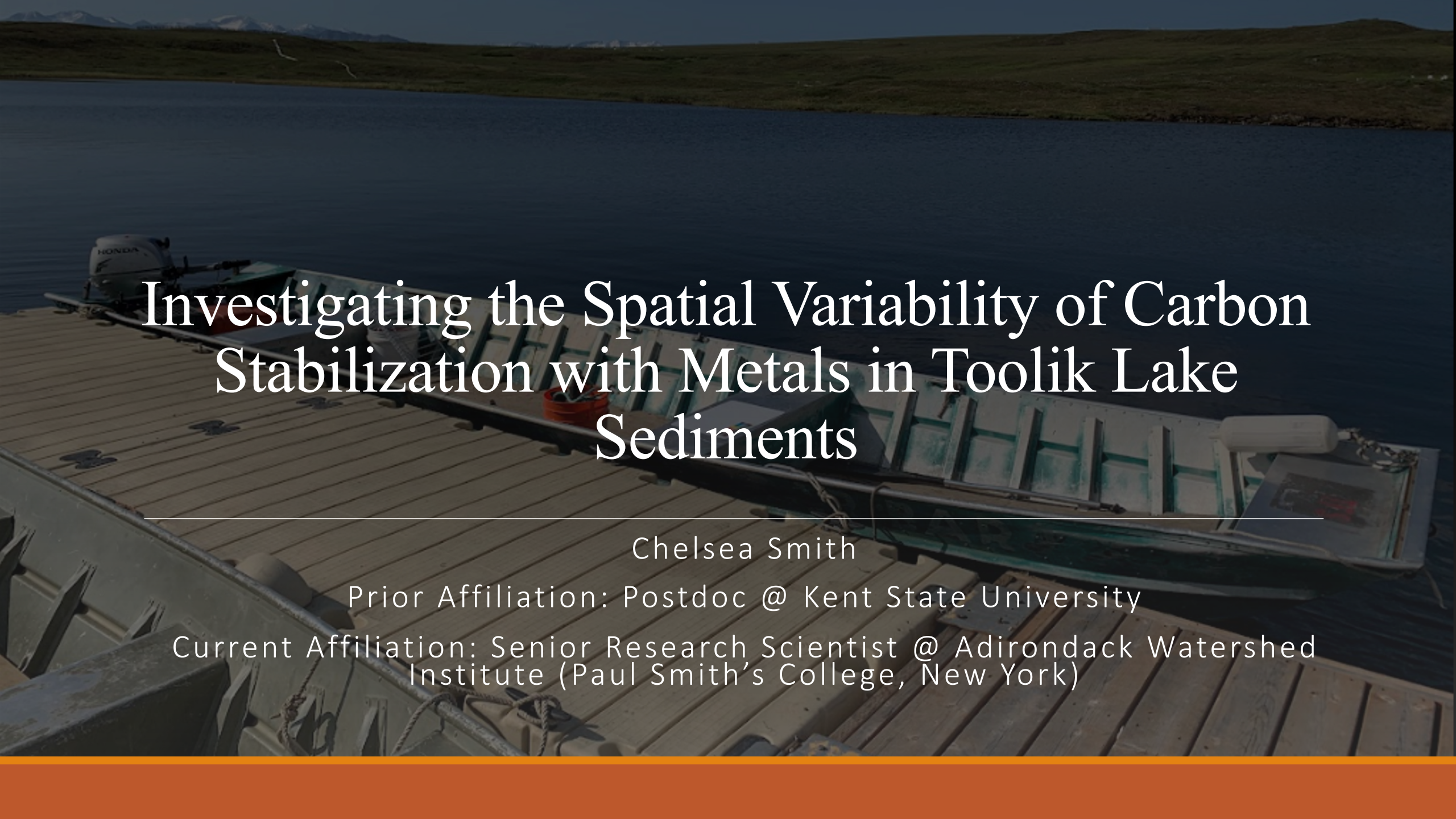

Investigating the Spatial Variability of Carbon Stabilization with Metals in Toolik Lake Sediments

Chelsea Smith

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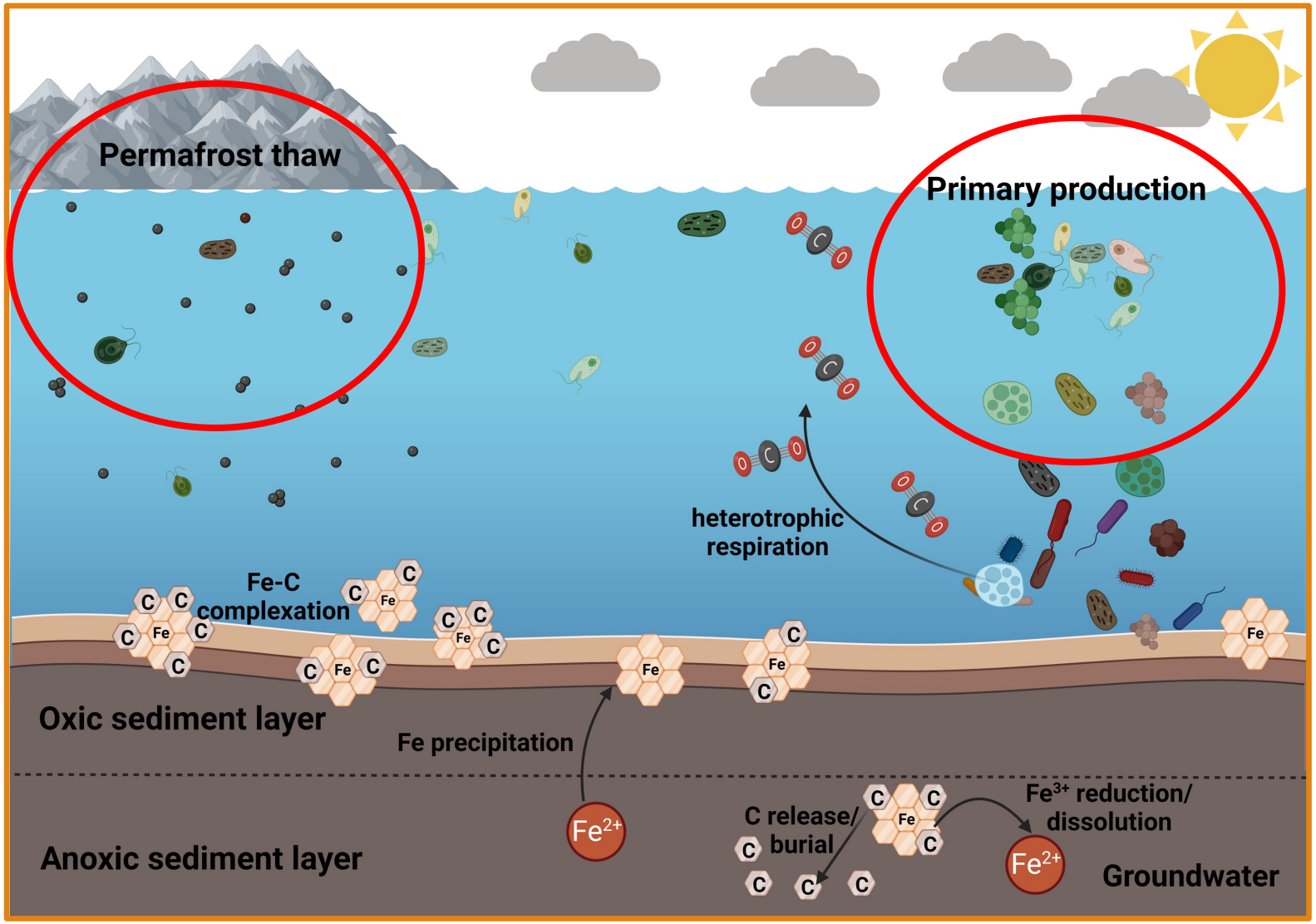
Toolik Field Station Tundra Award

National Geographic Explorers Grant

2024 KSU ESDRI Seed Grant

Carbon storage in Arctic lakes

- Lake sediments are large reservoirs for carbon
- Permafrost thaw causes an influx of organic carbon
- Carbon stabilization with iron (Fe) oxides
  - Manganese (Mn) oxides



