(Sub)mesoscale modulation of phytoplankton community structure and diversity

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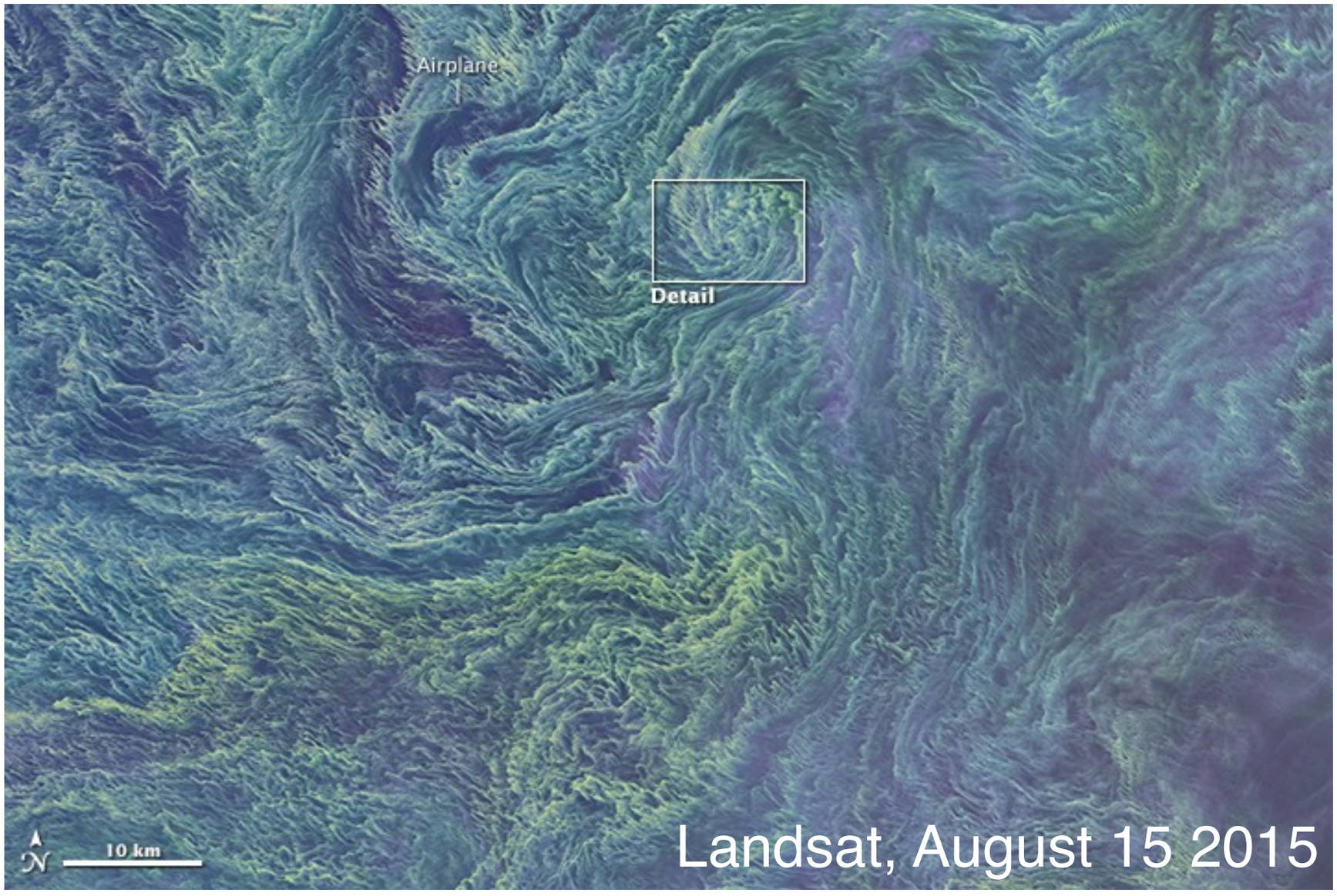

