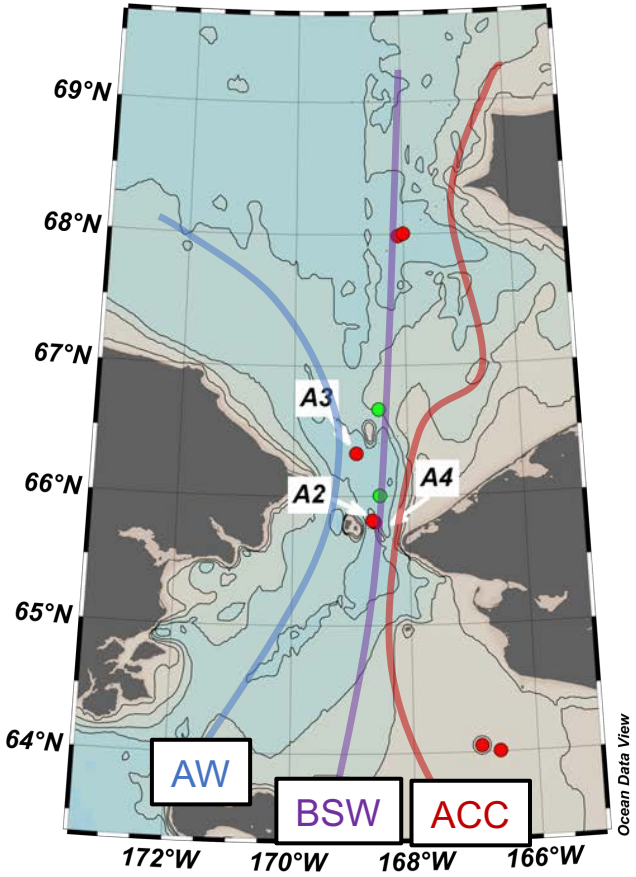


Trace metal data coverage in the Bering Strait and Chukchi Shelf



Bering Strait is the “chokepoint” of 3 branches of incoming Pacific water that we want to distinguish

Circulation in the Bering Strait



AW = Anadyr Water
cold, salty, nutrient-rich

ACC = Alaskan Coastal Current ***(seasonal)***
warm, fresh, nutrient-poor

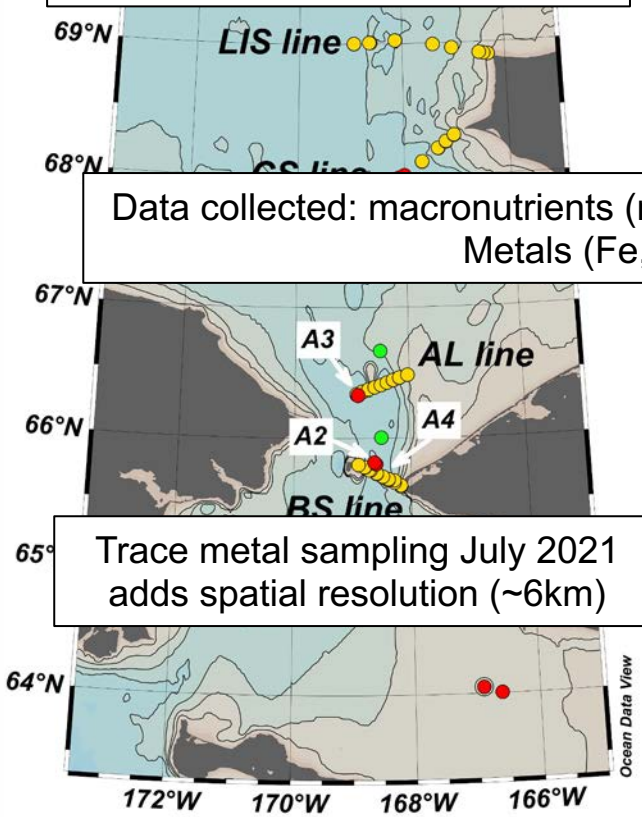
BSW = Bering Sea Water
mean flow

Trace metals are governed by physical mixing farther north, what about in the Bering Strait?

