GeoMICS:

Global scale Microbial Interactions across Chemical Surveys

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Alyssa Kent, Adam Martiny (UC Irvine), Curtis Deutsch (UW), Craig Carlson (UCSB),
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Liz Kujawinski, Winn Johnson (WHOI), Greg Cutter, Chris Powell (ODU), Simone Alin (NOAA PMEL),
Jessica Green (UO), Adrian Marchetti, Kim Delong (UNC),Ann Pearson, Hilary Close, Sarah Hurley,
Naomi Levine (Harvard), Karen Casciotti (Stanford), Carl Cerrano (SDS),
Astrid Gaerdes (MPI) , Mick Follow (MIT)

A brief history…

Nov, 2010: NSF OCB-sponsored workshop:
"The Molecular Biology of Biogeochemistry: Using Molecular Methods to Link Ocean Chemistry with Biological Activity"
Jim Moffett, Eric Webb

Establish a "stand-alone sectional survey program in microbial biogeography...[with] GEOTRACES [as] a good model … inclusive process for designing [a] program and securing funding, as well as establishing an infrastructure for intercalibration and data management

Implement "pilot study linking high-resolution metagenomic sampling with high-resolution sampling for GEOTRACES core parameters across pronounced gradients"

May, 2012: GeoMICS is launched

1 week cruise on the R/V Thompson along subset of Line P

- Identify interactions between changes in microbial diversity, community functions, and chemical features across a gradient
- Coordinate sampling protocols: inorganic geochemistry, organic geochemistry, and molecular biology

Data from cruise
(31 different labs)

Physics/chemistry along transect

Model of surface water movement at time of transect based on ADCP, surface altimetry
Regional model of average water movement at time of year
[Chl], [O_2], nutrients [NO_3, NO_2, NH_4^+, PO_4, Si], carbonate chemistry
TOC, DOC, POC
Temperature, salinity, chlorophyll fluorescence
Total dissolved Mn, Fe, Cu, Zn, Cd
Total refractory & labile Mn, Fe, Cu, Zn, P, Al, Cd, Mo, Co, Ti, V, Ni

Diversity:

Underway and traditional flow cytometry for phytoplankton
16S and18S diversity (tag sequences)
Diatom species counts
Distribution of *Thalassiosira* species (ARISA)
Distribution of *Pseudo-nitzschia* species (ARISA)
Quantitative counts (qPCR) of *Bathycoccus*, *Ostreococcus, Synechococcus* Clades I, IV
Viral counts (Sybr-stained)
Cell counts for DAPI-stained prokaryotess, FISH-based for bacteria/archaea,
GDCT concentrations and types (archaeal lipids)
Metagenomics of marine aerosols
Metagenomes (0.2-1.6)

Data from cruise
(31 different labs)

Organismal readouts of chemical environment:

Photosynthetic efficiency of phytoplankton: Fv/Fm (FIRe)

Expression of diatom *Thalassiosira oceanica* flavodoxin as indicator of Fe limitation

Fe, Cu ligand data

Total cellular Mn, Fe, Ni, Zn, S, C in different diatom taxa

Photoreactive siderophore gene abundances (*Marinobacter*, *Vibrio*, *Xanthomonads*)

μDOC

Intact polar diacylglycerolipids (9 classes)

Synechococcus-specific lipidomics

Glycolipid and phospholipid fatty acids $\delta^{13}C$ values for different size classes.

Metatranscriptomics: prokaryotes (0.2-1.6); eukaryotes (1.6-53); eukaryotes (<1.6)

Metaproteomics: prokaryotes (0.2-1); eukaryotes (>1)

Targeted metabolomics (LCTSQ) prokaryotes (0.2-1.6 μm) and eukaryotes (>1.6 μm)

Growth rate and loss rate estimates for *Synechococcus*, pico-eukaryotes based on SeaFlow data

amoA gene counts, diversity (t-rflp)

NH_4^+ uptake rates

NH_4^+ oxidation rates

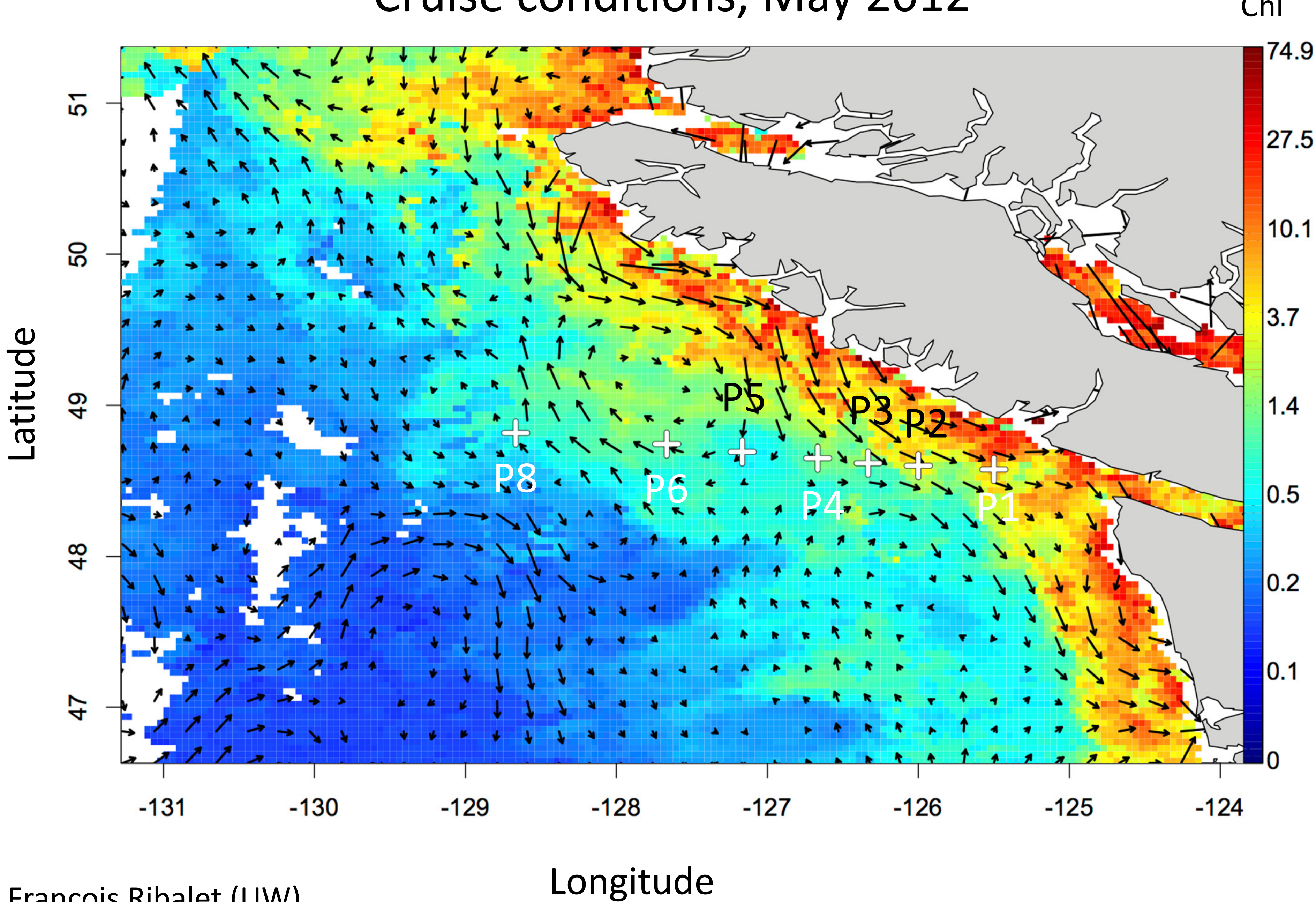
Nitrate $\delta^{15}N$

Feb, 2013: OCB-sponsored workshop to collate/merge data

Coordinate analysis across 5 groups: inorganic geochemists, organic geochemists, molecular ecologists, modelers, computer scientists

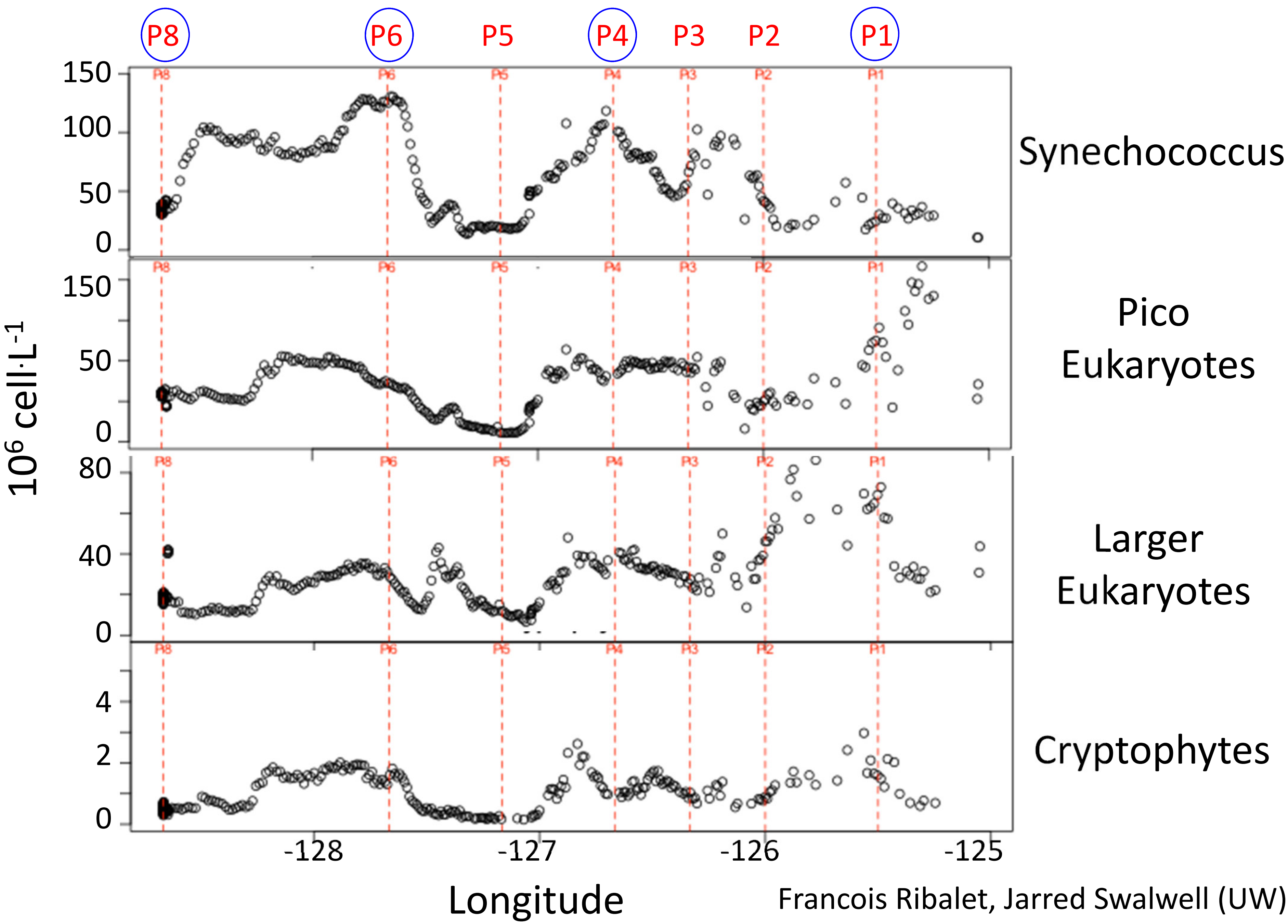
Query across data sets in real-time – “not just faster…different!”
UW eScience program