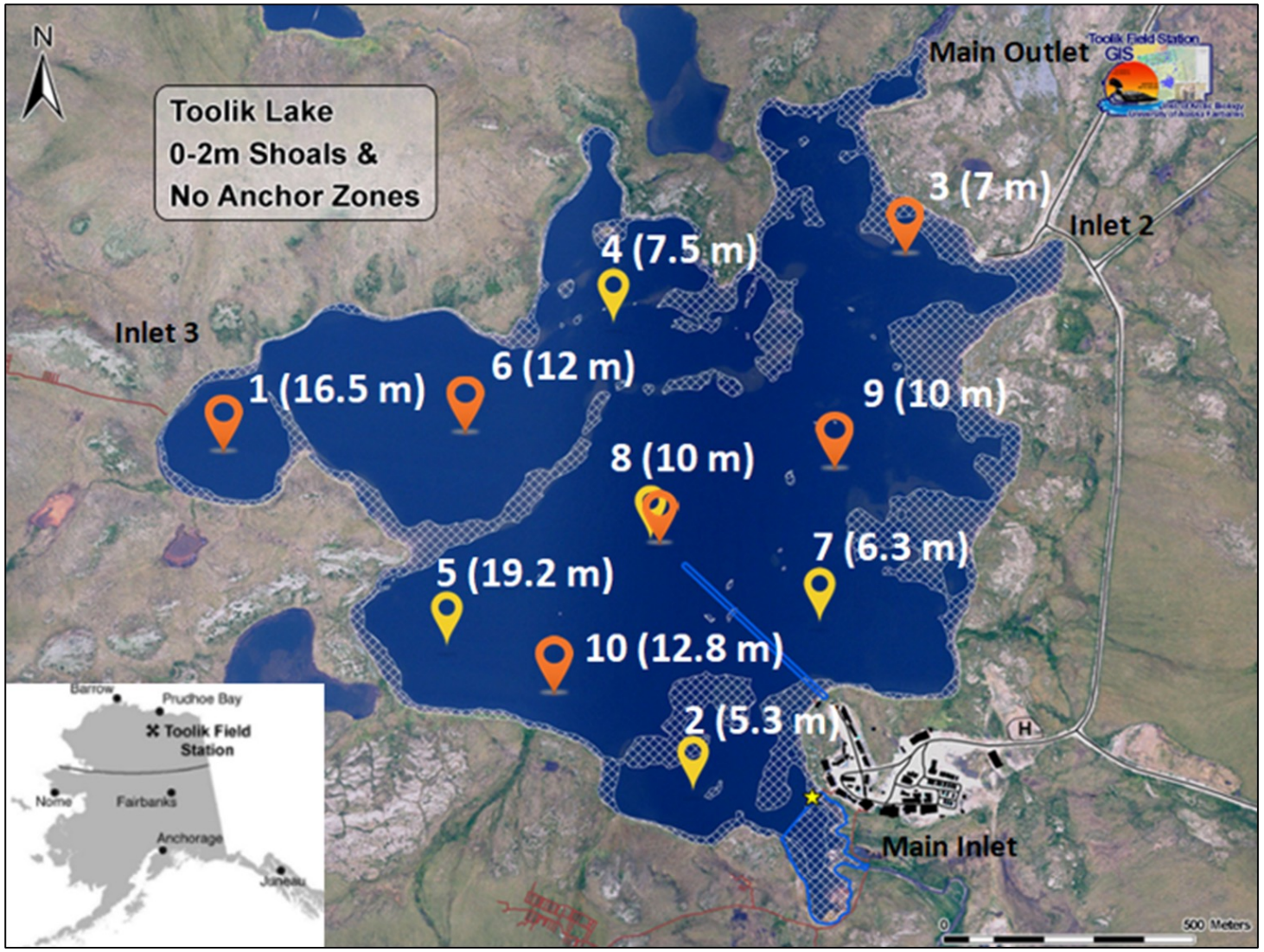
Made with BioRender.com

Carbon stabilization in Arctic lake sediments

Questions

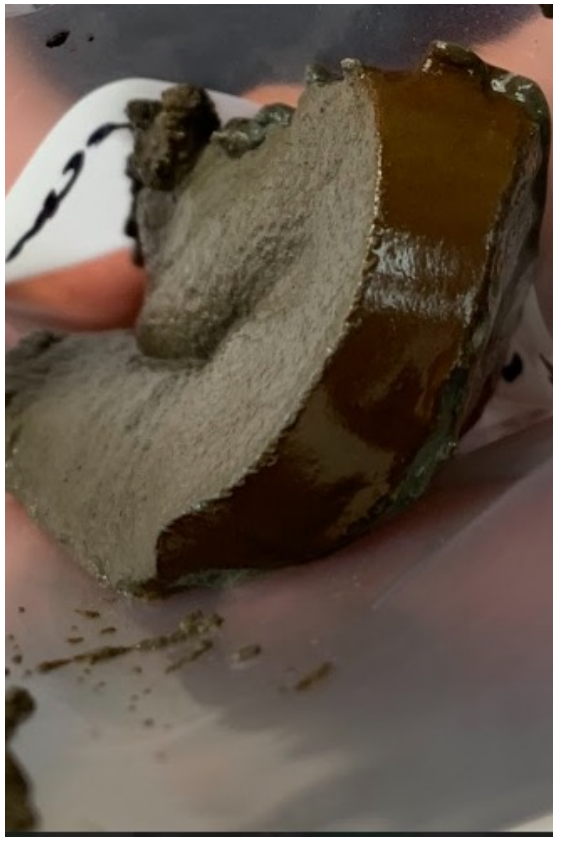
1. Are metals stabilizing organic carbon or fueling heterotrophic respiration in lake surface sediments?

2. How is the carbon that reaches the lakebed altered biologically and chemically?



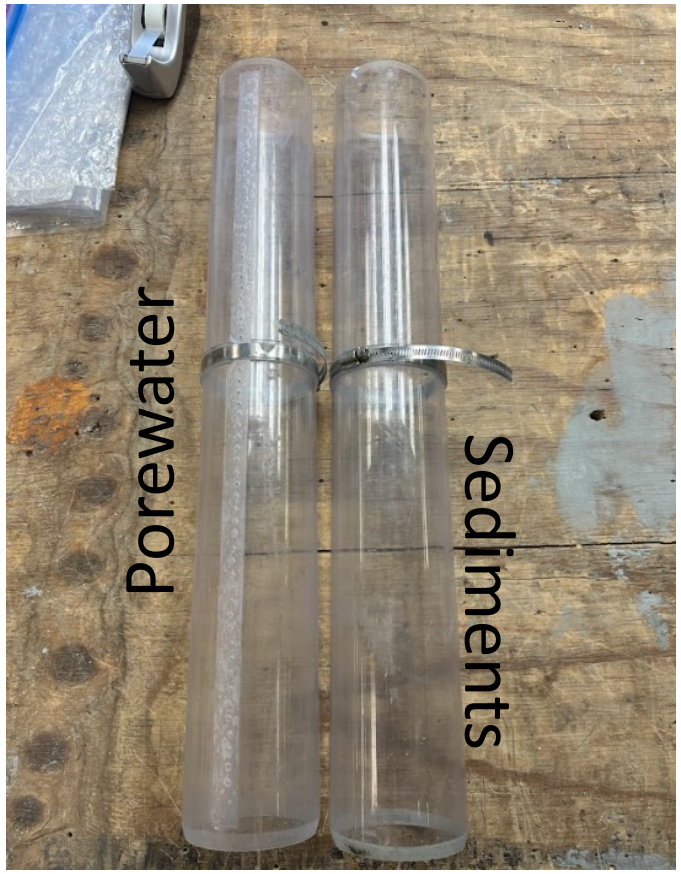
Toolik Lake

- 10 sites in total
- 5 sites sampled in 2022
- 6 sites samples in 2024
- Site 8 sampled both years