Sparse data points are not sufficient to characterize all 3 branches

Bering Strait July 2021

Bering Strait Mooring Program
R. Woodgate, UW

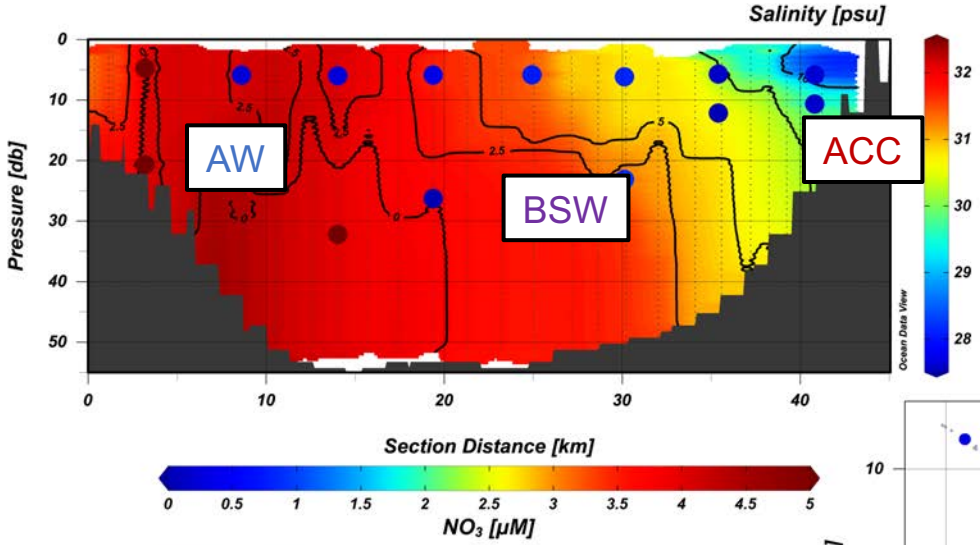


Data collected: macronutrients (nitrate, silicate, phosphate, nitrite, ammonium)
Metals (Fe, Mn, Cu, Ni, Zn, Cd, Pb)

Trace metal sampling July 2021
adds spatial resolution (~6km)

Surface, 5m
“Bottom”, 20-45m

Bering Strait water mass structure



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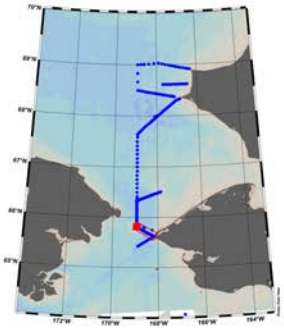
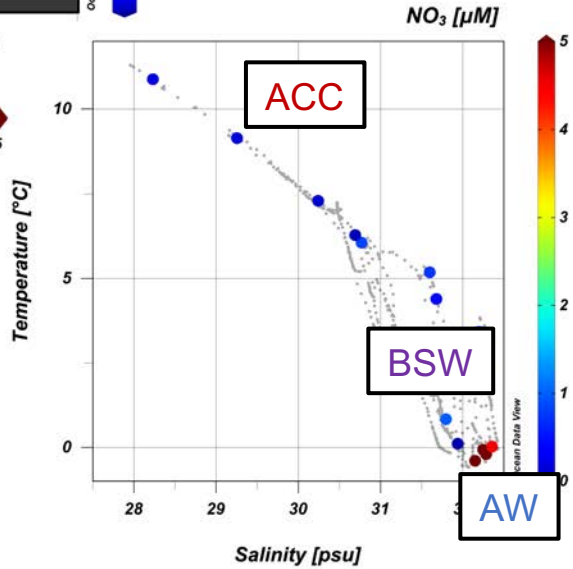
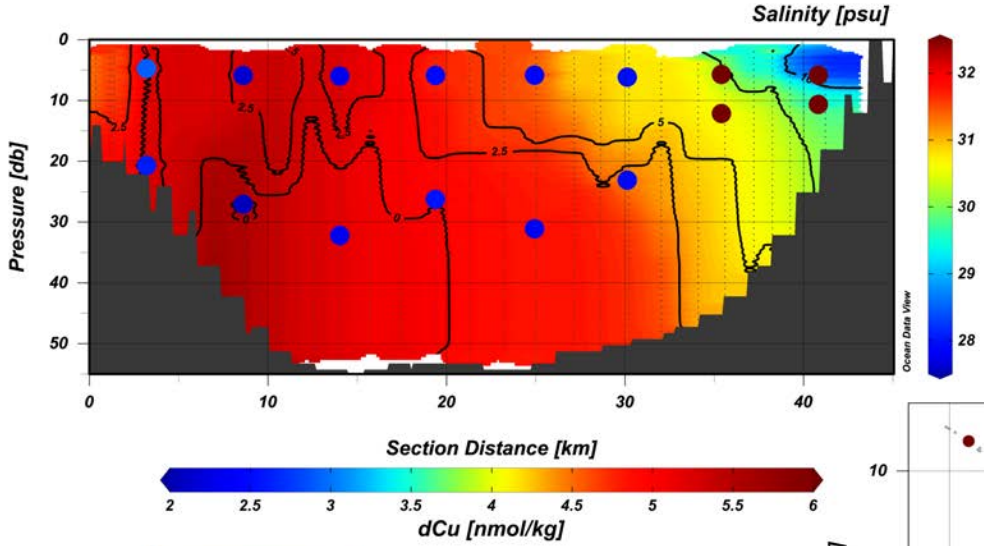