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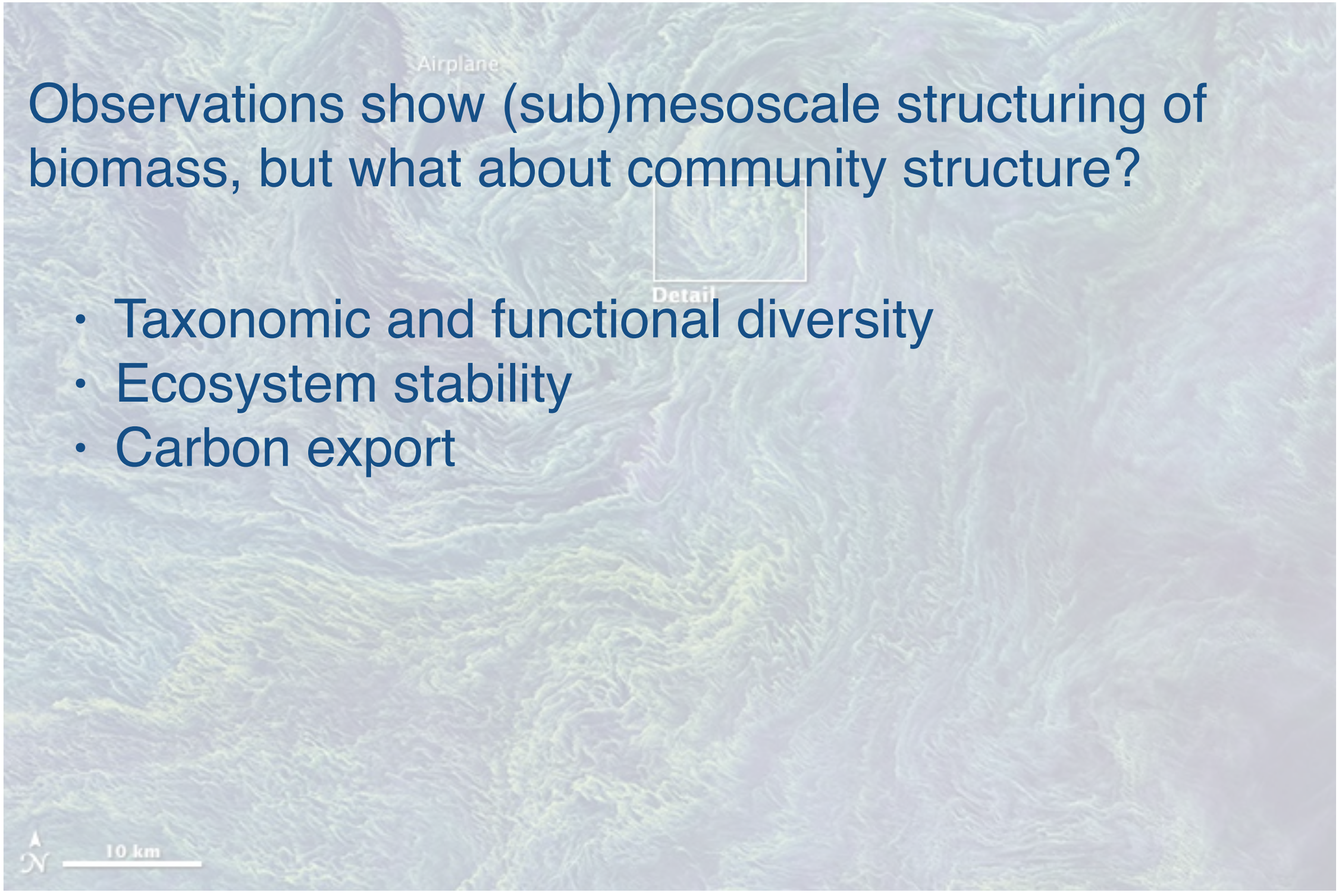
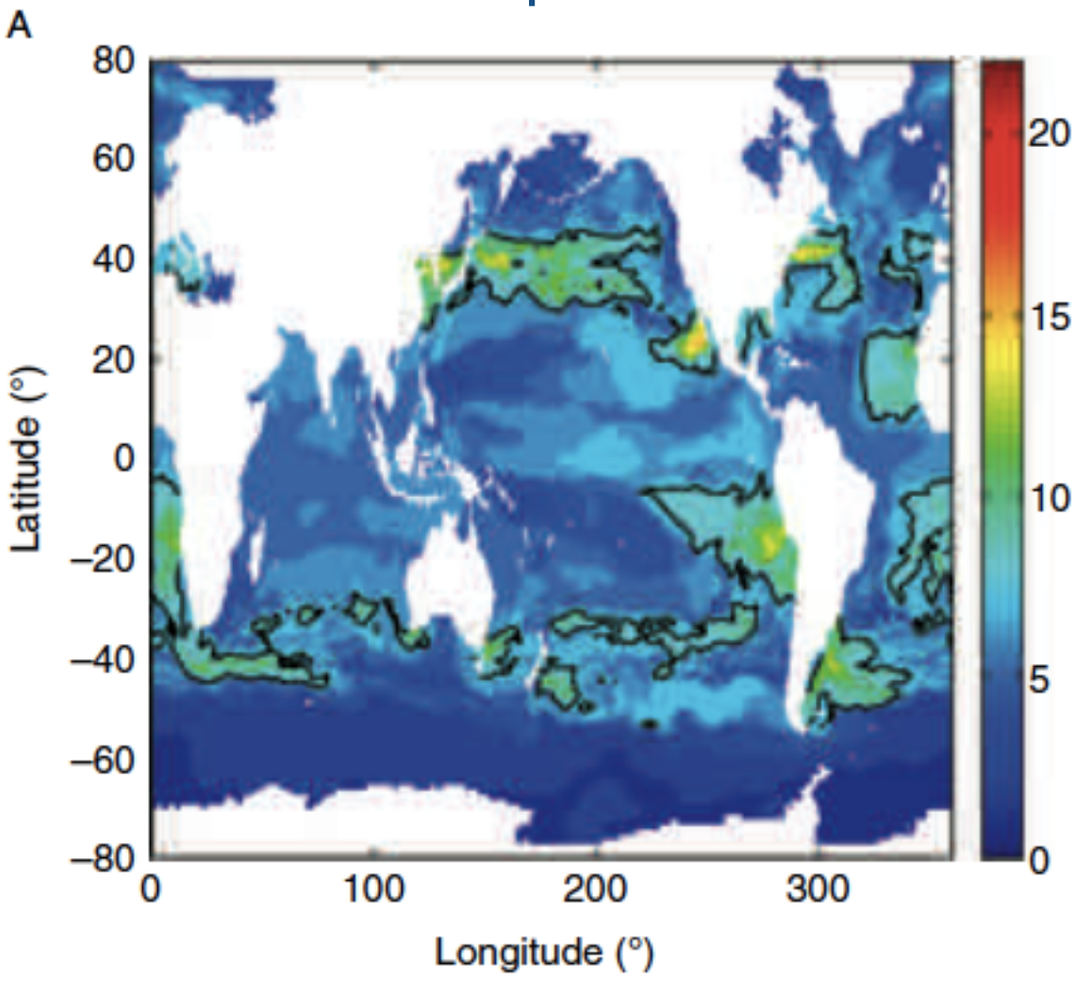
Observations show (sub)mesoscale structuring of biomass, but what about community structure?