Methods

HTH Gravity Corer

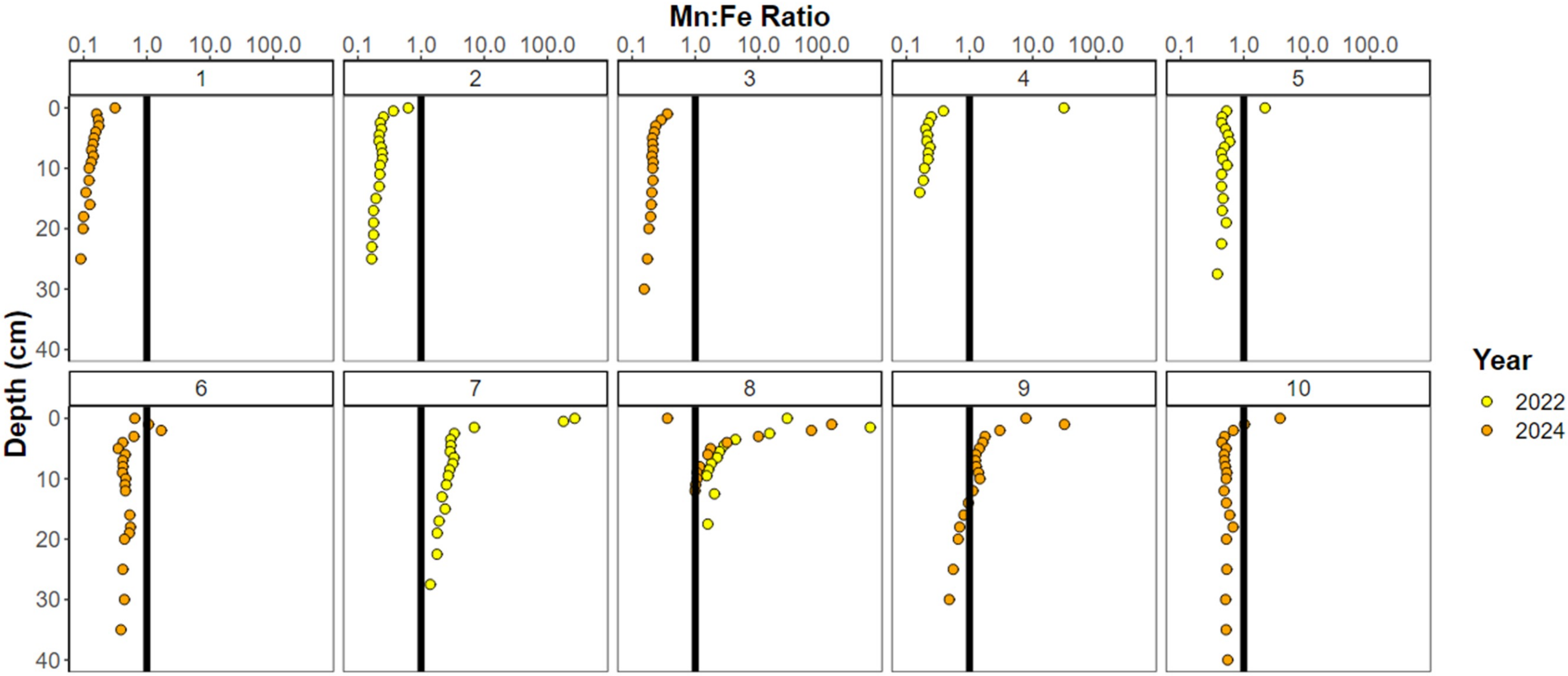


Core liners

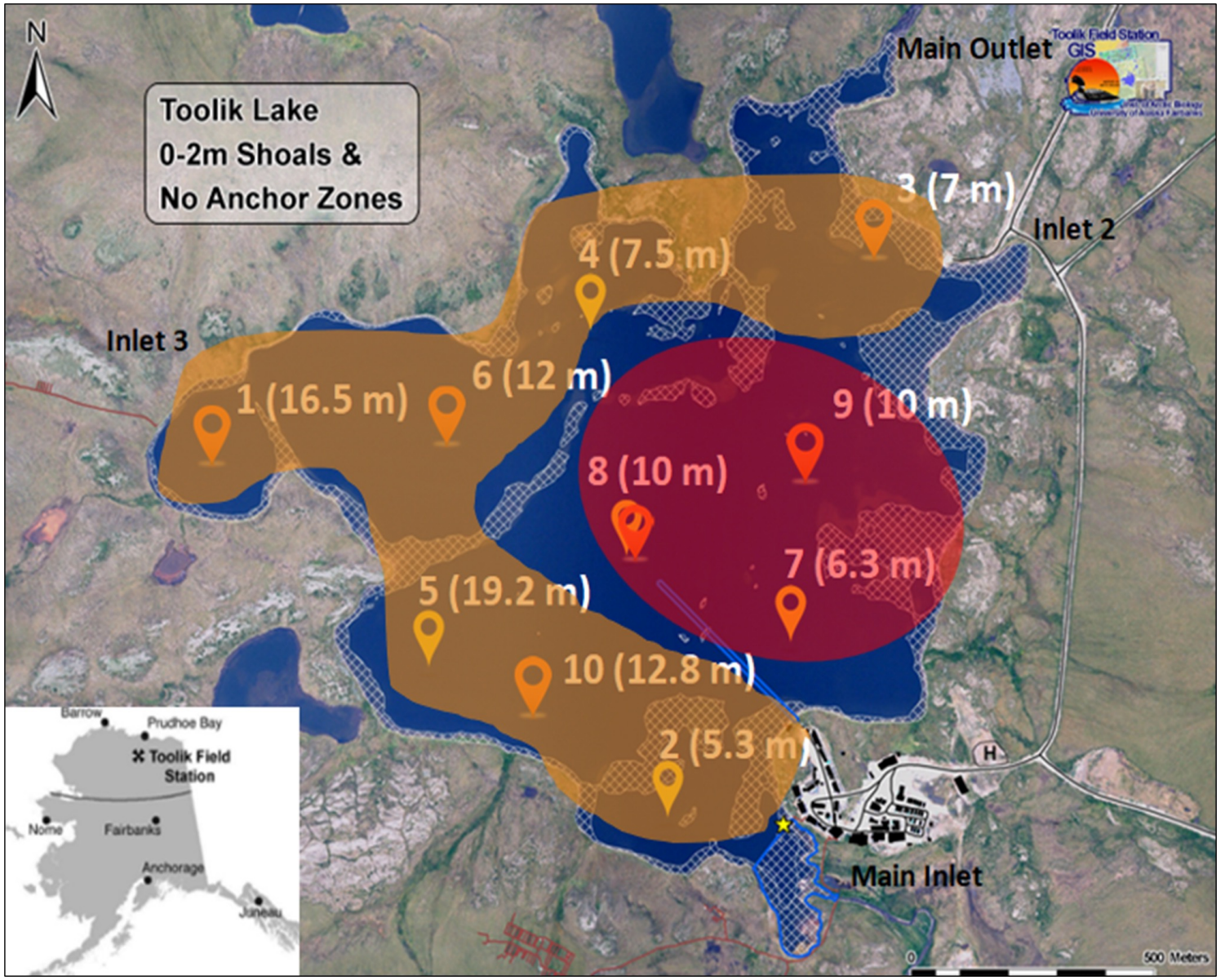
Slicing

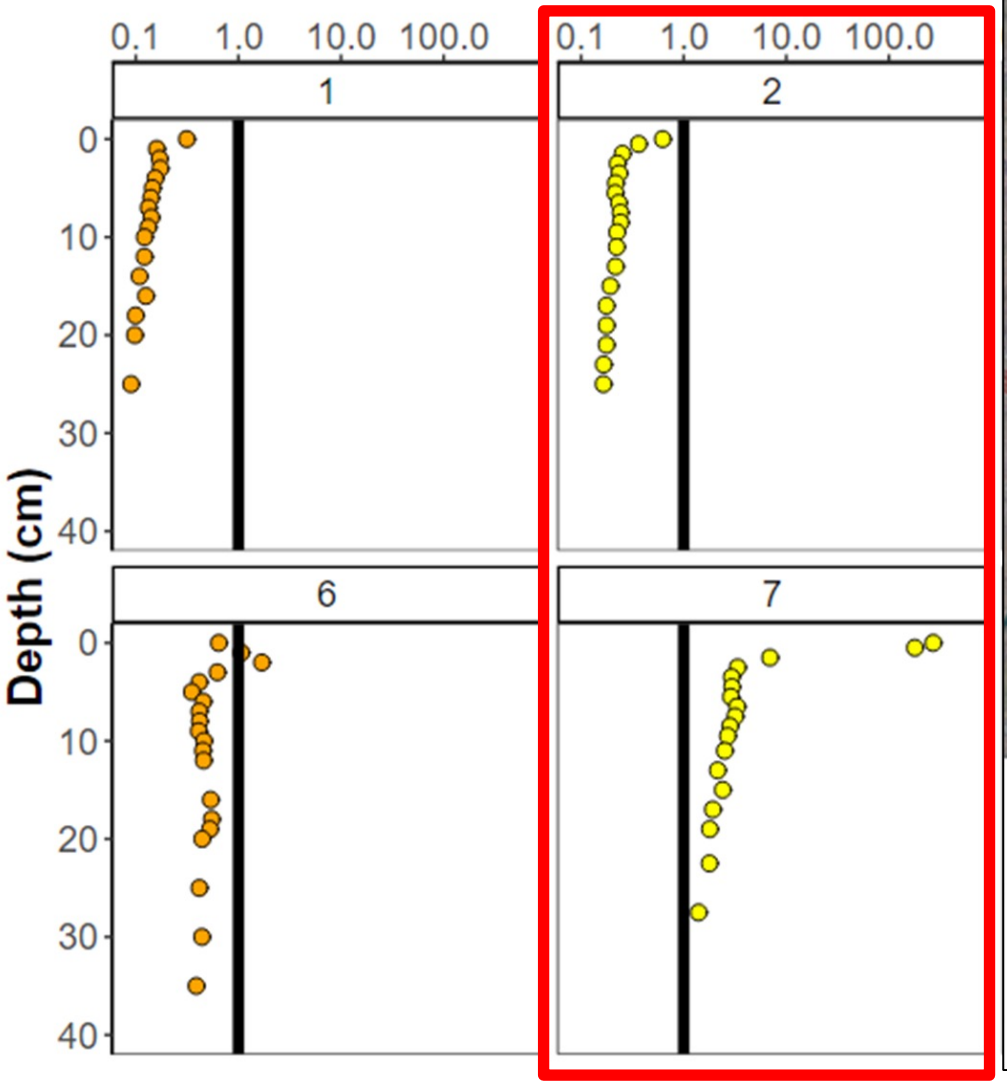
Sediment Sampling

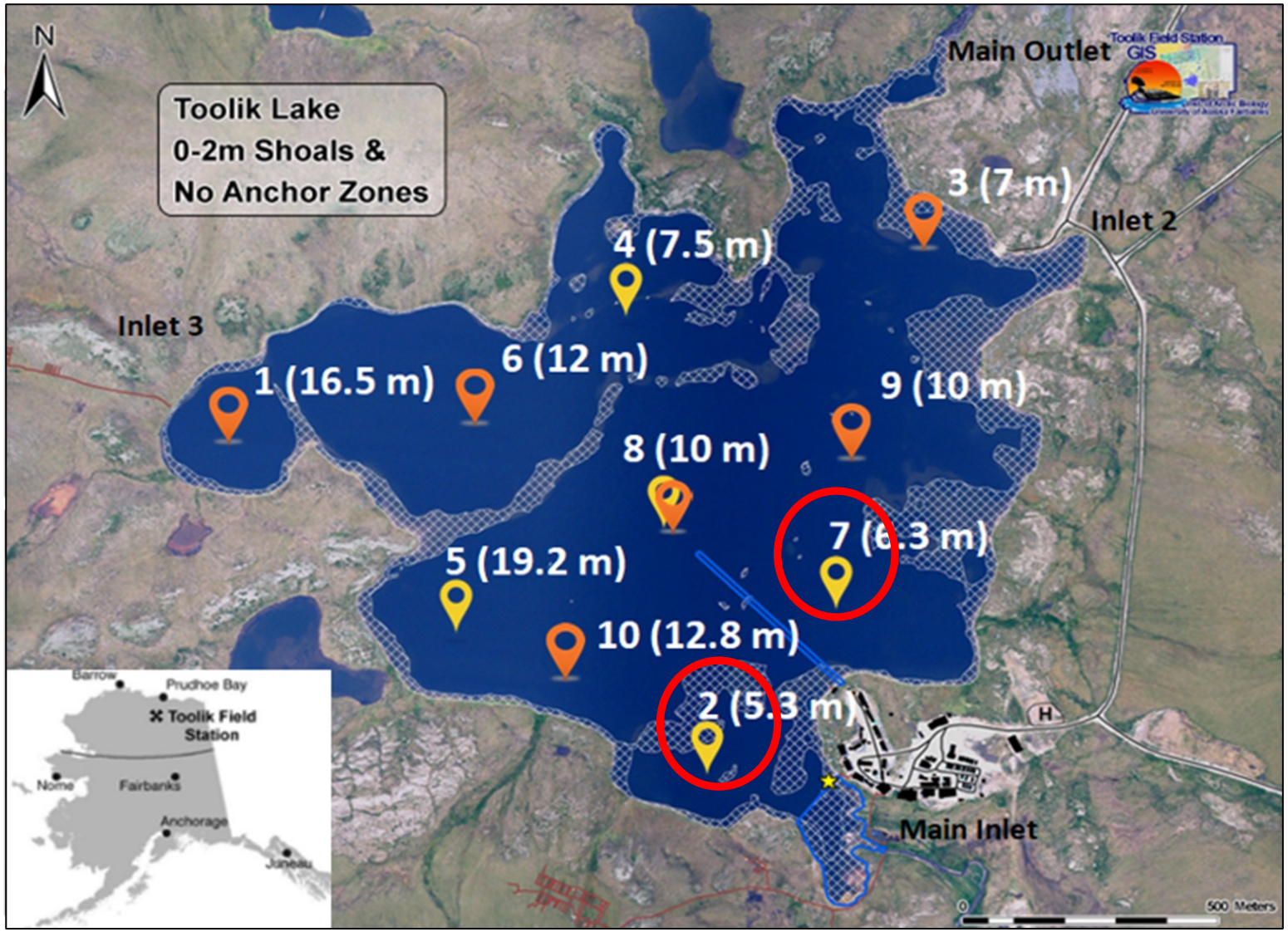
Porewater Sampling



Dissolved Fe and Mn in Porewater


N
Toolik Lake
0-2m Shoals &
No Anchor Zones
Main Outlet
Toolik Field Station GIS
3 (7 m)
Inlet 2
4 (7.5 m)
Inlet 3
6 (12 m)
1 (16.5 m)
9 (10 m)
8 (10 m)
7 (6.3 m)
5 (19.2 m)
10 (12.8 m)
2 (5.3 m)
H
Main Inlet
500 Meters
Barrow
Prudhoe Bay
Toolik Field Station
Nome
Fairbanks
Anchorage
Juneau