Bering Strait trace metals: Cu



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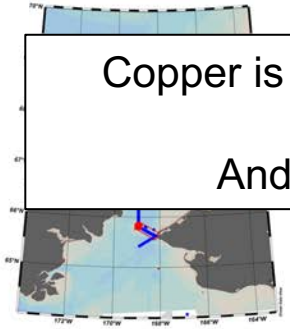
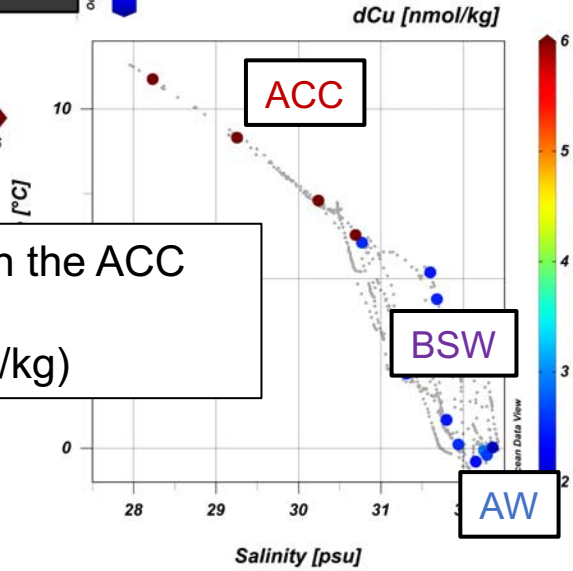


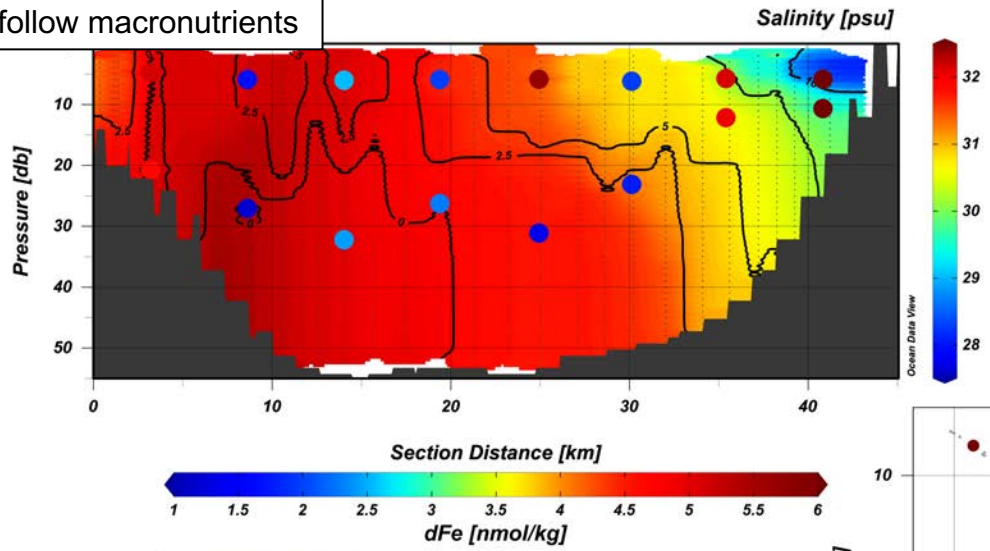


Copper is HIGH (~11 nmol/kg) in the ACC

And LOW in AW (~2 nmol/kg)

Bering Strait trace metals: Fe

Fe should follow macronutrients



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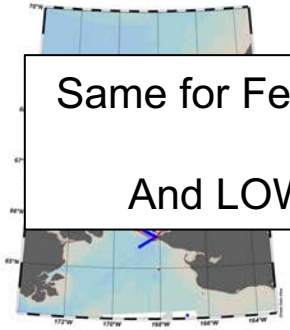
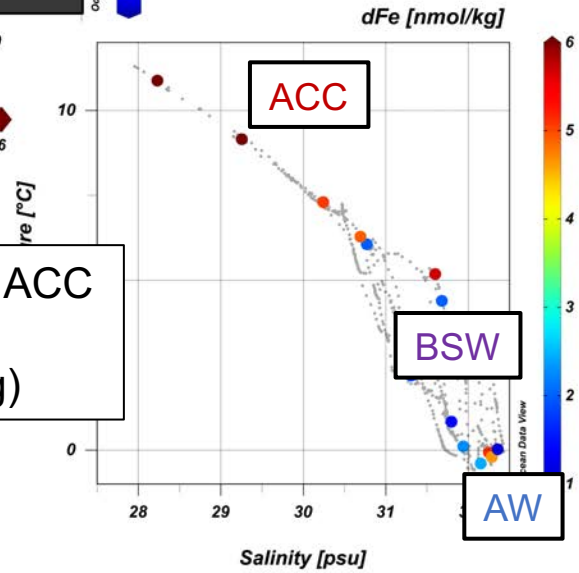