- Taxonomic and functional diversity
- Ecosystem stability
- Carbon export

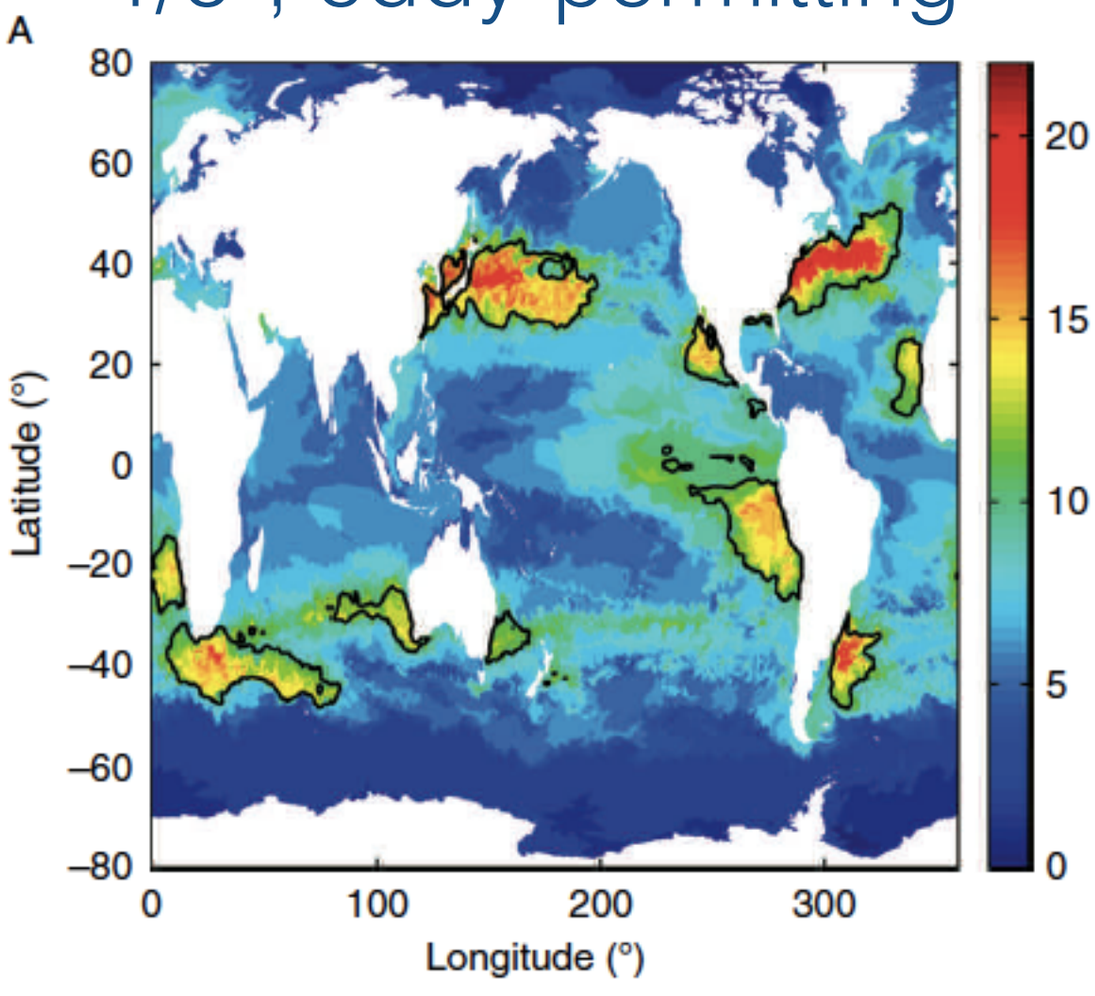


In ecological models, mesoscales enhance diversity

1°



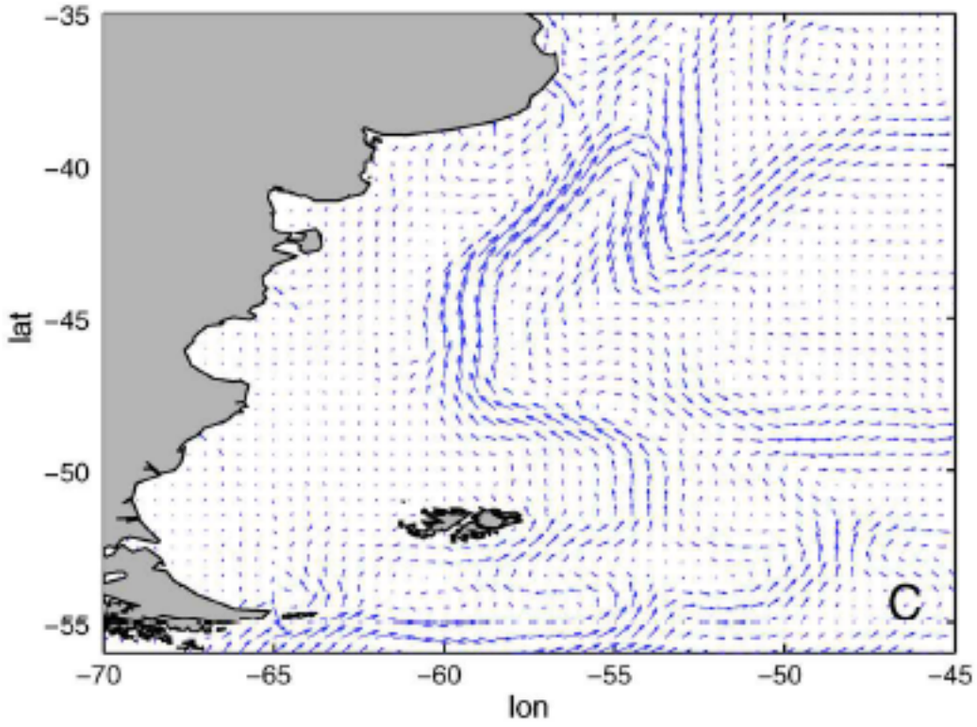