0.1
1.0
10.0
100.0
1
2
6
7
Depth (cm)
0
10
20
30
40


N
Toolik Lake
0-2m Shoals &
No Anchor Zones
Main Outlet
Toolik Field Station GIS
3 (7 m)
Inlet 2
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5 (19.2 m)
10 (12.8 m)
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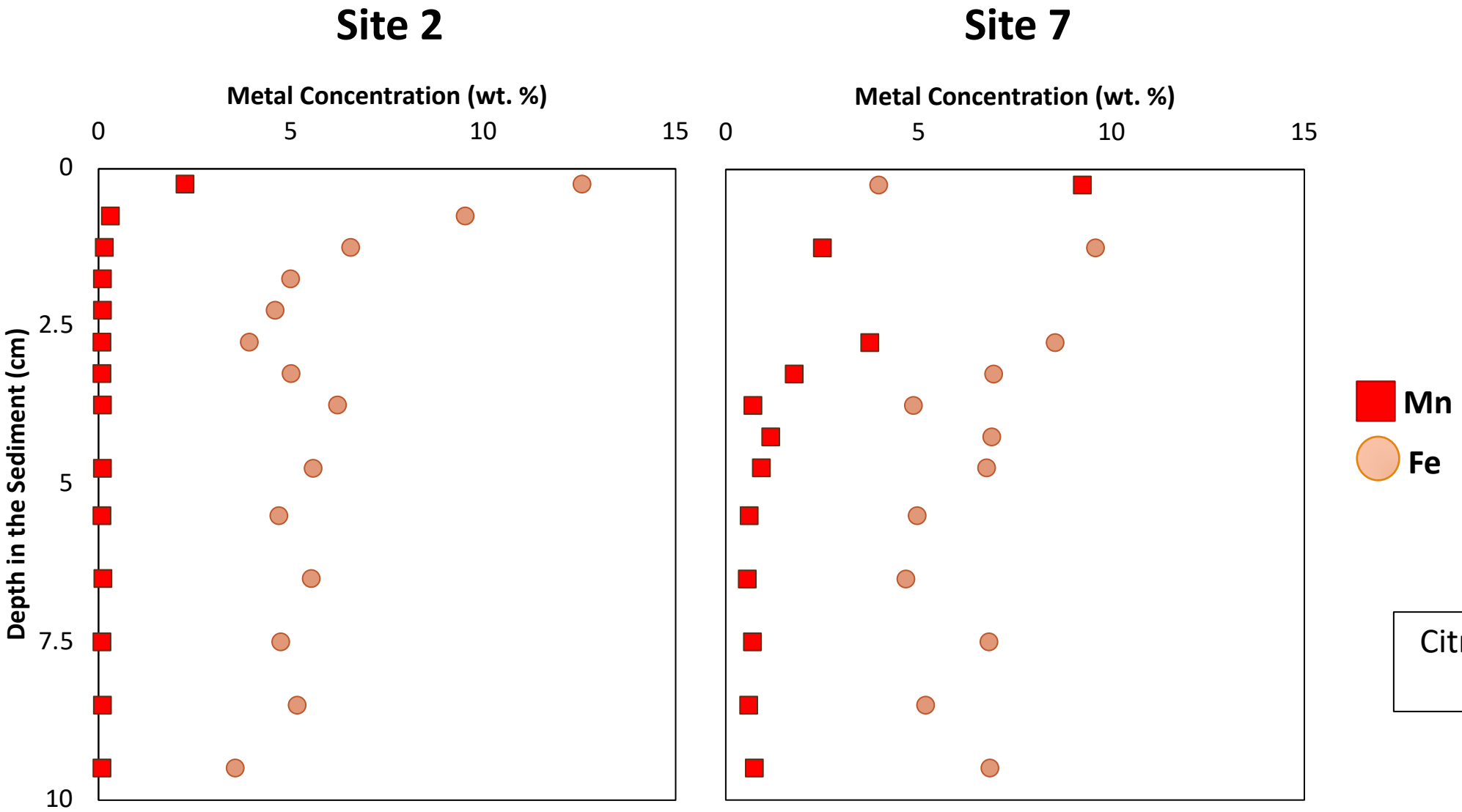
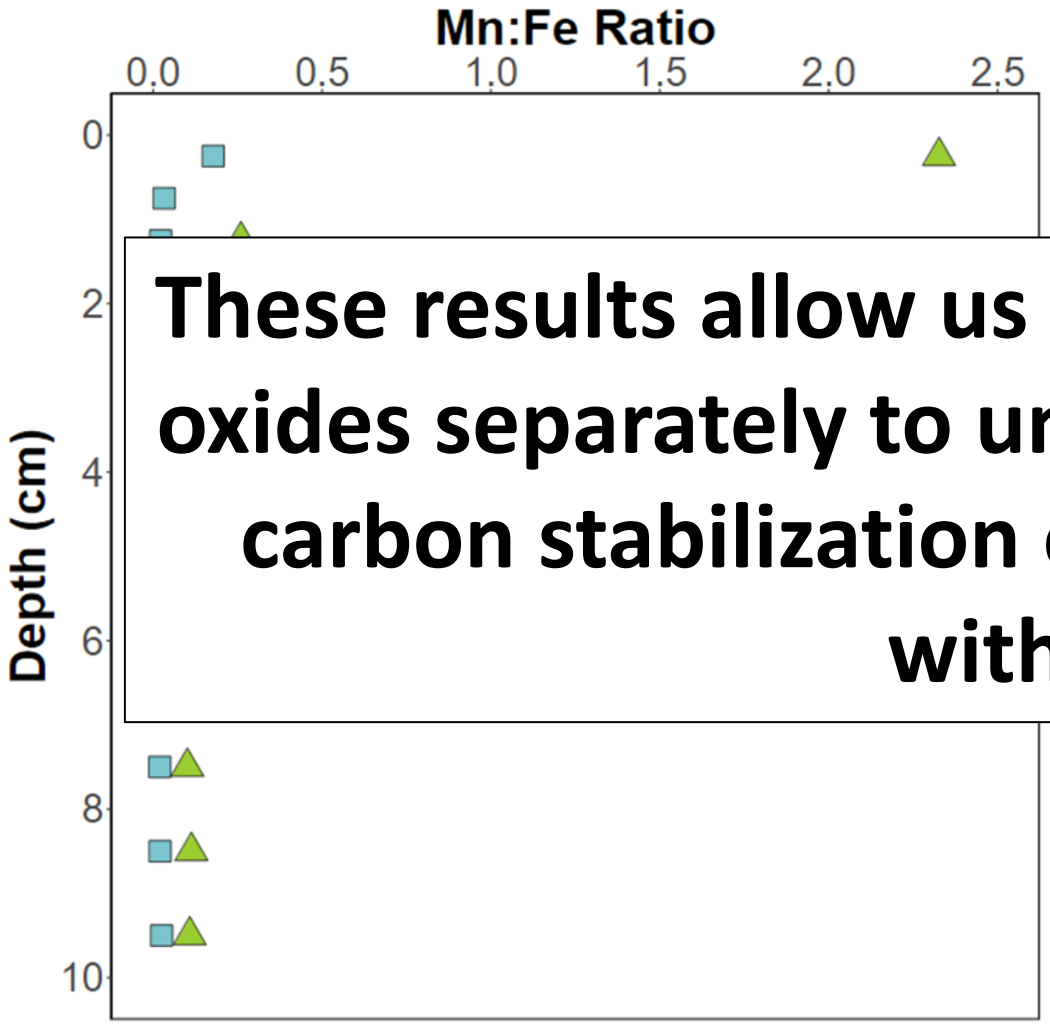
H
Main Inlet
500 Meters
Barrow
Prudhoe Bay
Toolik Field Station
Nome
Fairbanks
Anchorage
Juneau