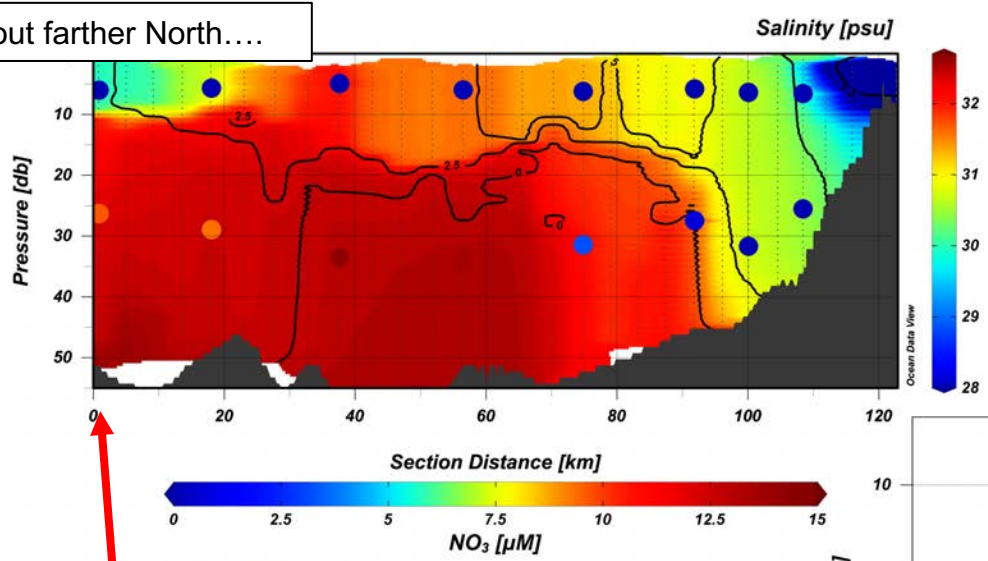
Same for Fe (~7.5 nmol/kg) in the ACC

And LOW in AW (~1.1 nmol/kg)



Bering Strait trace metals: NO_3

How about farther North….



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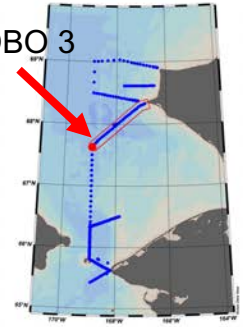
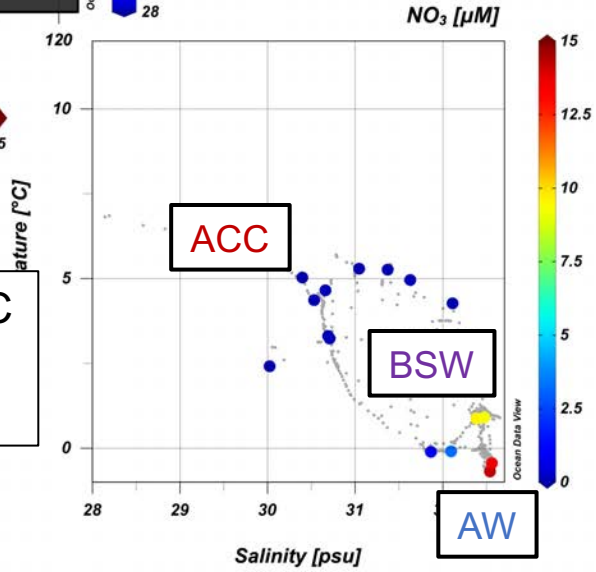
DBO 3