Cruise conditions, May 2012



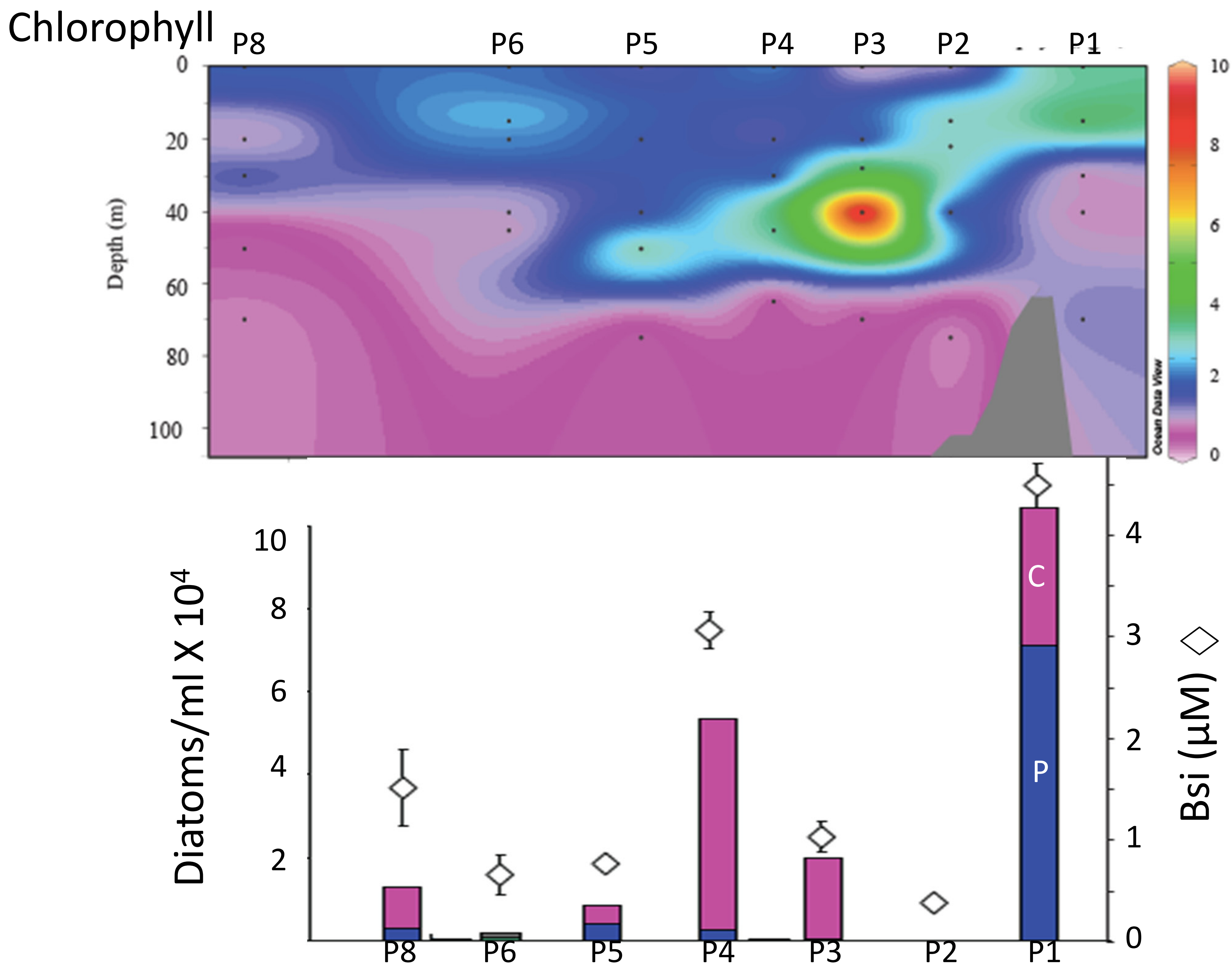
Francois Ribalet (UW)

Surface phytoplankton distributions defined sampling sites

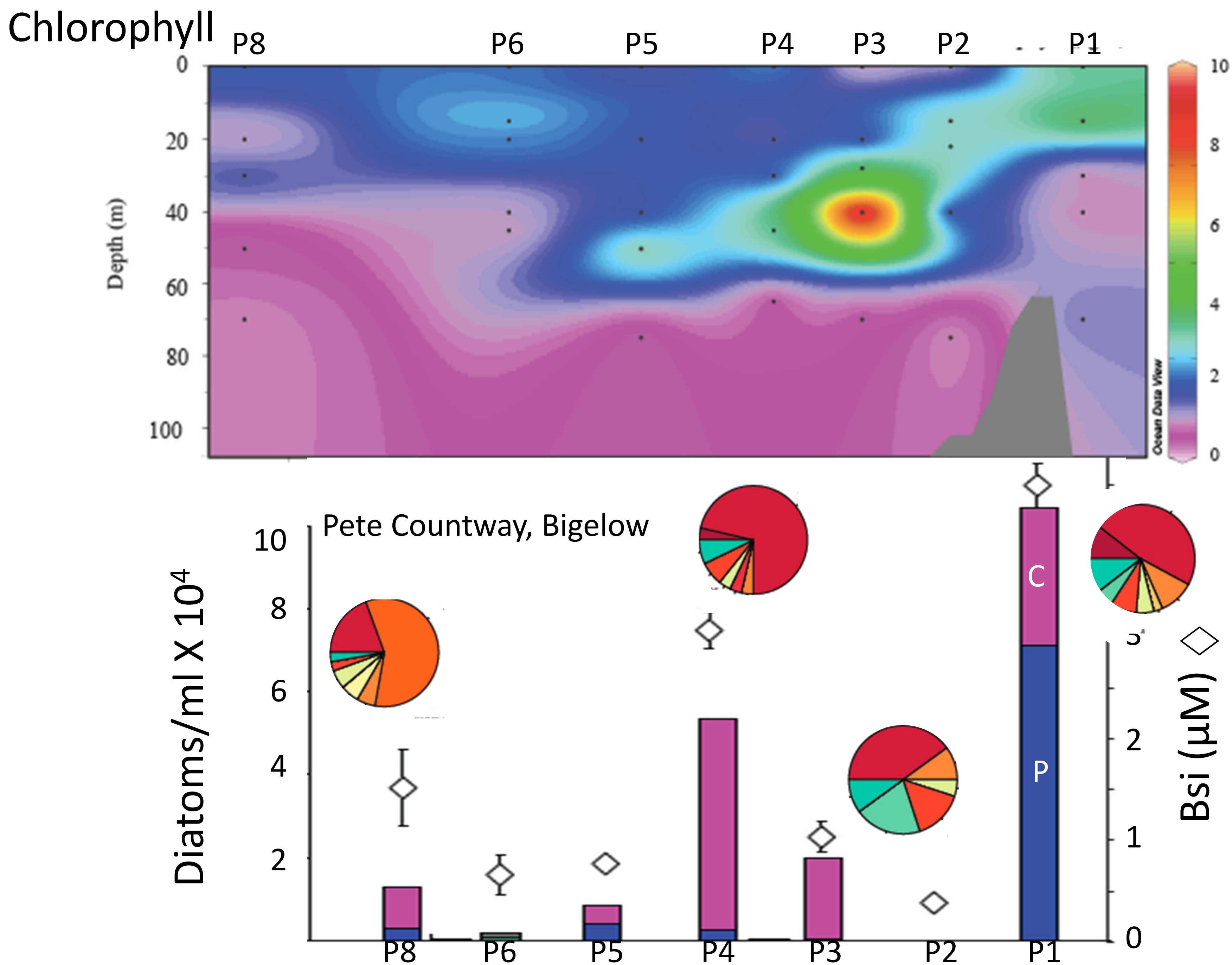


Francois Ribalet, Jarred Swalwell (UW)