1/6°, eddy-permitting

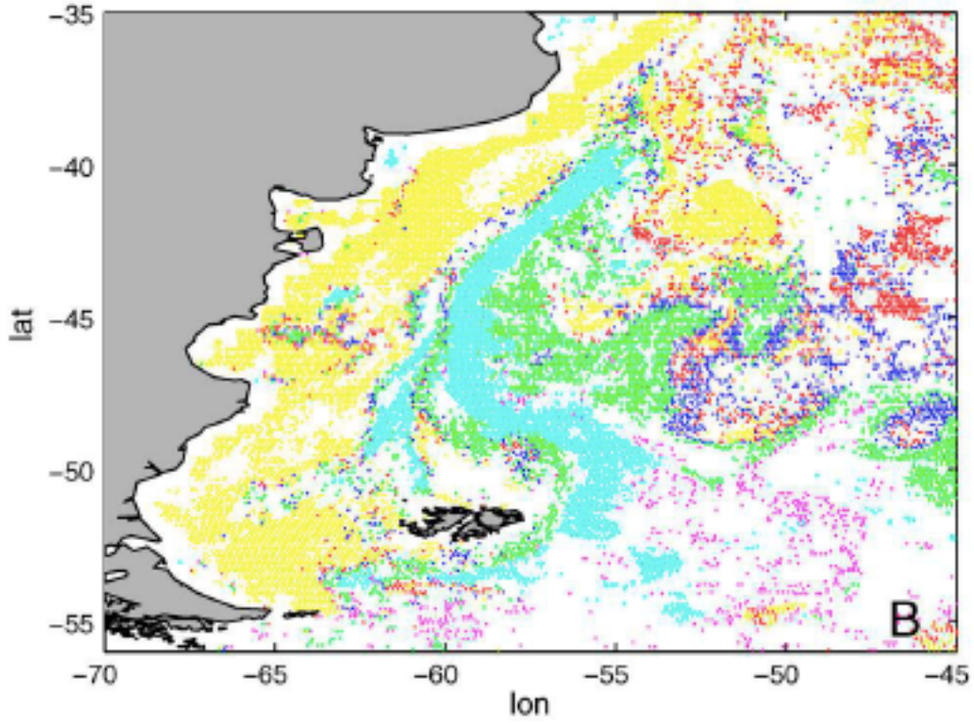


Combined effect of stirring and enhanced nutrient supply

Clayton et al, 2013, LO

Large scale fronts stir communities together (satellite data)