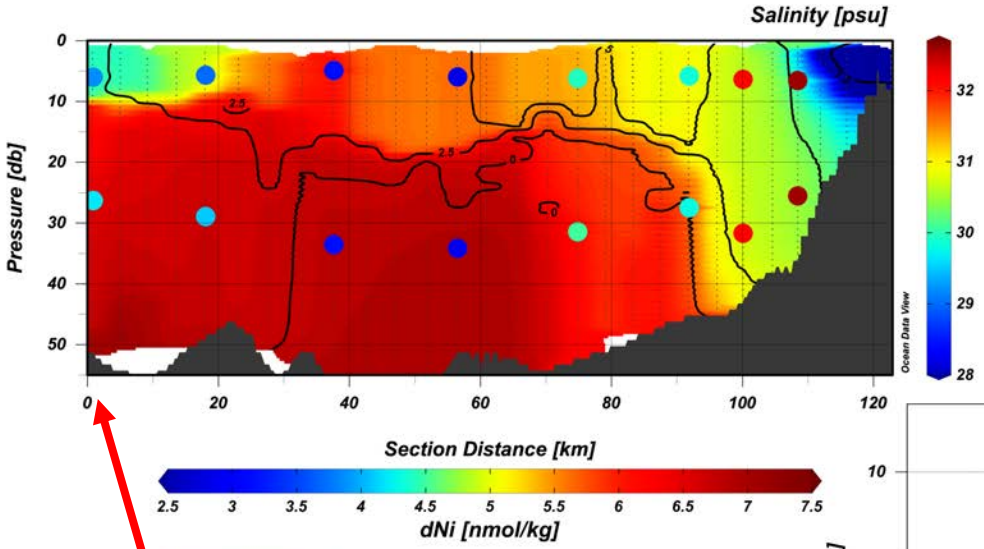


Nitrate **low** in the ACC

Nitrate **high** in AW



Bering Strait trace metals: Ni



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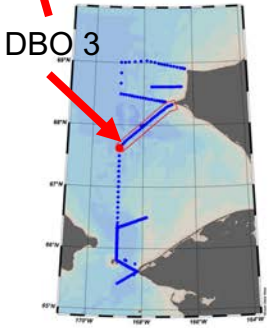
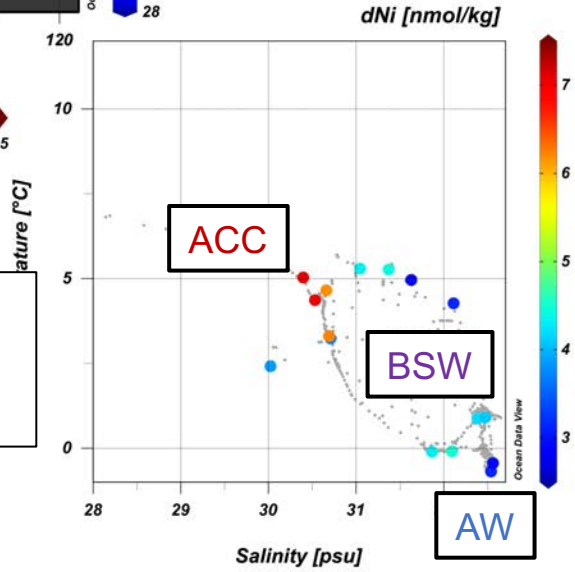


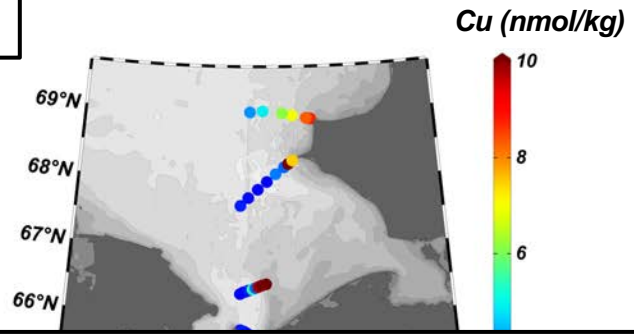
Ni high in the ACC

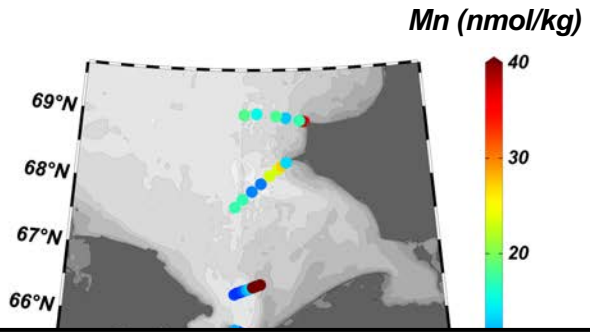
Ni low in AW



Trace metal endmember

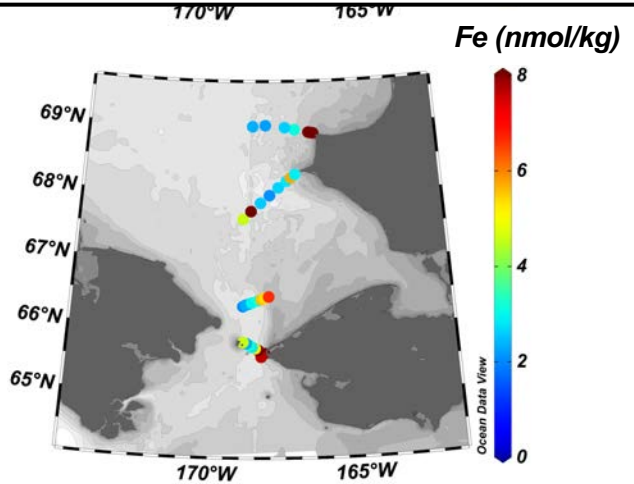
2021 (surface):