A diatom example…



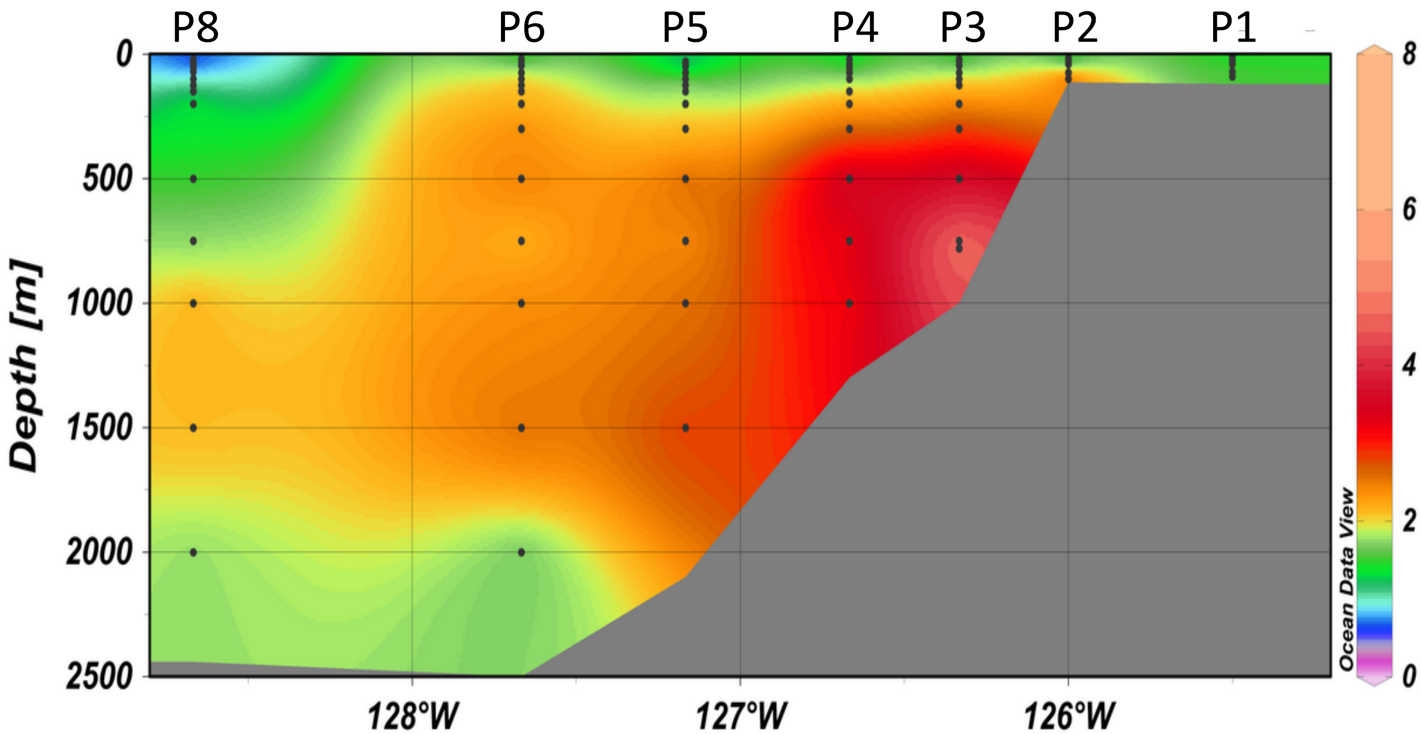
Sara Bender, Megan Schatz, UW



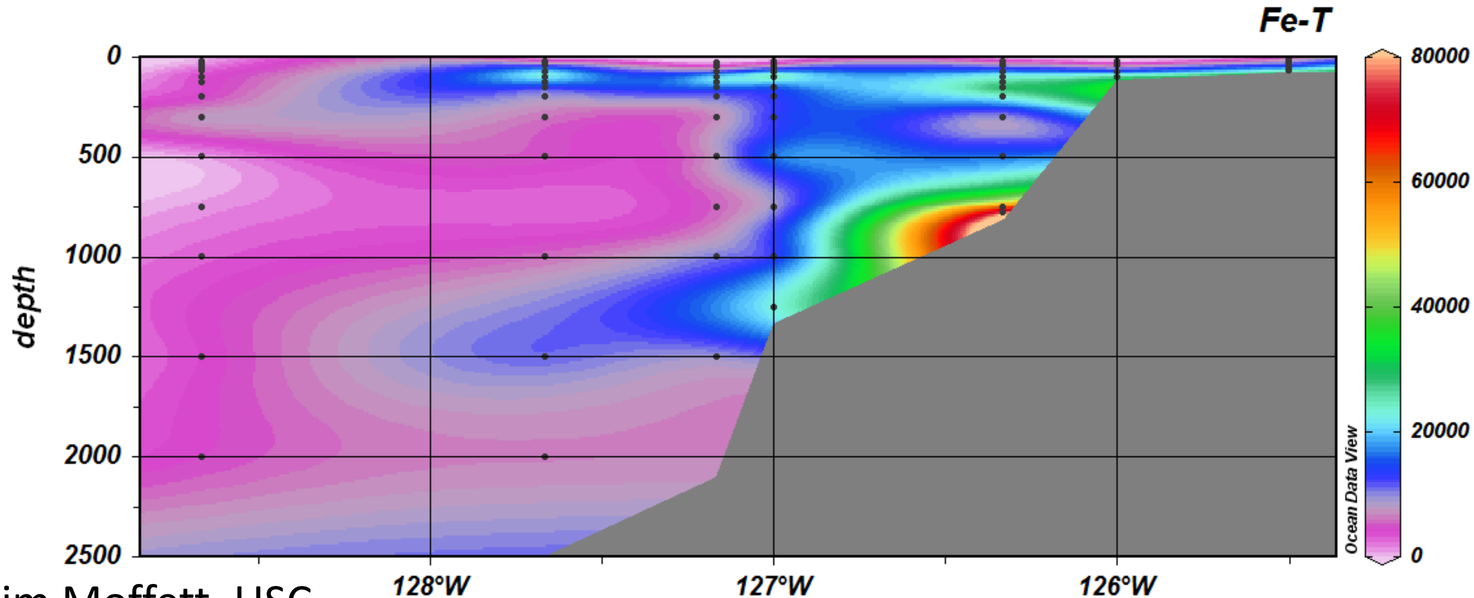
Sara Bender, Megan Schatz, UW

Iron

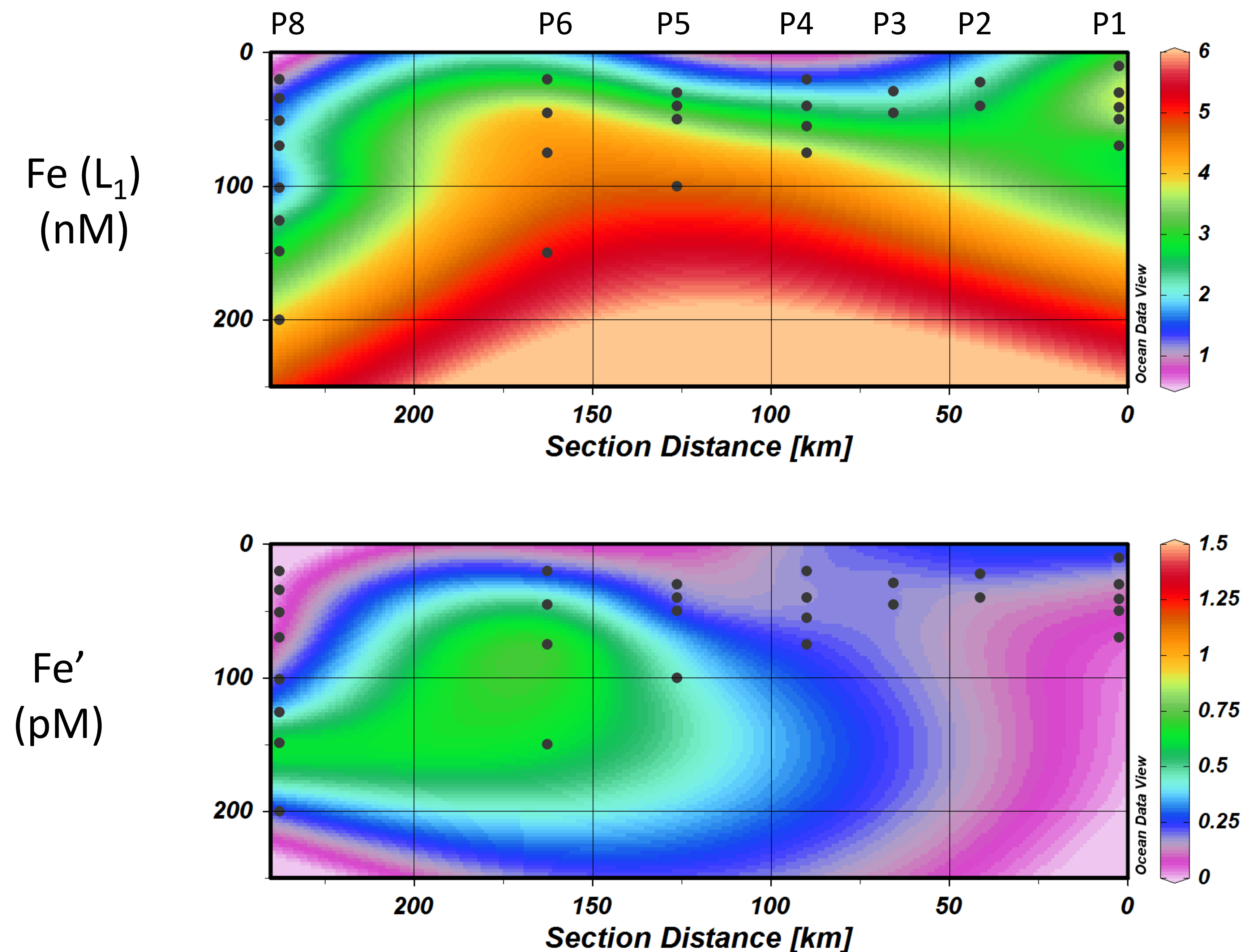
Total dissolved (nM)