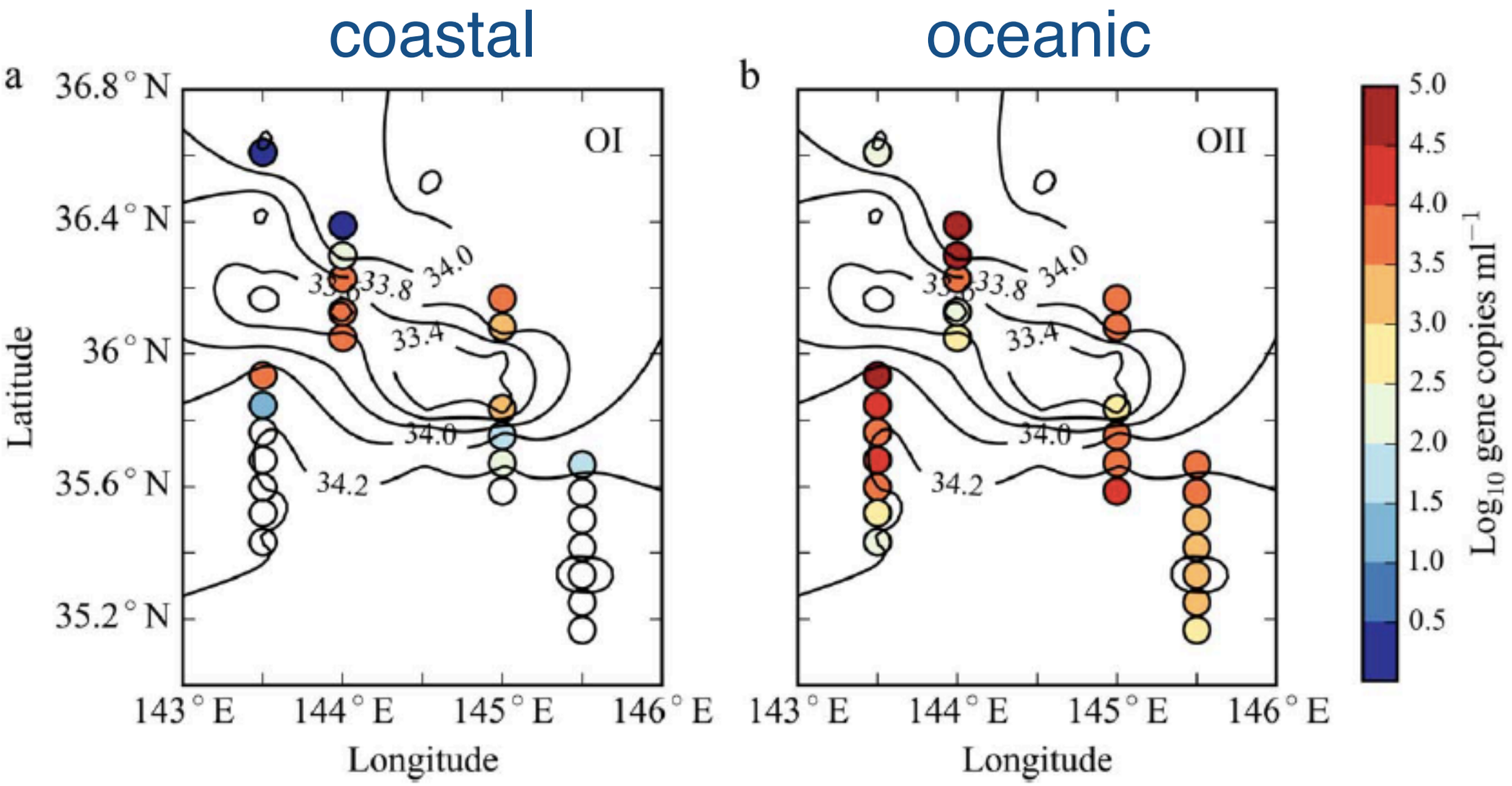




PHYSAT dominant PFTs in the Brazil-Malvinas confluence

d'Ovidio et al, 2010, PNAS

Large scale fronts stir communities together (in real life!)



Ostreococcus ecotypes in the Kuroshio Extension

Clayton et al, 2016, LO

Airplane

Detail

Taxonomically resolved observations at (sub)mesoscale resolution are rare.

Process studies represent individual systems at a given point in time and space.

What overall effect do submesoscale fronts have on phytoplankton community structure and diversity?

N 10 km

Outline

1. SeaFlow underway cytometer

2. Community structure at fronts

3. Overall impact of fronts

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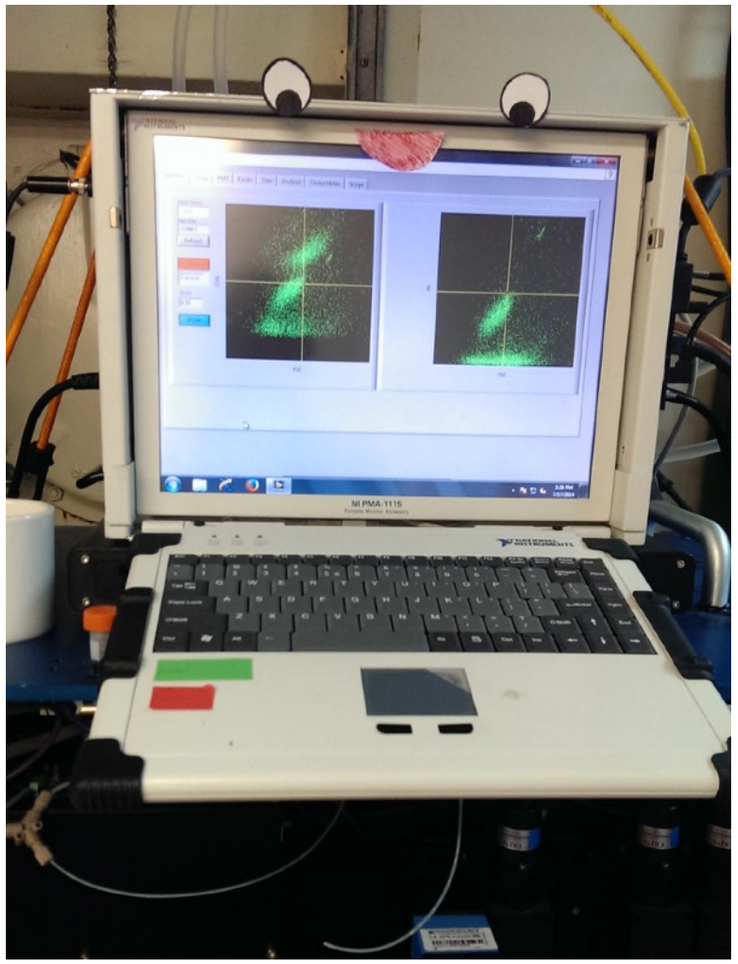
2. Community structure at fronts