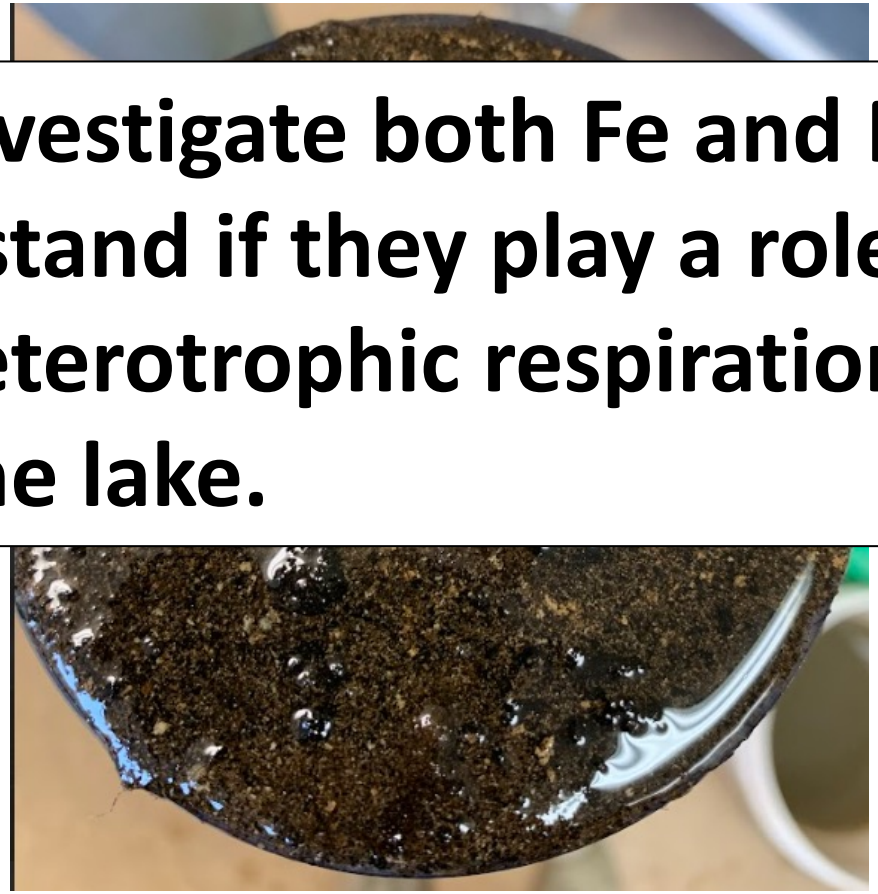


Citrate dithionite acetic acid extraction

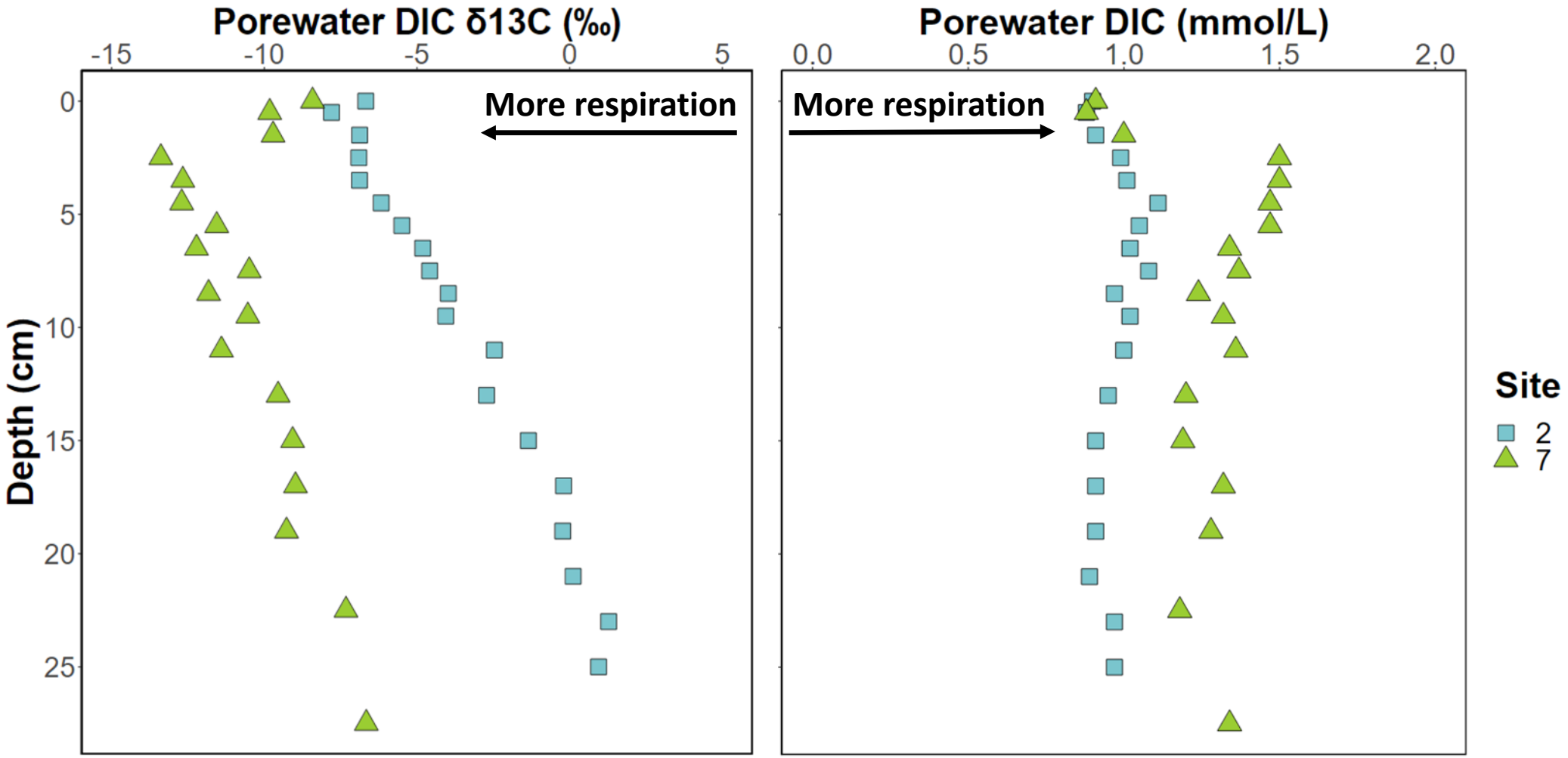
Reactive Fe and Mn near surface sediments

Manganese/Iron Ratio

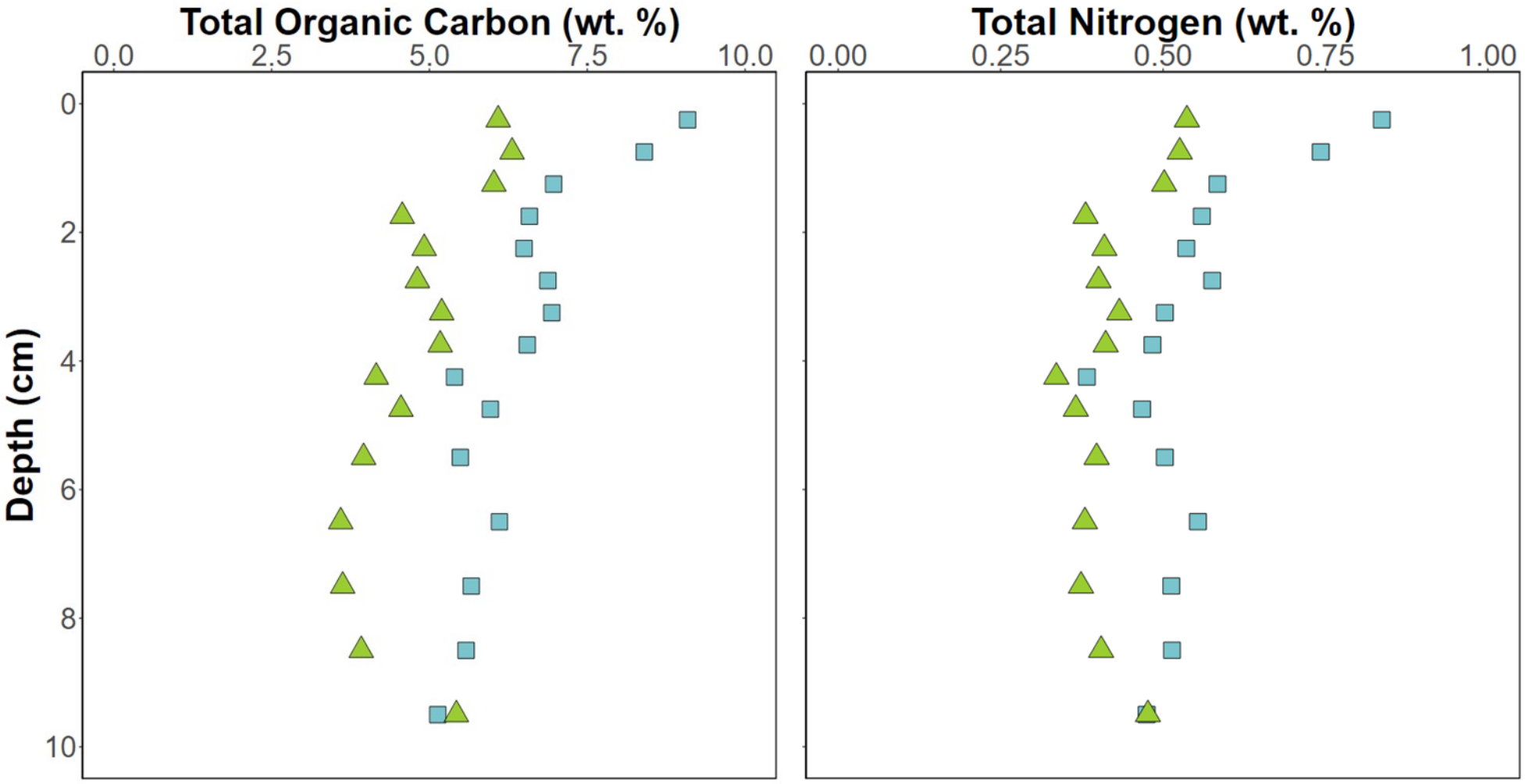




These results allow us to investigate both Fe and Mn oxides separately to understand if they play a role in carbon stabilization or heterotrophic respiration within the lake.