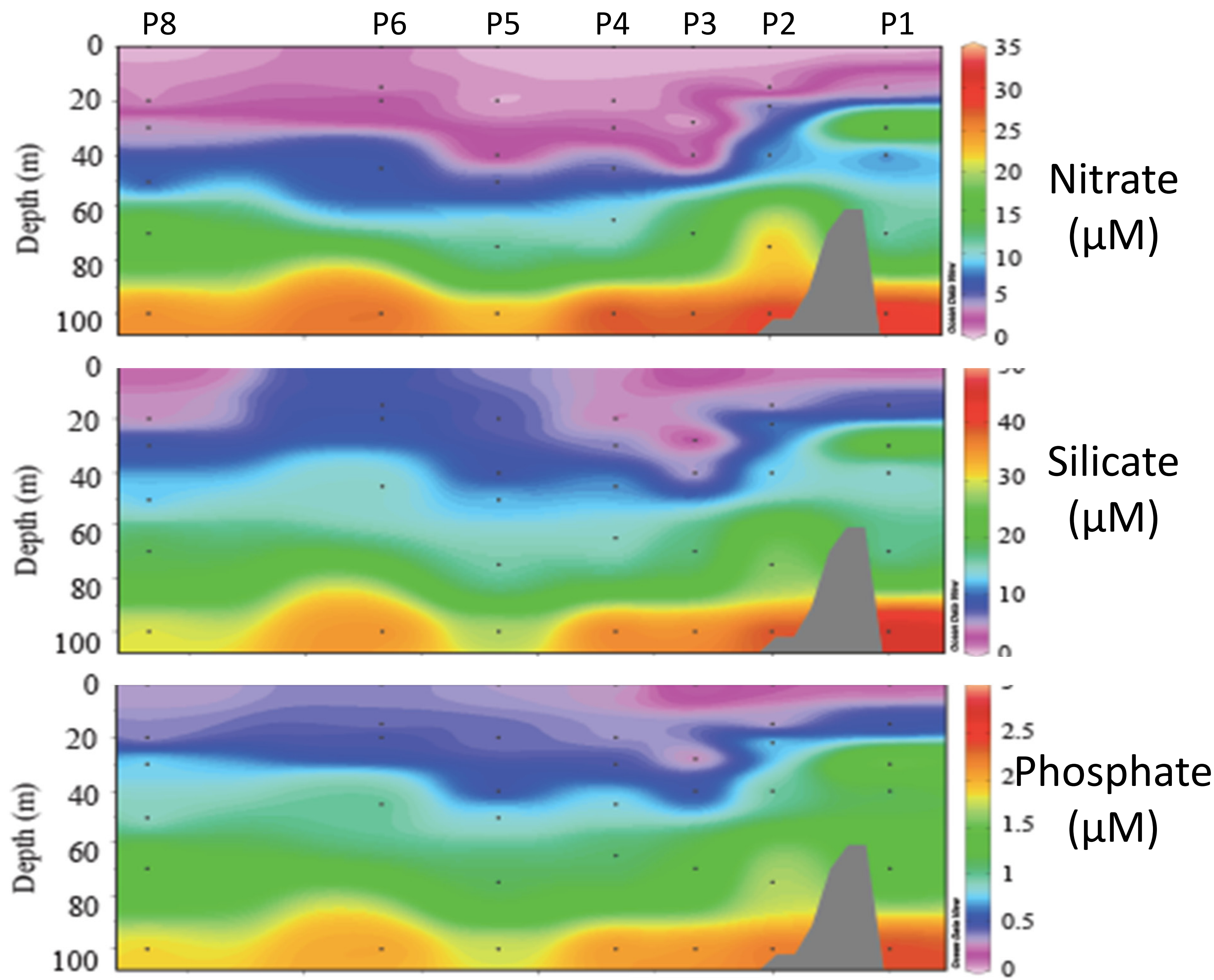
Total particula



Jagruti Vendemati, Jim Moffett, USC

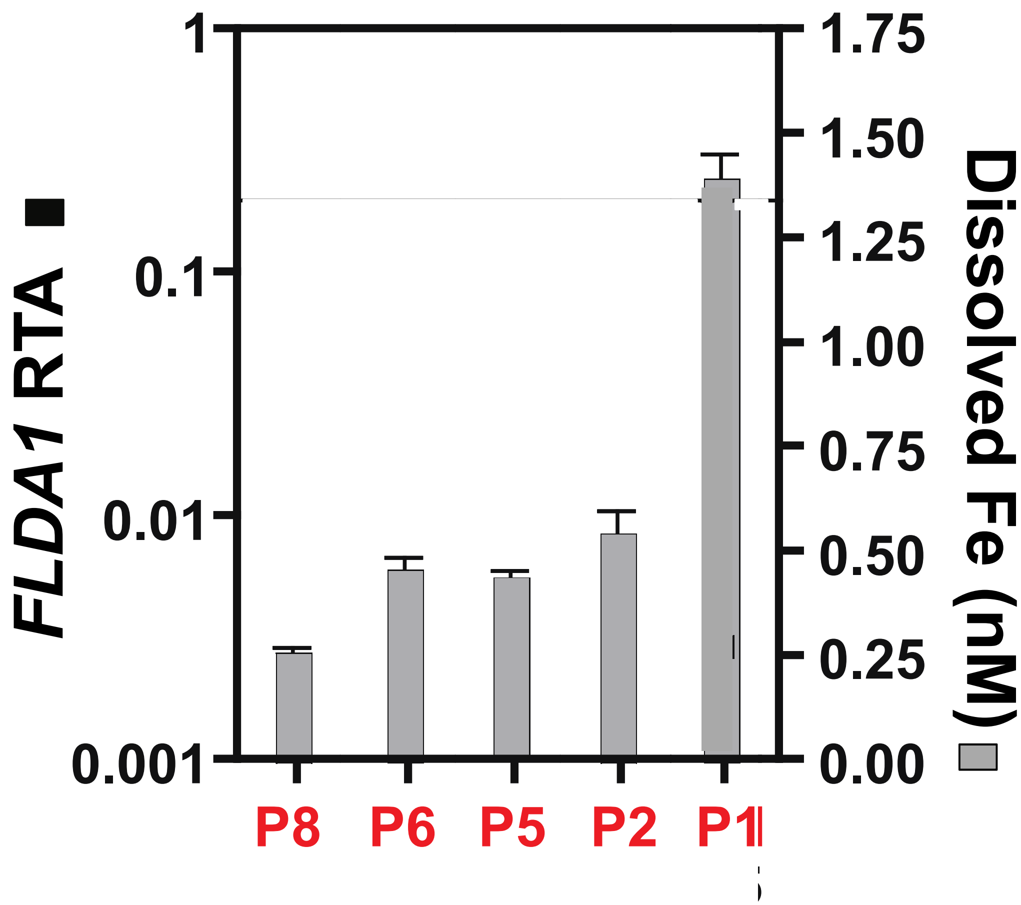


Randie Bundy, Kathy Barbeau, Scripps



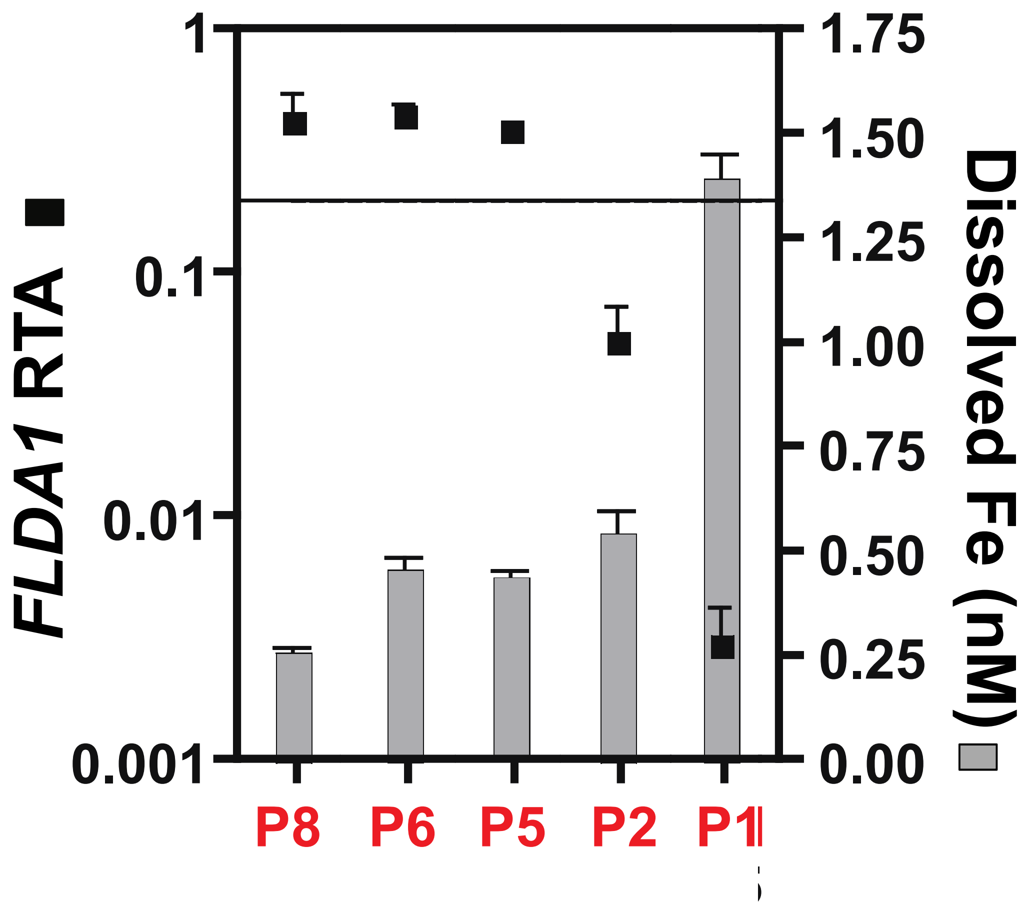
P8
P6
P5
P4
P3
P2
P1
Depth (m)
0
20
40
60
80
100
35
30
25
20
15
10
5
0
Nitrate (µM)
40
30
20
10
0
Silicate (µM)
2.5
2
1.5
1
0.5
0
Phosphate (µM)