3. Overall impact of fronts

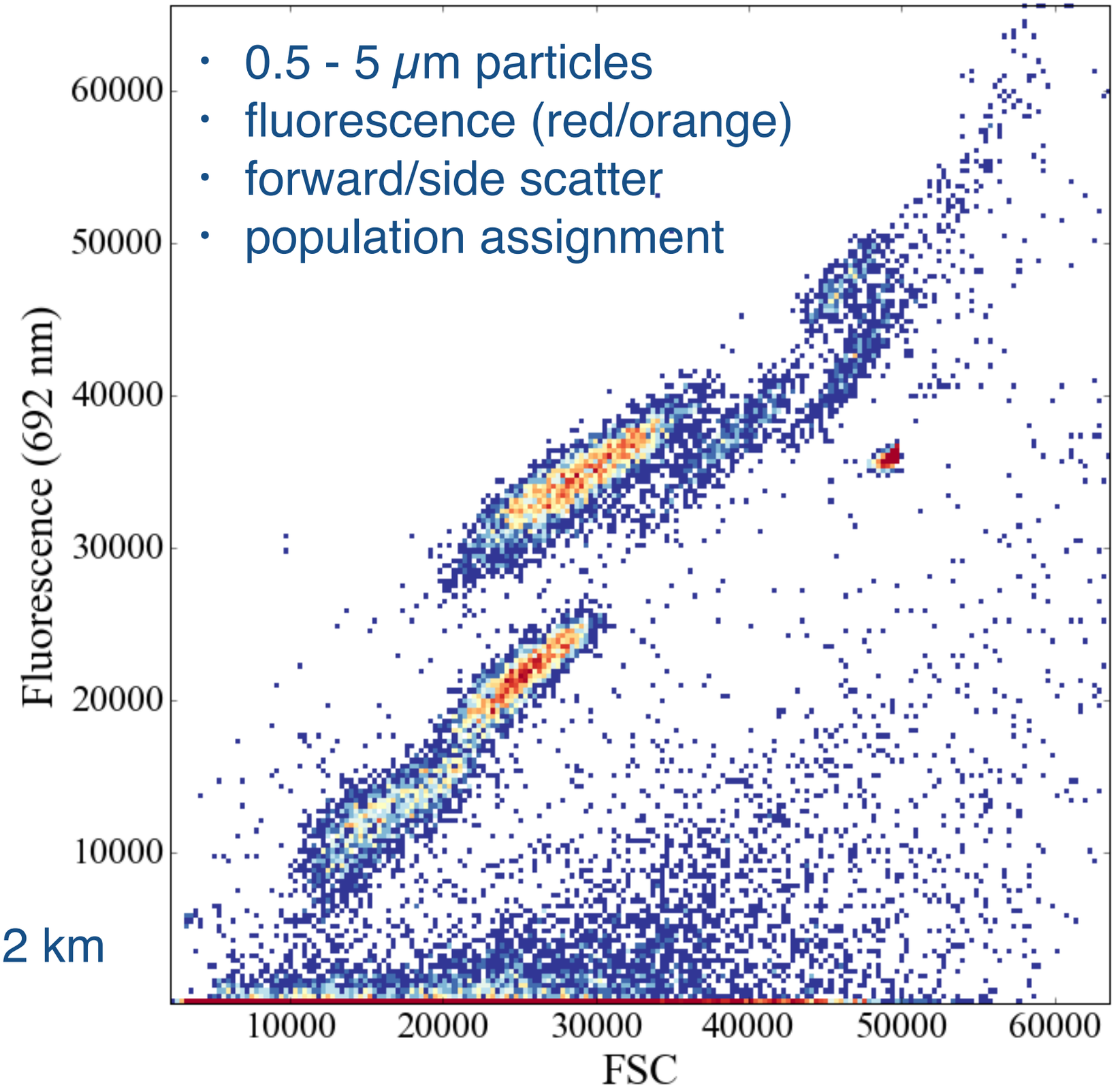
SeaFlow measures picoplankton abundances

High-resolution phytoplankton community structure



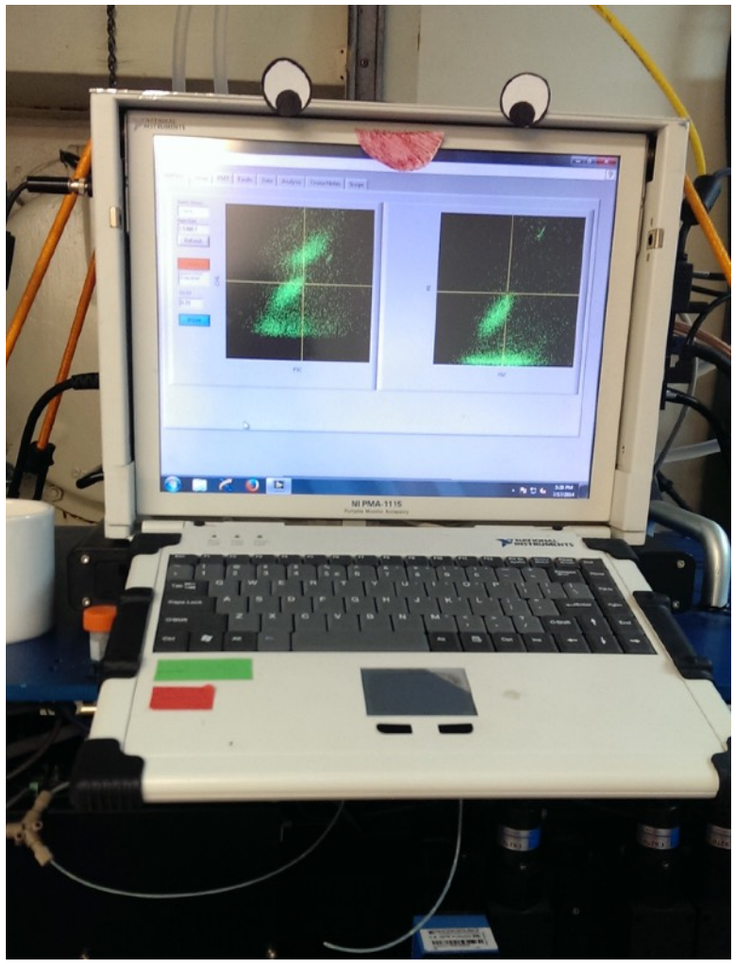
- sea surface only
- 3 min aggregates ~ 1-2 km

- 0.5 - 5 μm particles
- fluorescence (red/orange)
- forward/side scatter
- population assignment