Porewater Dissolved Inorganic Carbon

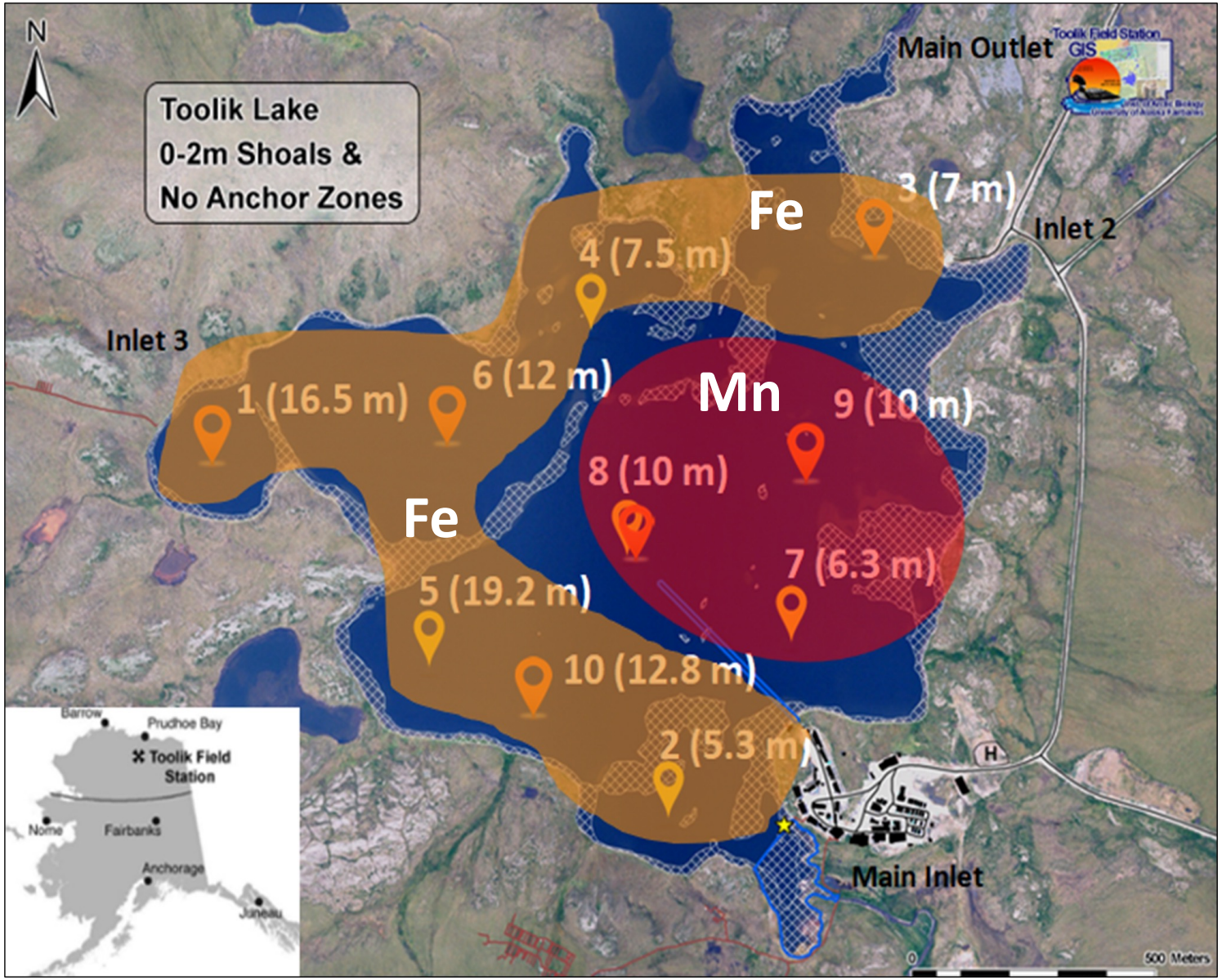

Total Organic Carbon (wt. %)
0.0
2.5
5.0
7.5
10.0
Depth (cm)
0
2
4
6
8
10
Total Nitrogen (wt. %)
0.00
0.25
0.50
0.75
1.00

TOC

TN

Preliminary Findings

- Spatial variability in dominant metal signatures across the lake
  - Pocket of Mn dominated sites in the lake (sites 7-9)
- Variable heterotrophic respiration signatures
  - Site 7: higher heterotrophic respiration
- Variable concentrations of TOC and TN
  - Site 7: lower TOC and TN



Preliminary Conclusions

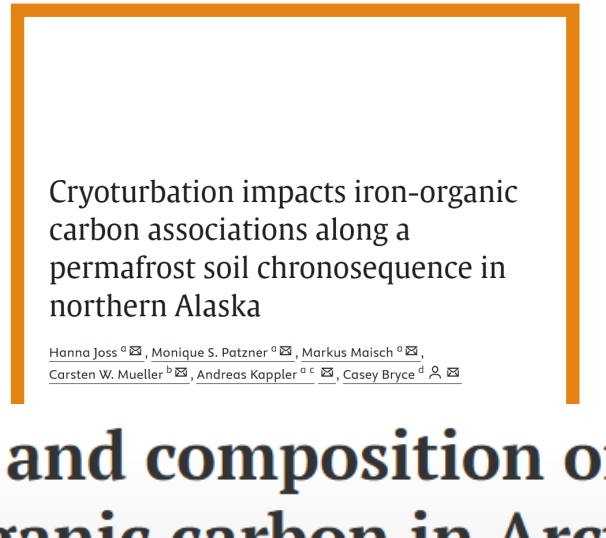
Sites dominated by iron reduction appear to be stabilizing organic carbon while sites dominated by manganese reduction are fueling heterotrophic respiration and carbon degradation

Article | Open access | Published: 12 January 2021

Millennial scale persistence of organic carbon bound to iron in Arctic marine sediments

Johan C. Faust, Allyson Tessin, Ben J. Fisher, Mark Zindorf, Sonia Papadaki, Katharine R. Hendry, Katherine A. Doyle & Christian März

Nature Communications **12**, Article number: 275 (2021) | Cite this article



Cryoturbation impacts iron-organic carbon associations along a permafrost soil chronosequence in northern Alaska

Hanna Joss [a], Monique S. Patzner [a], Markus Maisch [a], Carsten W. Mueller [b], Andreas Kappler [a c], Casey Bryce [d]

Distribution and composition of redox-active species and dissolved organic carbon in Arctic lacustrine porewaters

Danhui Xin, Jeffrey M. Hudson, Anthony Sigman-Lowery & Yu-Ping Chin

Article: 2371534 | Received 29 Jan 2024, Accepted 19 Jun 2024, Published online: 22 Jul 2024

Article | Open access | Published: 10 December 2020

Iron mineral dissolution releases iron and associated organic carbon during permafrost thaw

Monique S. Patzner, Carsten W. Mueller, Miroslava Malusova, Moritz Baur, Verena Nikeleit, Thomas Scholten, Carmen Hoeschen, James M. Byrne, Thomas Borch, Andreas Kappler & Casey Bryce

Nature Communications **11**, Article number: 6329 (2020) | Cite this article

Review Article | Published: 24 August 2023

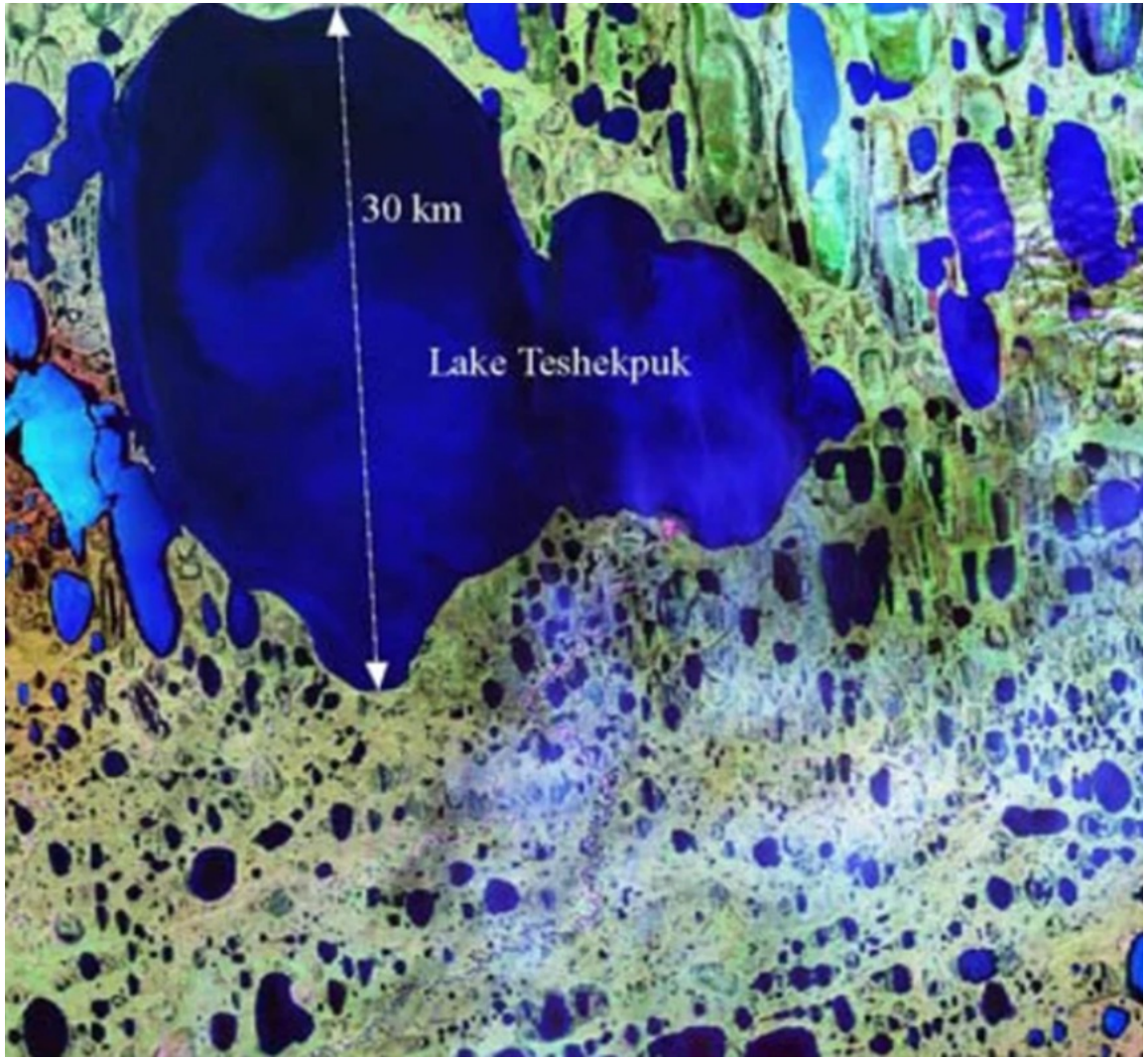
Coupled iron cycling and organic matter transformation across redox interfaces

Hailiang Dong, Qiang Zeng, Yizhi Sheng, Chunmei Chen, Guanghui Yu & Andreas Kappler

Nature Reviews Earth & Environment **4**, 659–673 (2023) | Cite this article

What

Remain?