Flavodoxin transcription: indicator of iron limitation
Thalassiosira oceanica



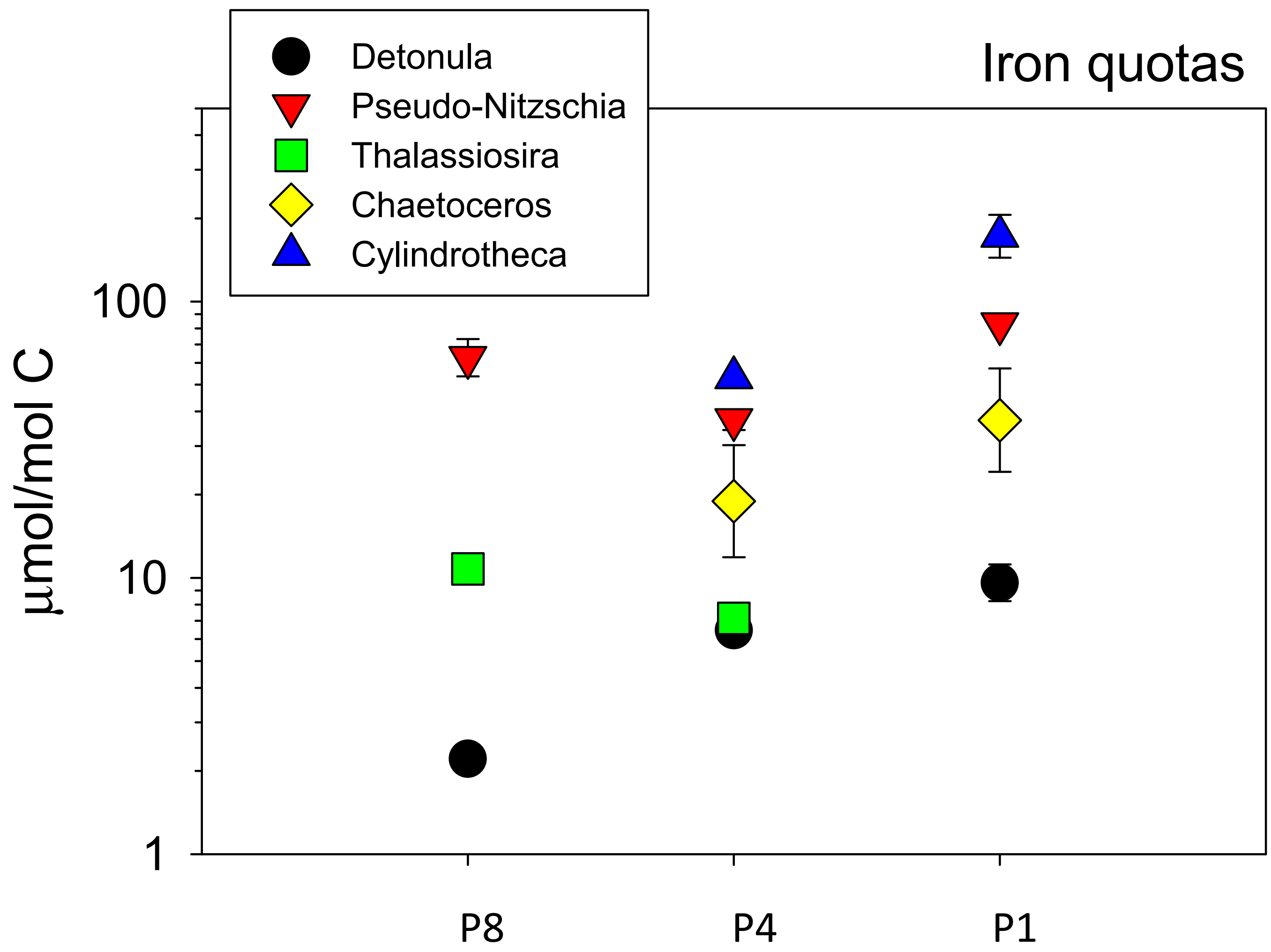
Dreux Chappell, Bethany Jenkins, URI

Flavodoxin transcription: indicator of iron limitation
Thalassiosira oceanica



Dreux Chappell, Bethany Jenkins, URI

Less iron per cell as move offshore

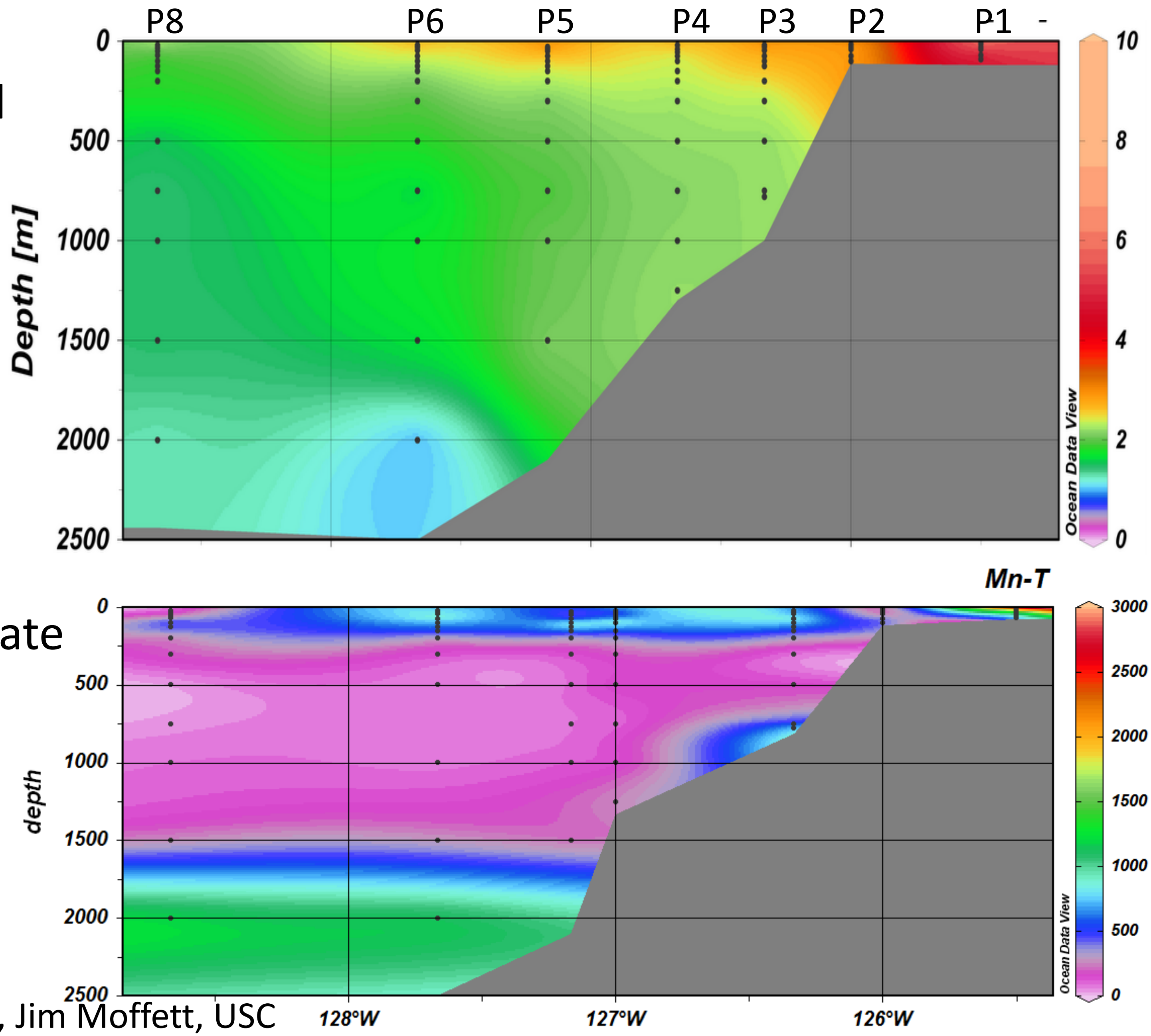


Ben Twining, Sara Rauschenberg, Bigelow Lab

Manganese

Total dissolved (nM)

Total particulate (nM)