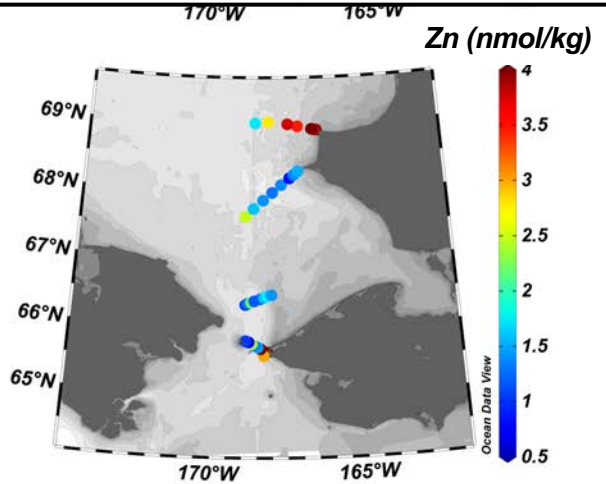




There is not one “Pacific Endmember”, it is a range linked to water mass

We can put bounds on this value





Bering Strait trace metals

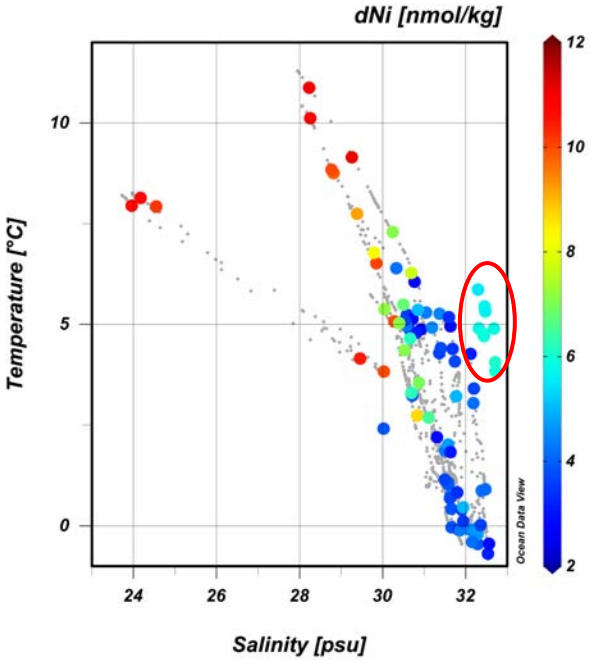
Many trace metals closely follow water mass movement in the Bering Strait and Chukchi Sea

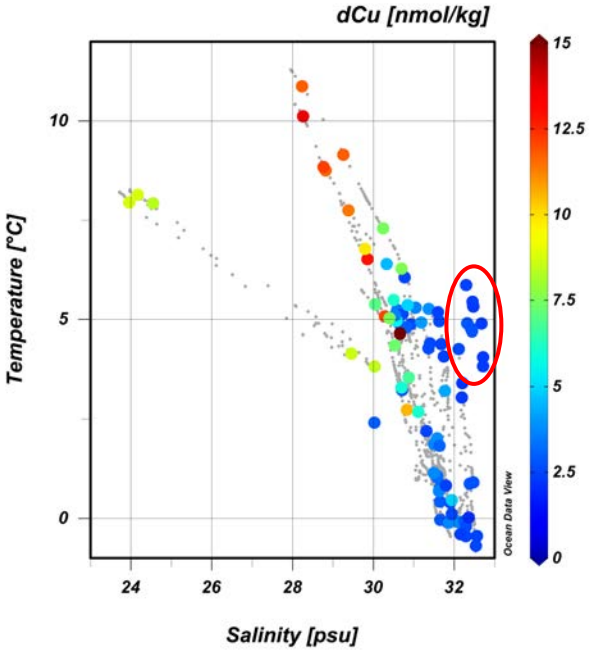
- ACC is a riverine source, not surprisingly it is high in TMs
  - But low in nutrients

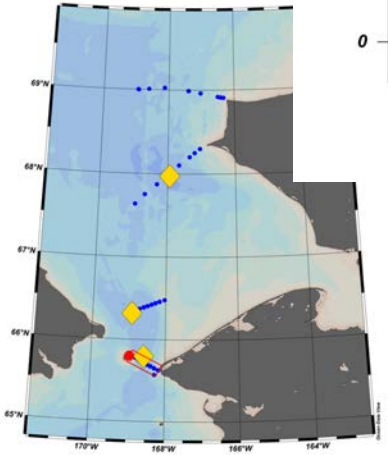
- AW is elusive in these study sites but is thought to be a major source of nutrients to the Chukchi Sea
  - Does not appear to be a significant source of TMs

How does this compare to historical data?

Comparison to 2015 (GEOTRACES)