SOURCE: ROBERT ROY BRITTC

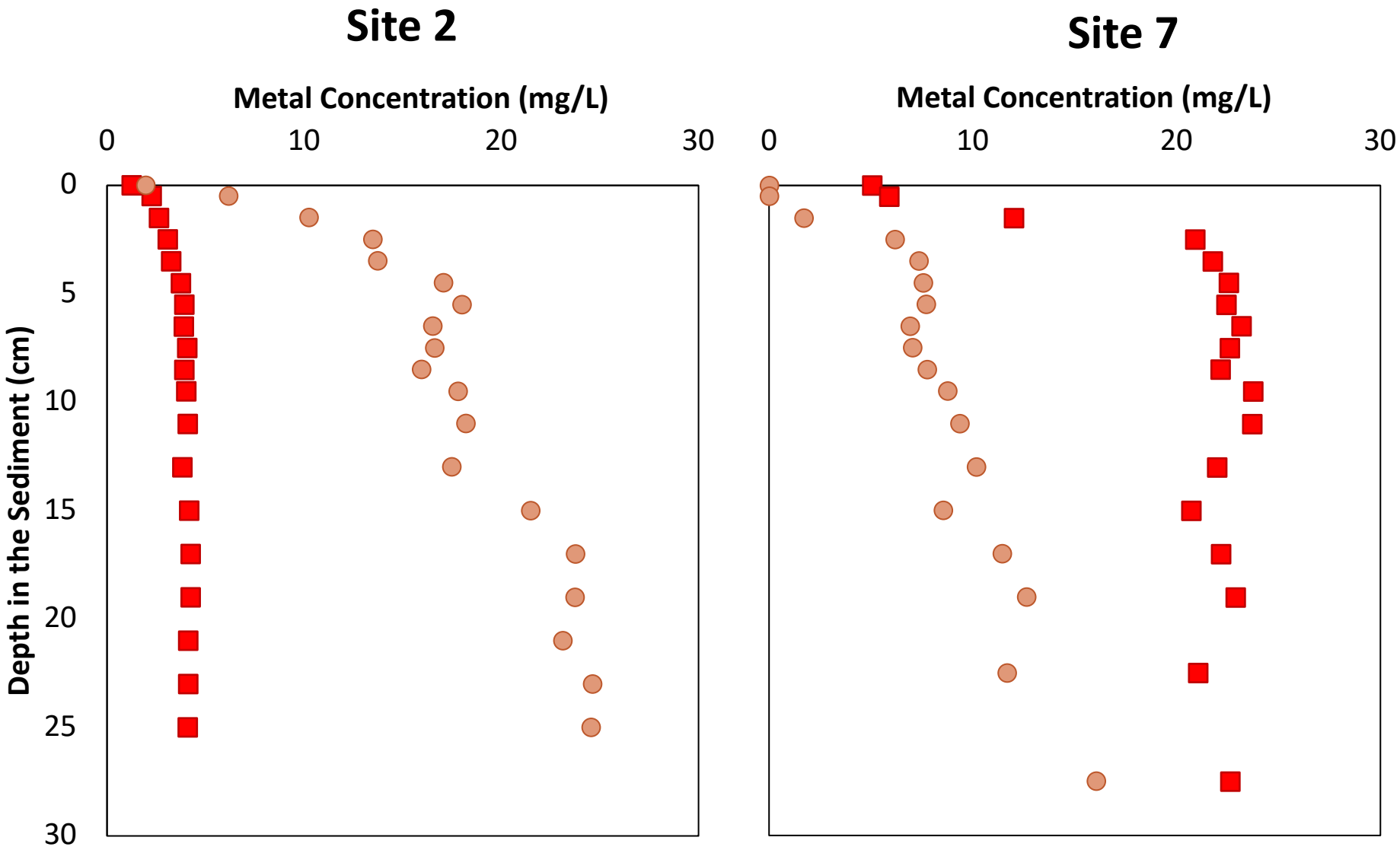
What Mysteries Remain?

SATELL
PHONE
#11

Thanks for listening!

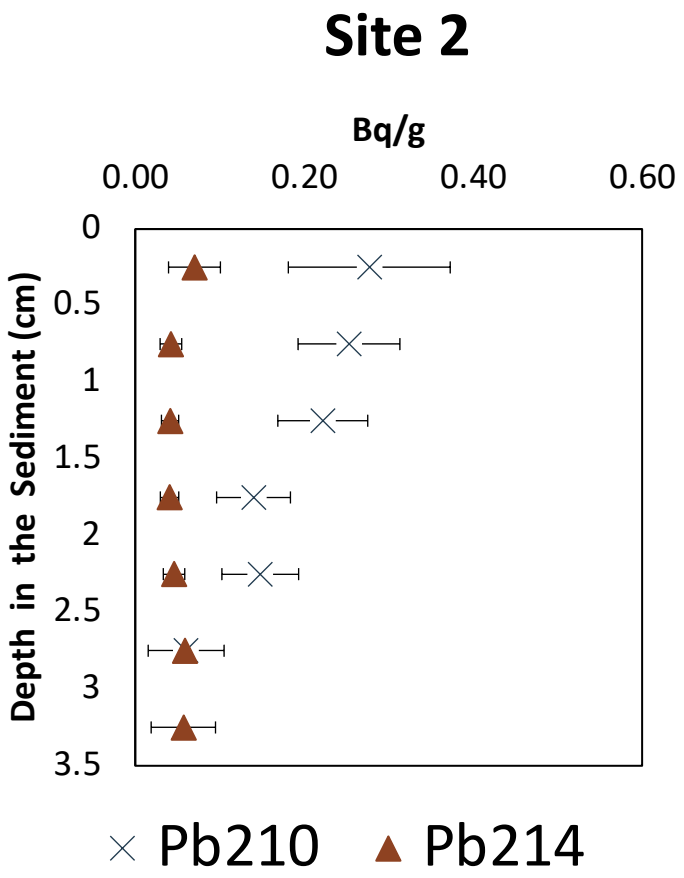
EMAIL:
CSMITH6@PAULSMITHS.EDU

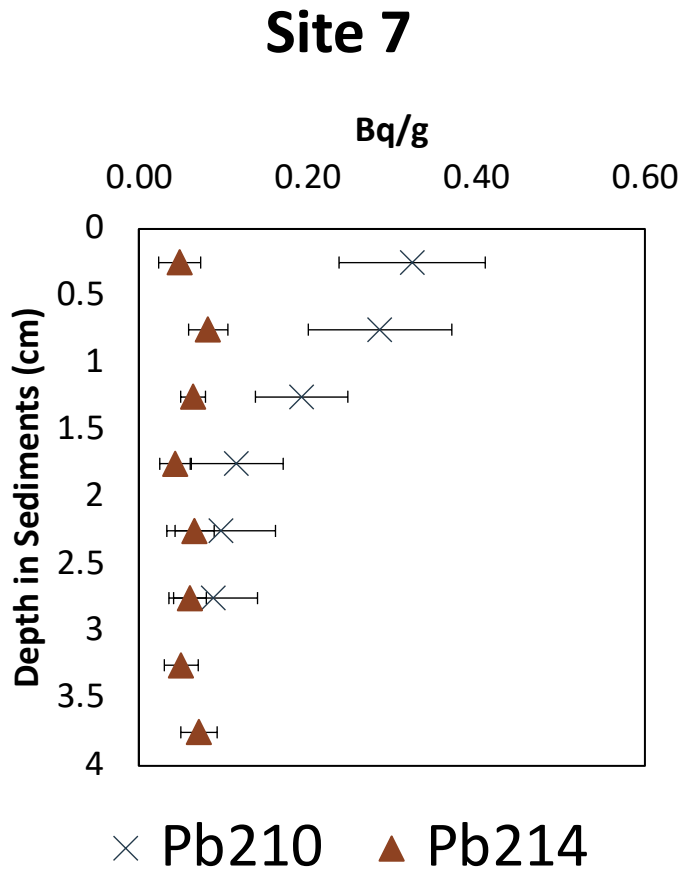
Slides below are extra



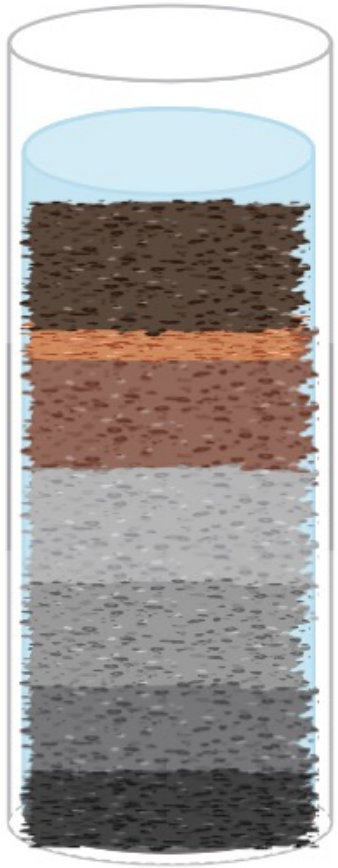
Dissolved Fe and Mn in Porewater

Pb^{210} Data

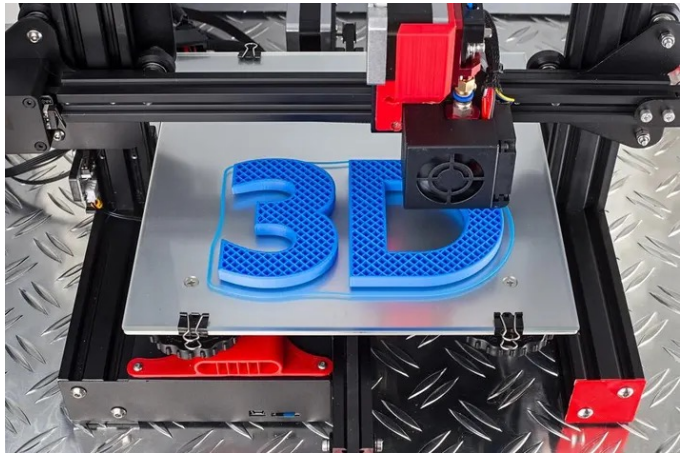

Site 2
Bq/g
0.00
0.20
0.40
0.60
Depth in the Sediment (cm)
0
0.5
1
1.5
2
2.5
3
3.5
Pb210
Pb214


Site 7
Bq/g
0.00
0.20
0.40
0.60
Depth in Sediments (cm)
0
0.5
1
1.5
2
2.5
3
3.5
4
Pb210
Pb214