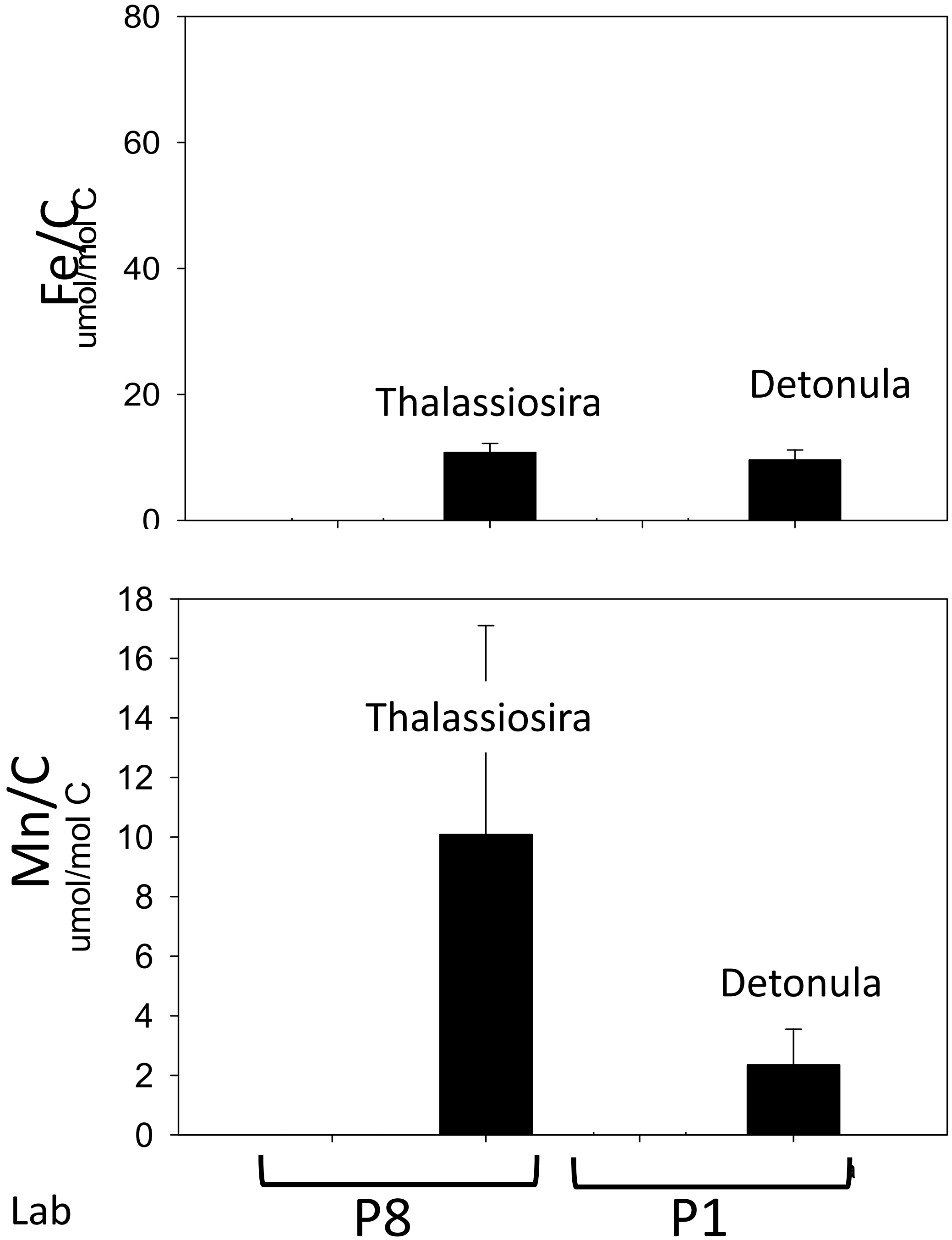


Jagruti Vendemati, Jim Moffett, USC

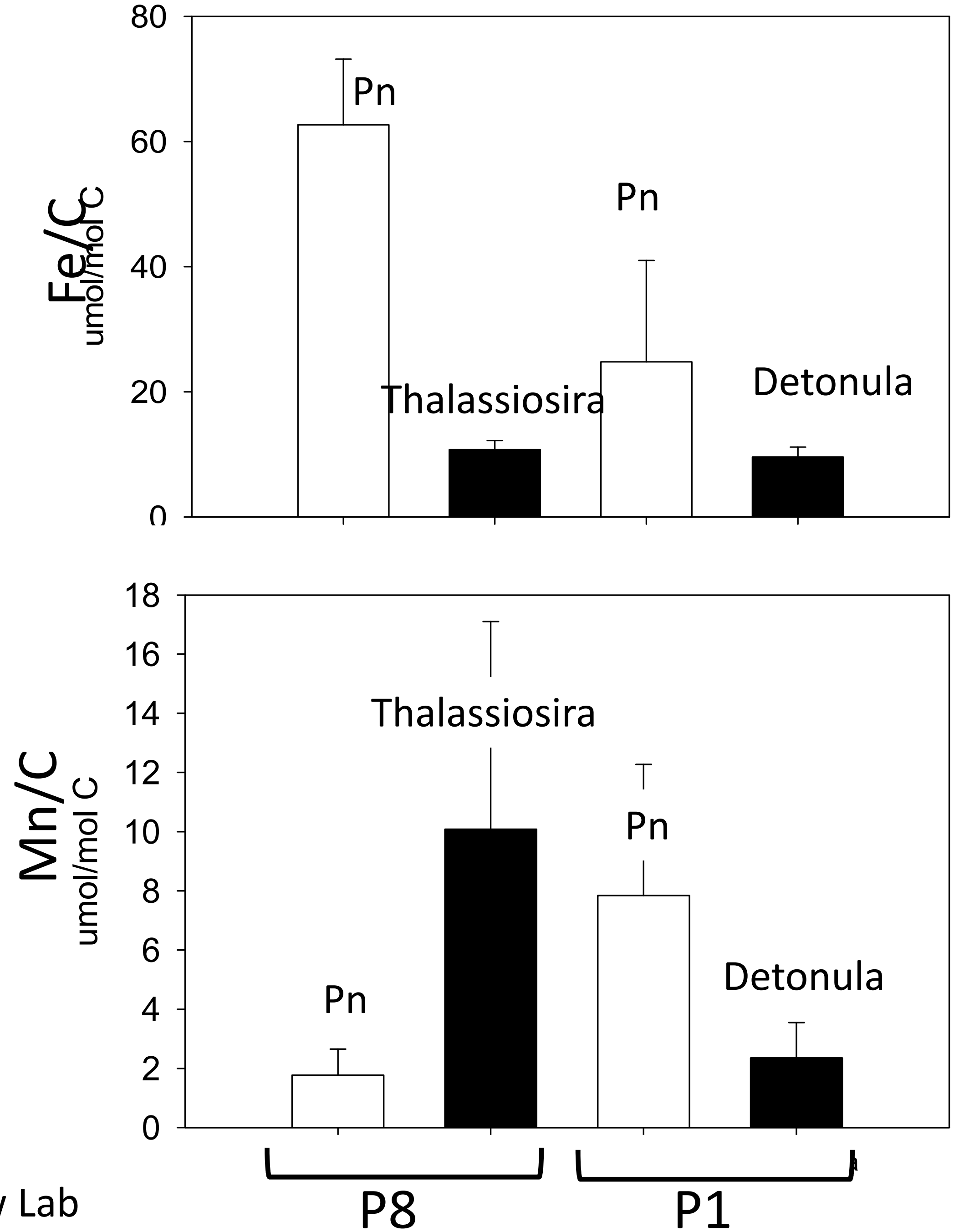
A role for manganese in superoxide dismutases and growth of iron-deficient diatoms

Graham Peers[1] and Neil M. Price
Department of Biology, McGill University, 1205 Avenue Dr. Penfield, Montreal, Quebec, H3A 1B1
Limnol. Oceanogr., 49(5), 2004, 1774–1783

coastal and oceanic diatoms require more manganese (Mn) to grow in iron (Fe)-deficient than in Fe-sufficient seawater. …SODs [superoxide dismutase] contain Mn and may account for part of the observed increase in the Mn quota. Such an increased biochemical requirement may elevate the Mn content of low Fe diatoms…resulting in high Mn: Fe ratios in particulate matter in Fe-limited regions of the sea.