SeaFlow measures picoplankton abundances

High-resolution phytoplankton community structure



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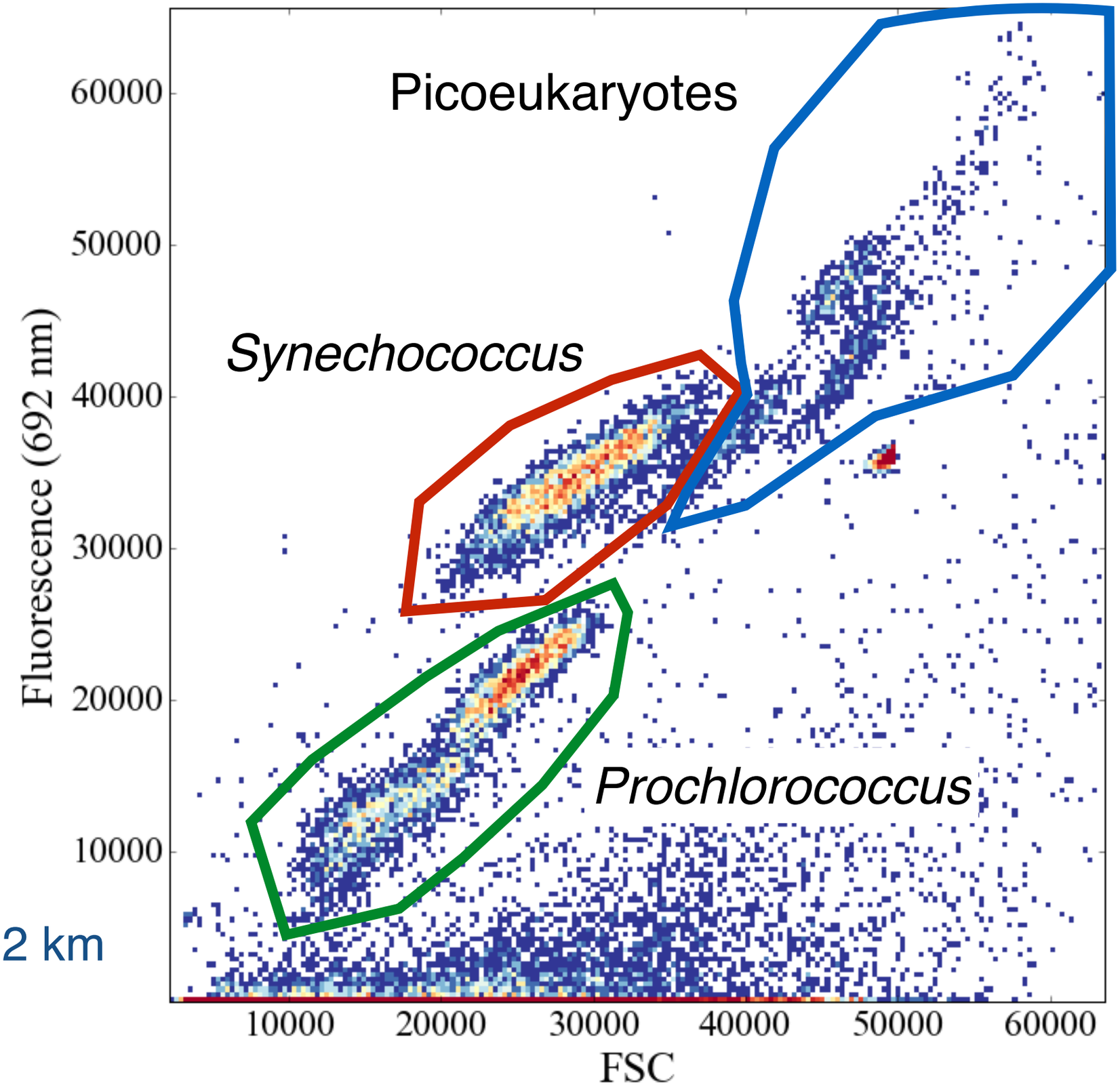
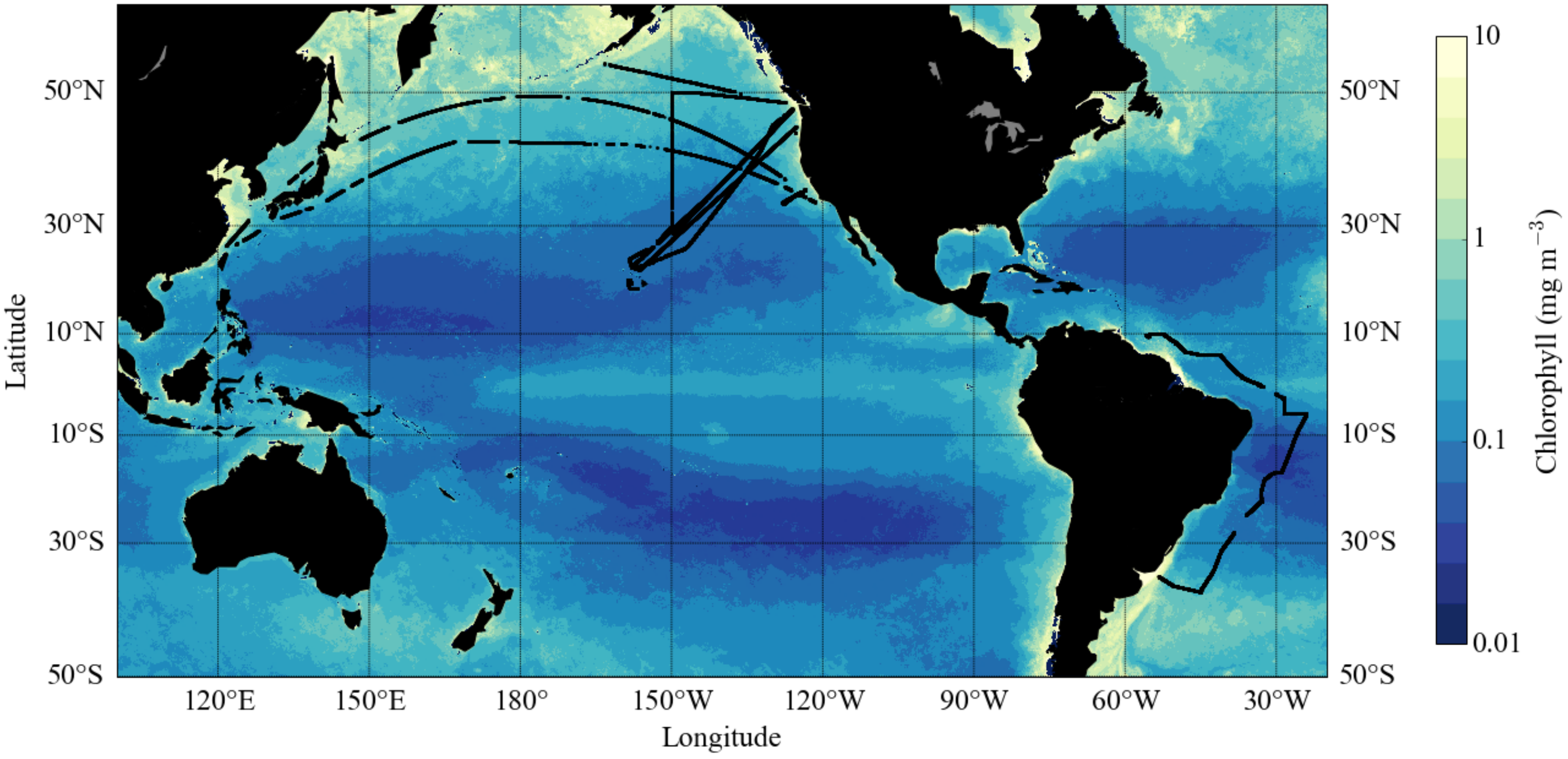