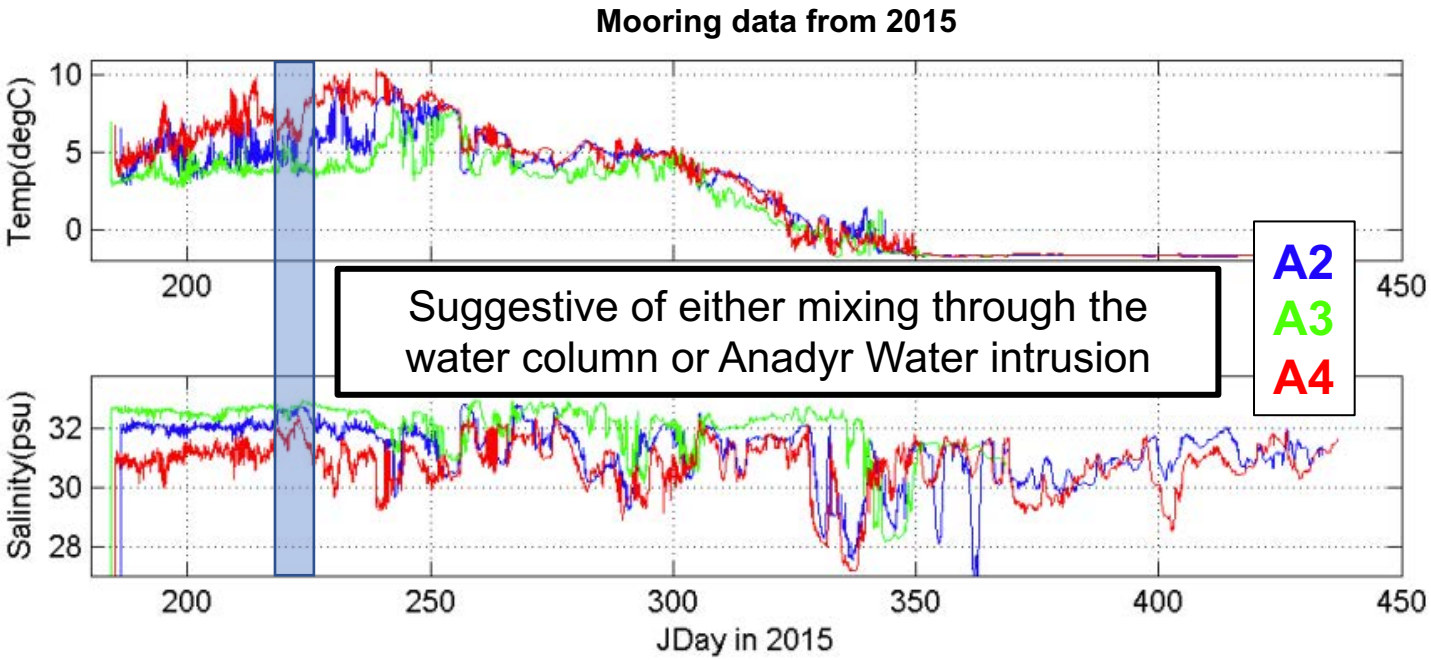


Dates sampled: August 15-16, 2015

Trace metals appear elevated or similar concentration to July 2021 data

T and S were far more homogeneous in 2015 than 2021

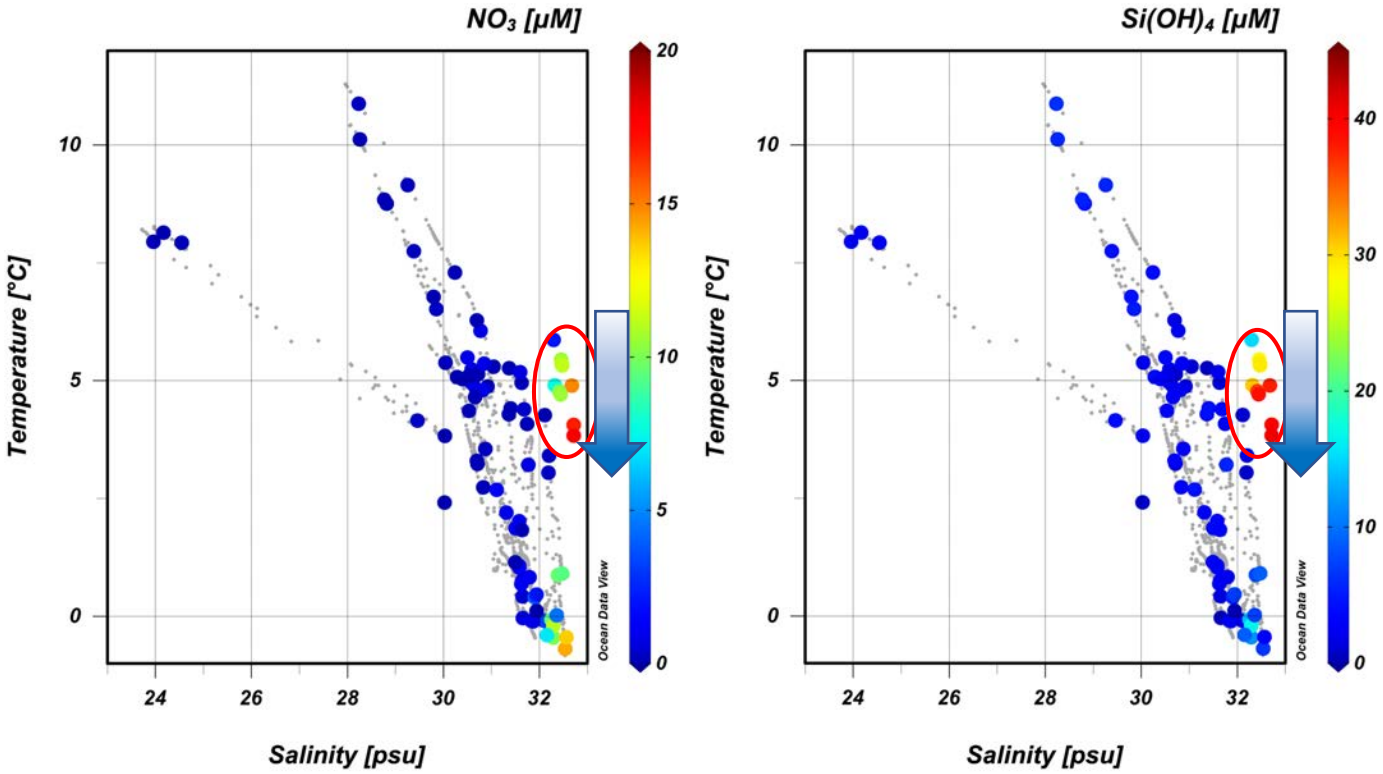
Why are T and S so uniform?