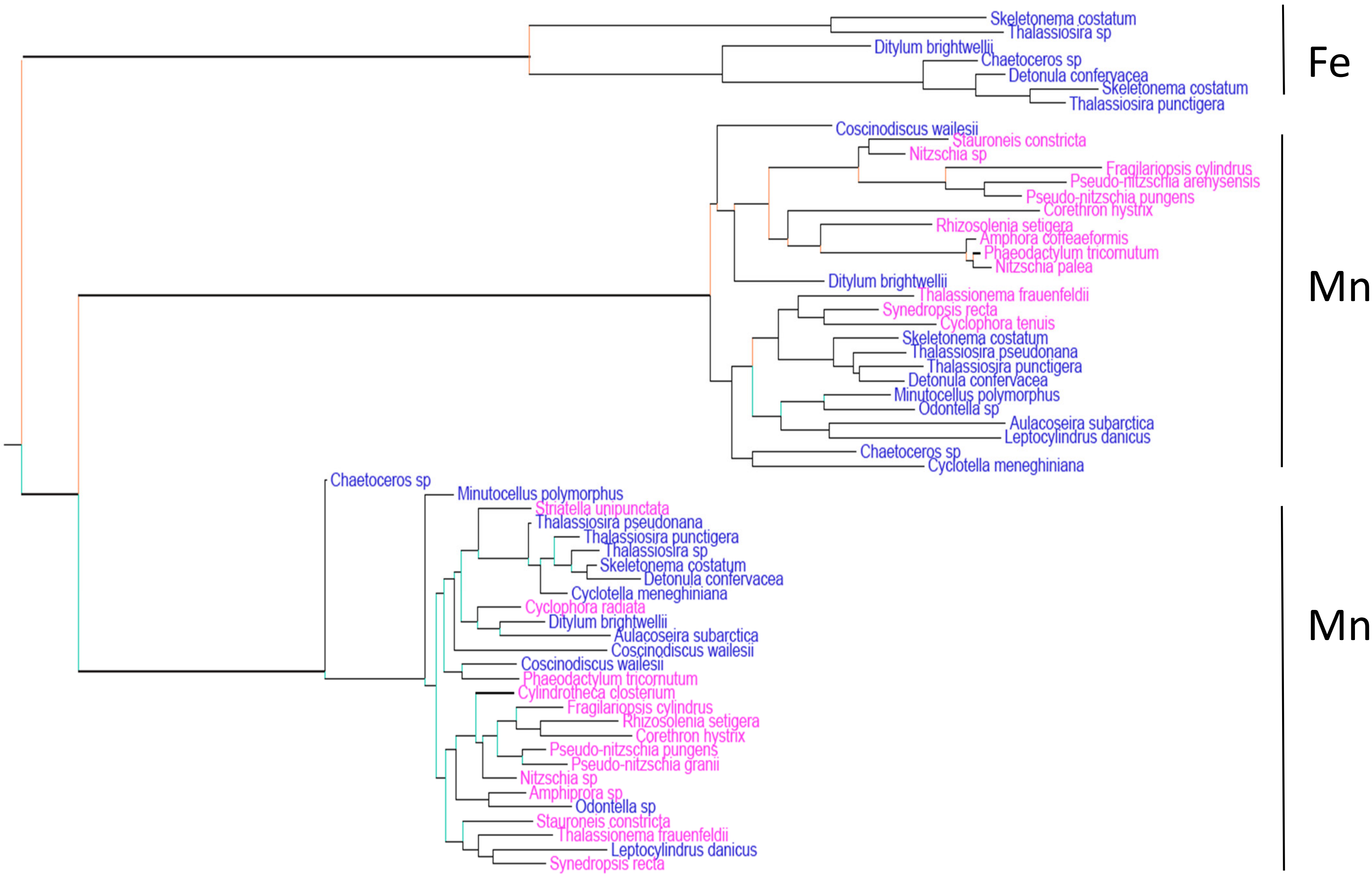


Ben Twining, Bigelow Lab



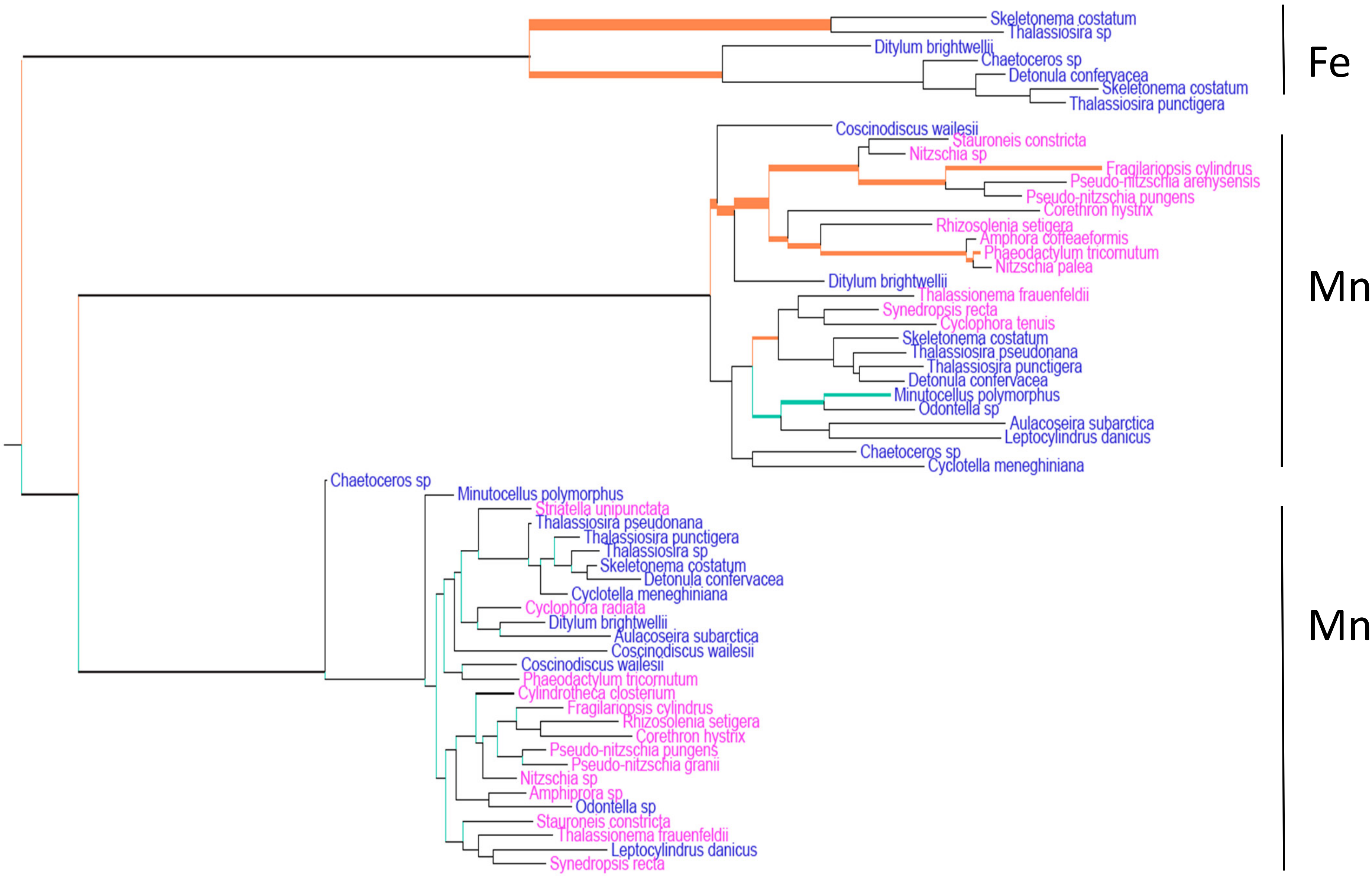
Ben Twining, Bigelow Lab

Diatom super oxide dismutase



Ryan Groussman, Micaela Parker, Sara Bender, UW

Diatom super oxide dismutase



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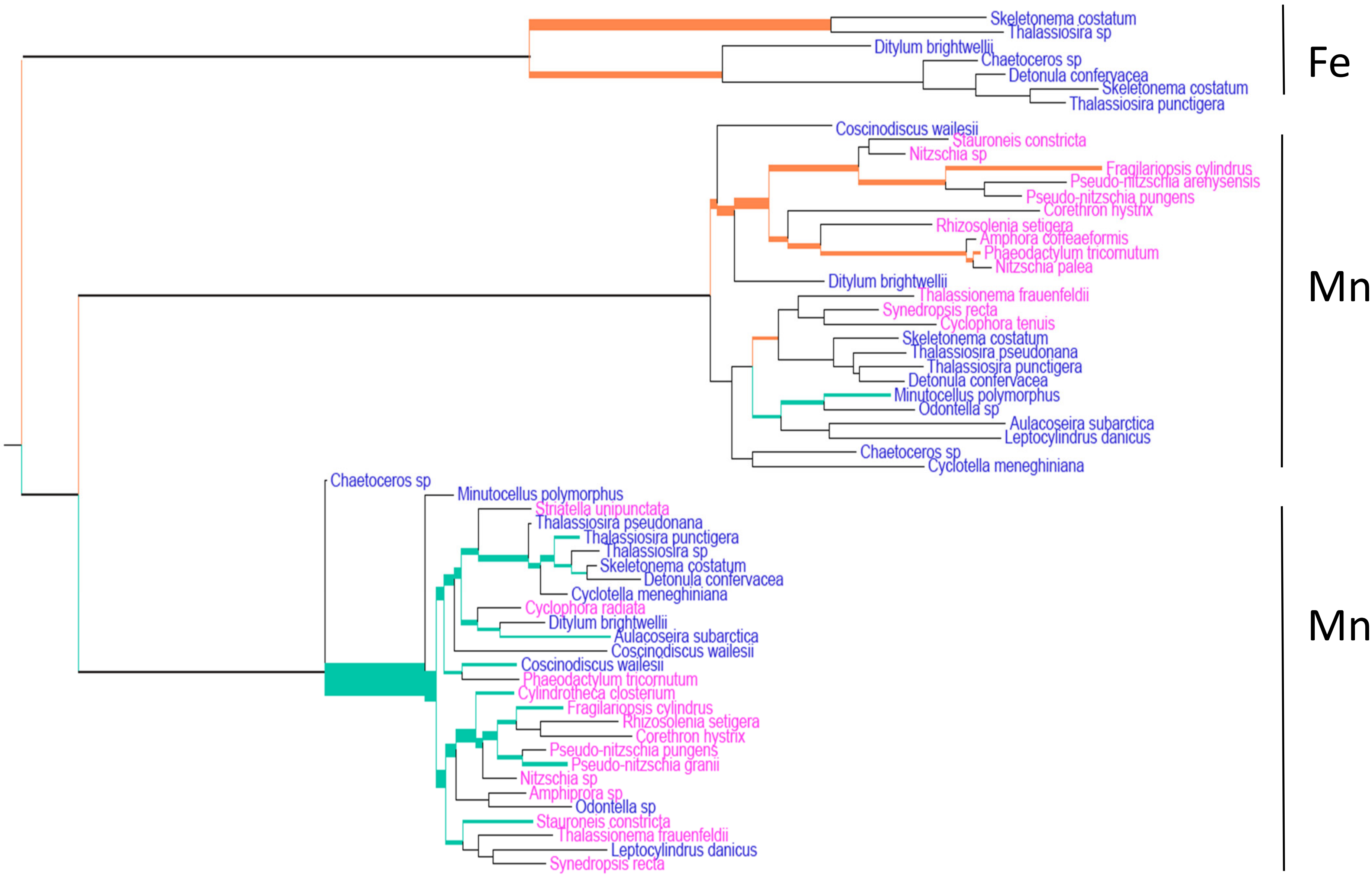

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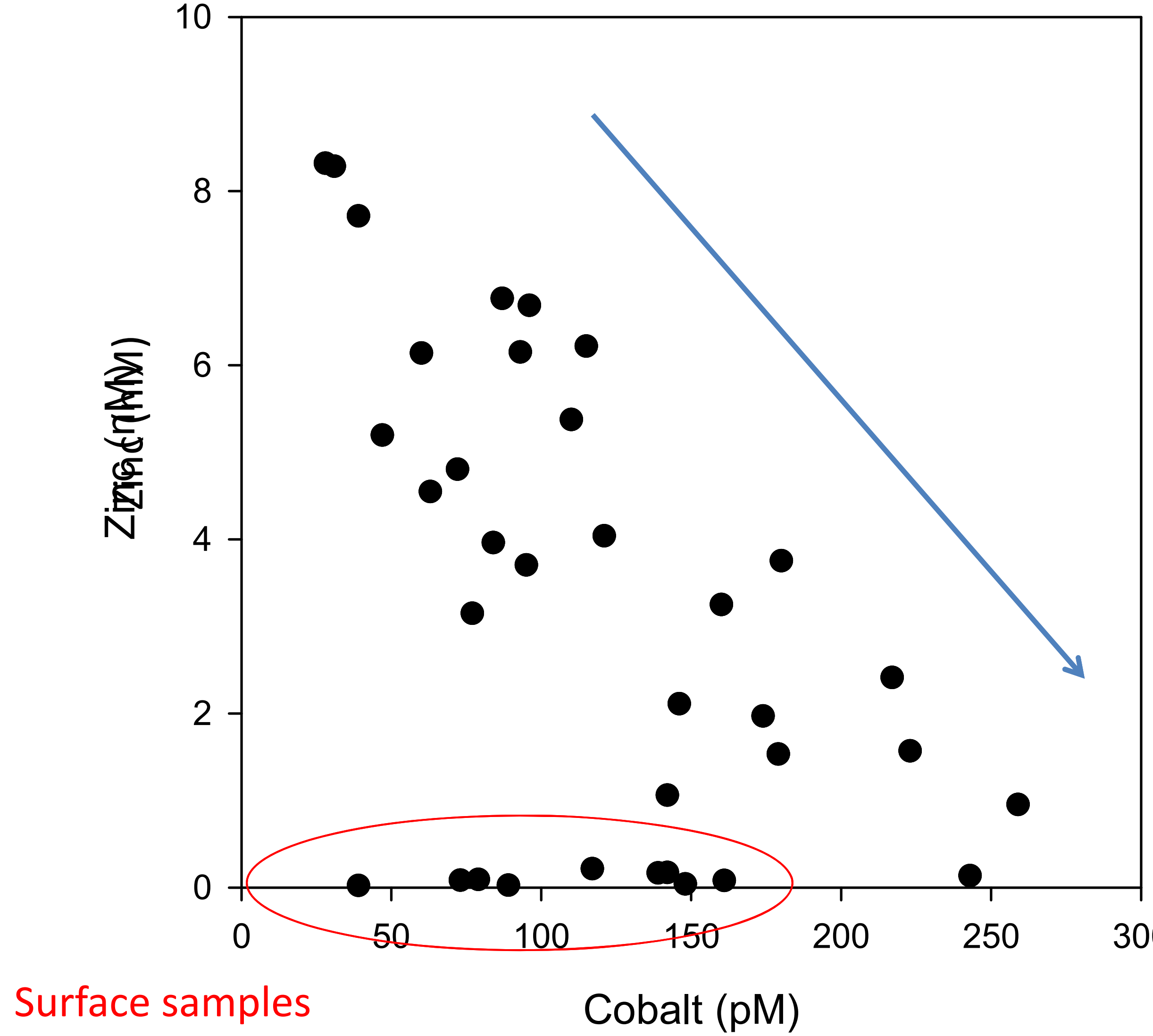
Substitution of Co for Zn?
Diatom signature? (prefer Zn to Co)