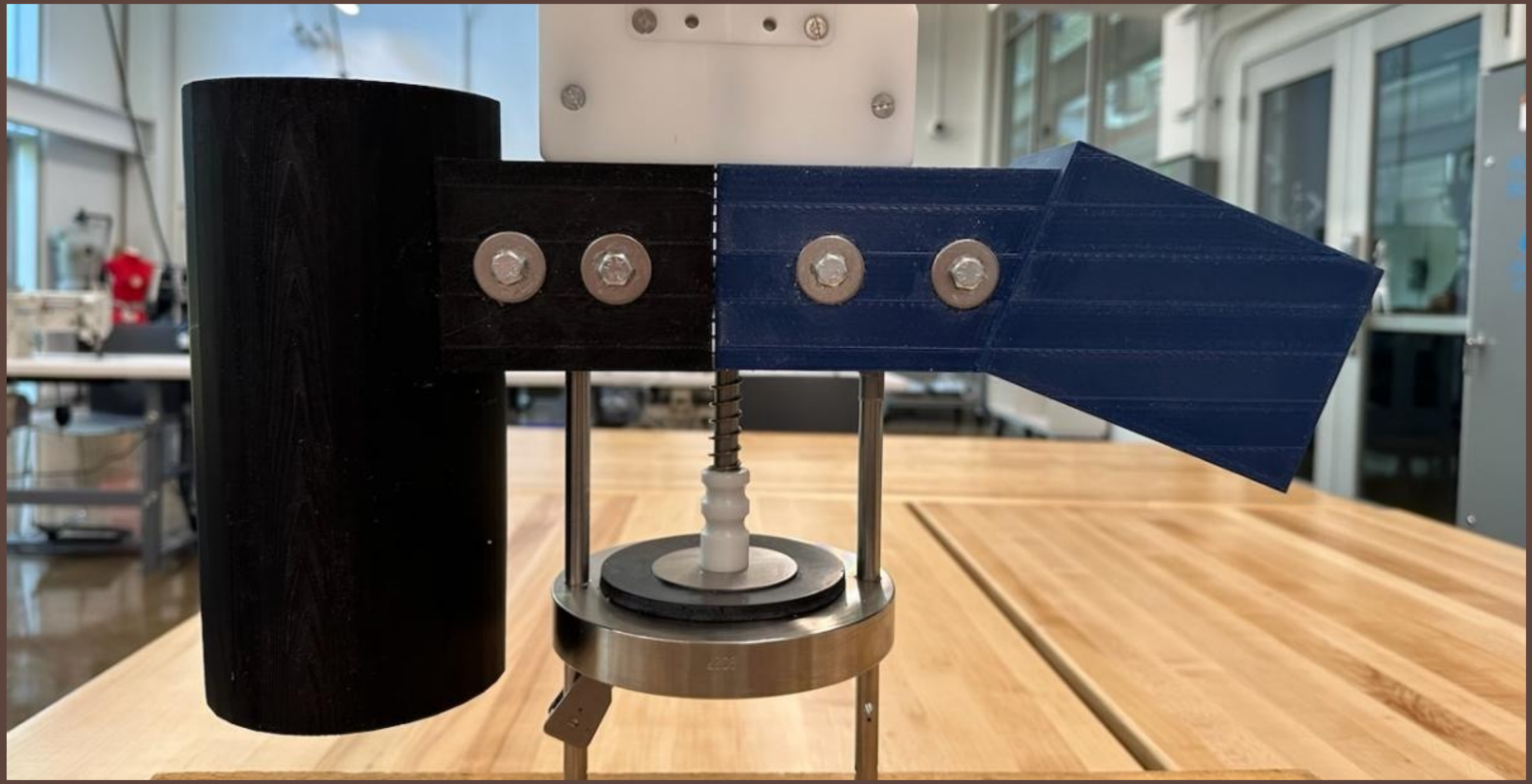
A Look Below

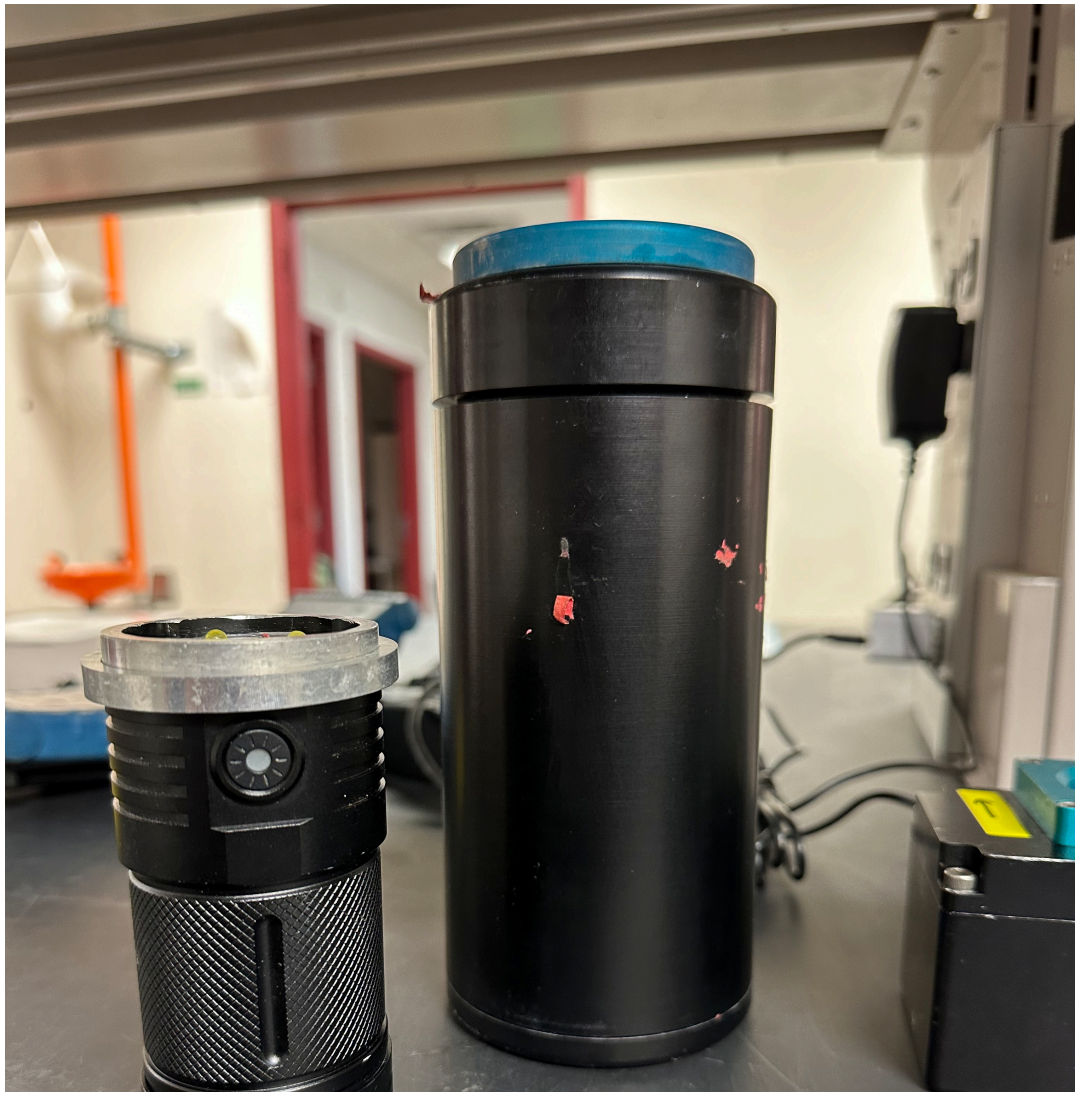


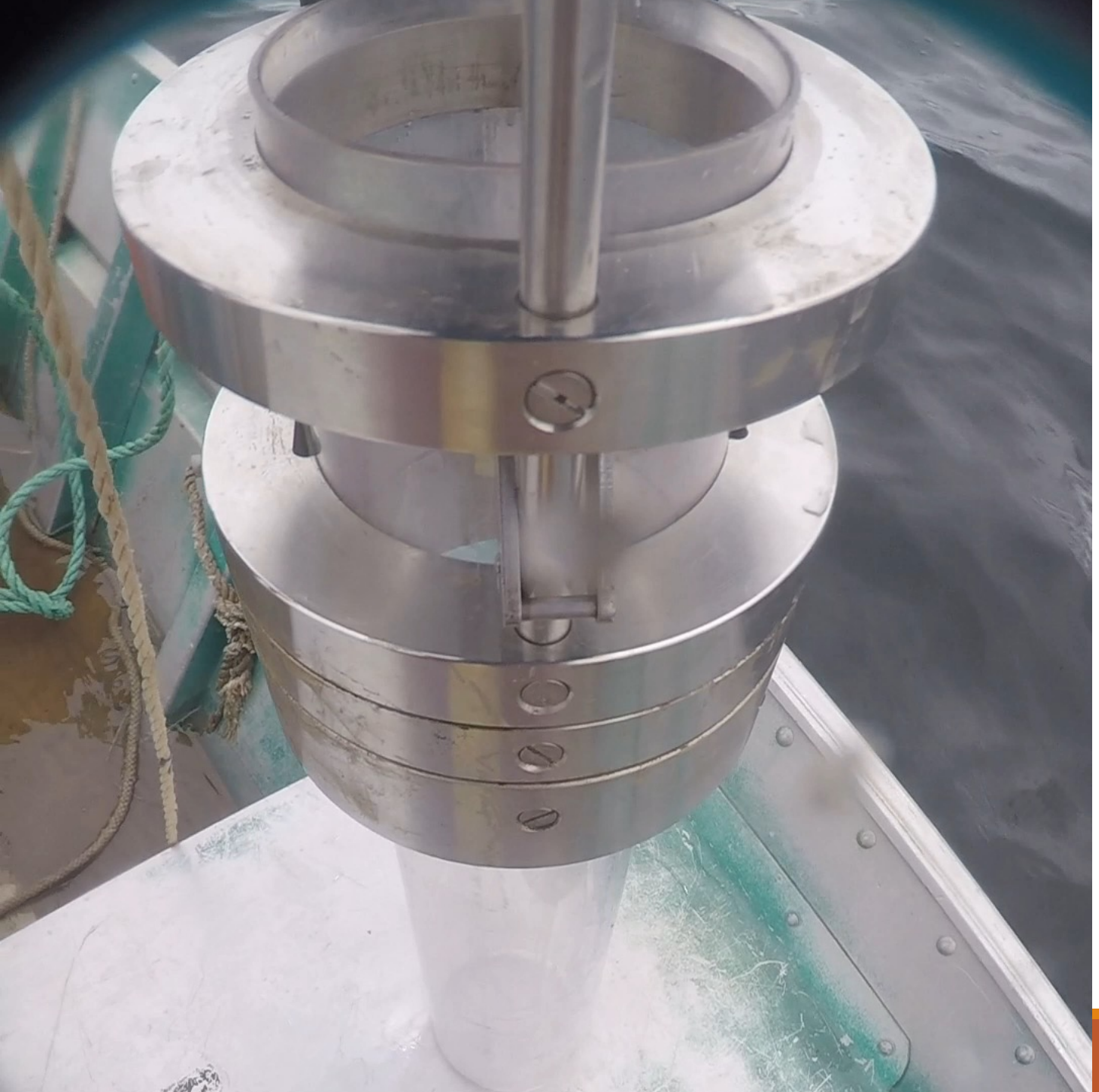
Kent State
DI Hub Collaboration



Stratasys F370
Acrylonitrile butadiene styrene (ABS)







ANSEP
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- Virtual and in person classroom visits
- Meet the scientists
- Aquatic science focused on lakes, fjords, and marine ecosystems