Dates sampled: August 15-16, 2015 (Jday = 227-228)

A2 (blue) and A3(green) have converged to T ~ 5 ºC , S ~ 32.5 psu

Nutrients are elevated

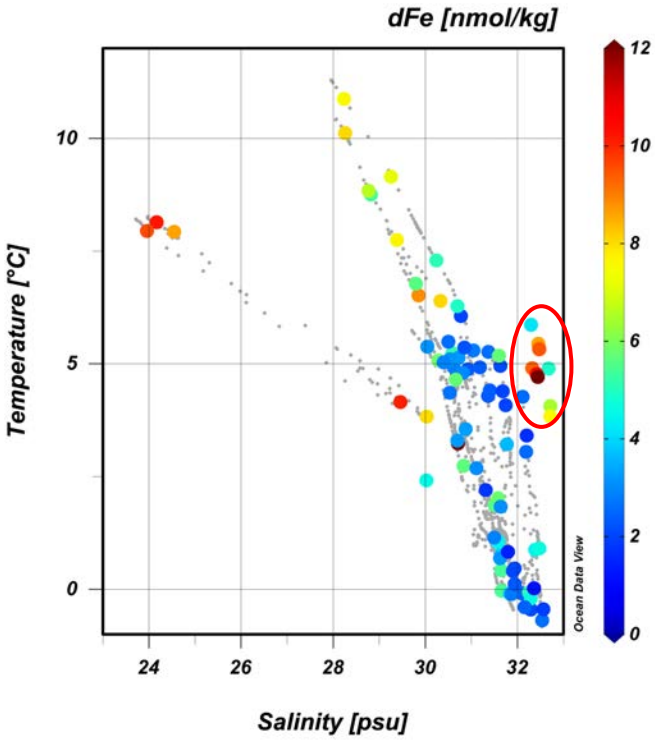


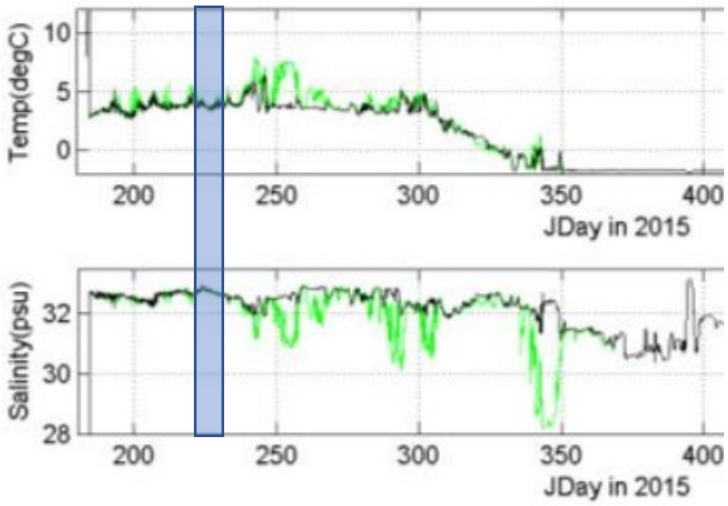
Nutrients, especially Si, increase in concentration with depth in 2015

This looks like it could be Anadyr Water (nutrient-rich)

Mixing and regeneration of organic matter

What do the trace metals point to?





Upper water column mooring measurements and metal data suggests water column is well-mixed AND evidence of regeneration of metals and nutrients in the water column

Conclusions

Many trace metals closely follow water mass movement in the Bering Strait and Chukchi Sea

- ACC = high in TMs, low in nutrients
- AW = low in TMs, high in nutrients

Trace metals can be used to track water mass movement and distinguish processes that may be unclear with just T, S, and nutrients

Seasonality and interannual variation does matter, hydrography and TMs were different between 2015 and 2021

Next steps:

- Fluxes of TMs through the Bering Strait using ADCP data

  ACC is 10% of volume transport but may contribute 45-50% of TM supply

- Effects of seasonality and interannual variability in the Bering Strait on TM supply (*sampling again September 2022, proposal in prep for subsequent field seasons*)