Carbonic anhydrase
Alkaline phosphatase

Mak Saito (WHOI), Jagruti Vedemati, Jim Moffett (USC)

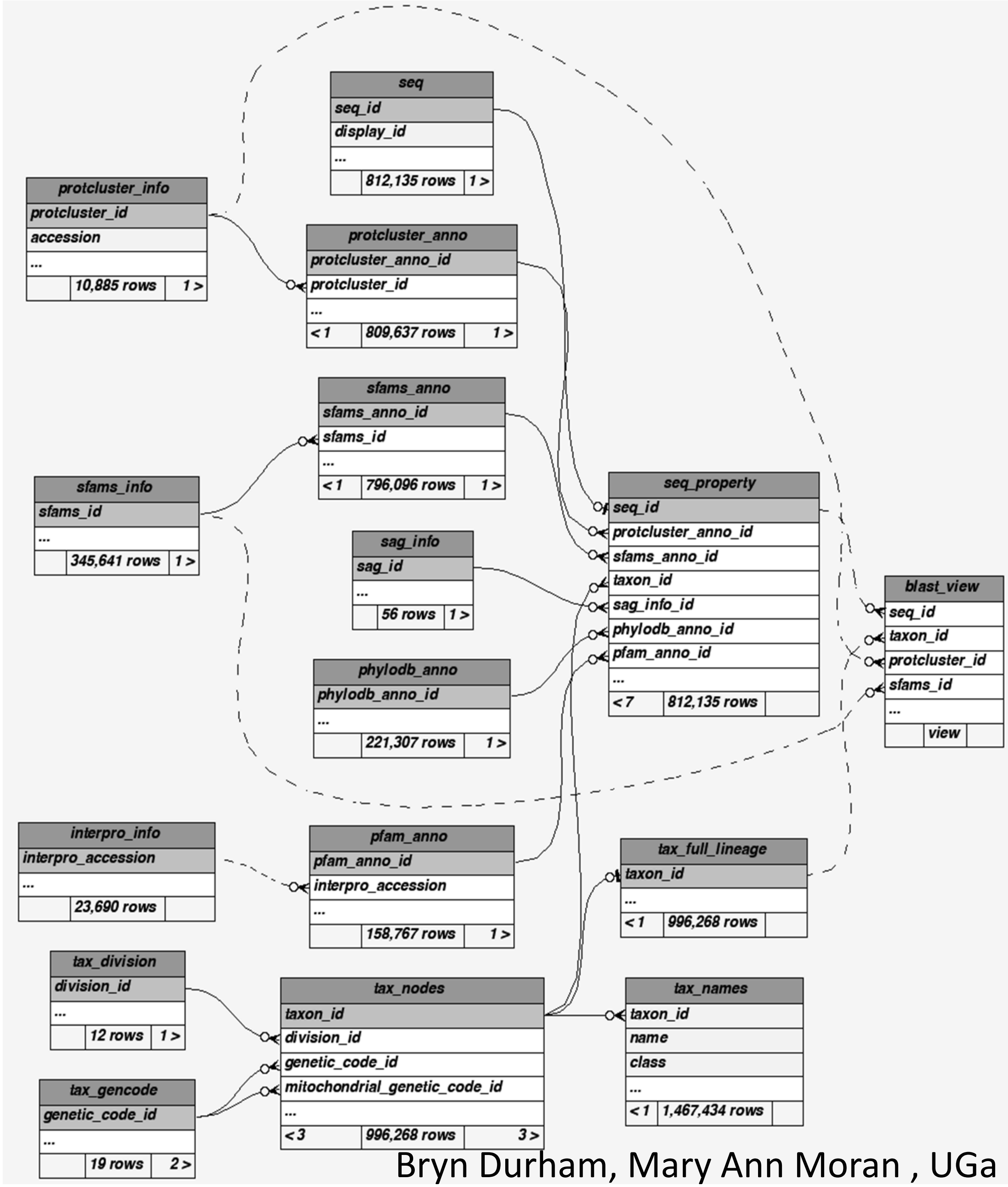
GeoMICS In-House Database Schema

SQL database

- Sfams (Sharpton et al. 2012)
- ProtClustDB (NCBI)

812,135 proteins and growing

Public prokaryote genomes	108
Single amplified prokaryote genomes	63
Moore Marine Microeukaryote EST datasets	15/85
Public eukaryotic genomes	29
Public EST datasets	10



Bryn Durham, Mary Ann Moran , UGa

Highlights of GEOMICS intact polar diacylglycerolipid (IP-DAG) data

Patrick Martin
Benjamin A.S. Van Mooy
WHOI

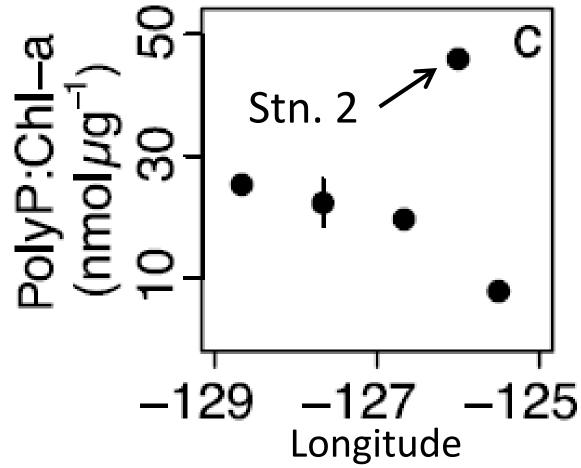
Concentrations of IP-DAGs (100+ different molecules) were determined across the transect.

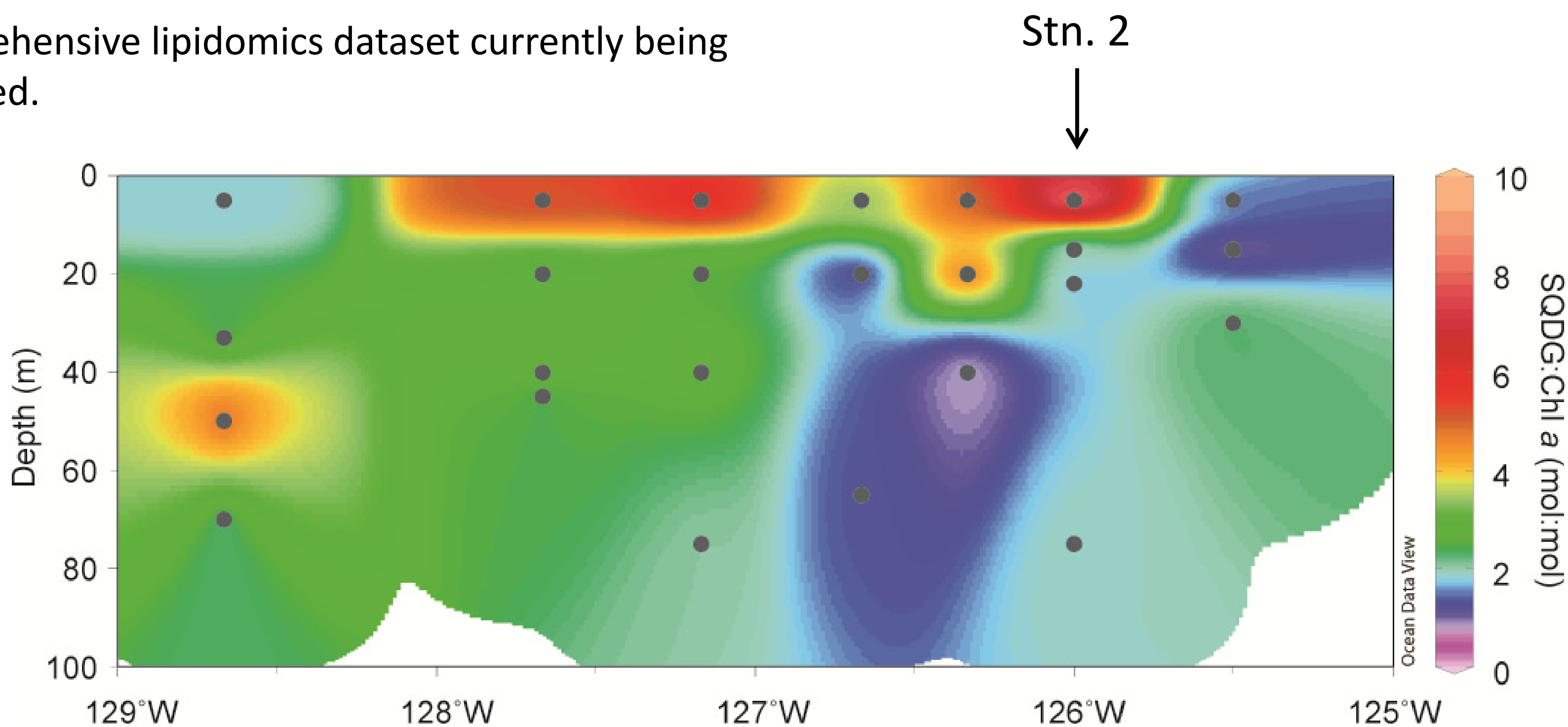
Polyphosphate quantified in surface samples only.

Two of the clearest signals are at Station 2.

- High SQDG/Chl-*a*
- High Poly-P/Chl-*a*
- Both signals are indicative of nutrient stress and characteristic of oligotrophic gyre communities.

Comprehensive lipidomics dataset currently being collected.





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