High-resolution basin-scale data coverage

SeaFlow data set

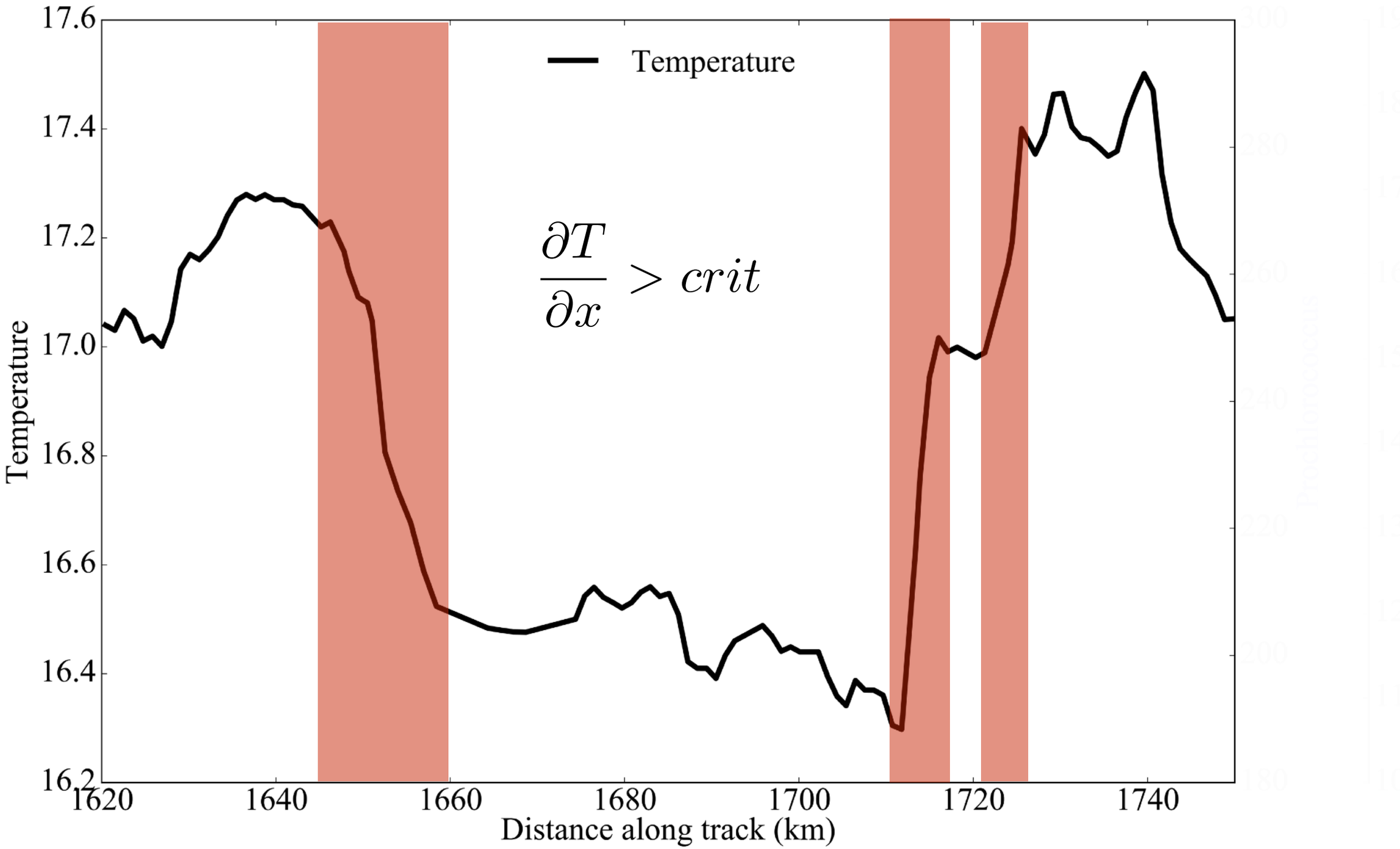


12 cruises, ~80,000 underway data points

1 - 2 km resolution

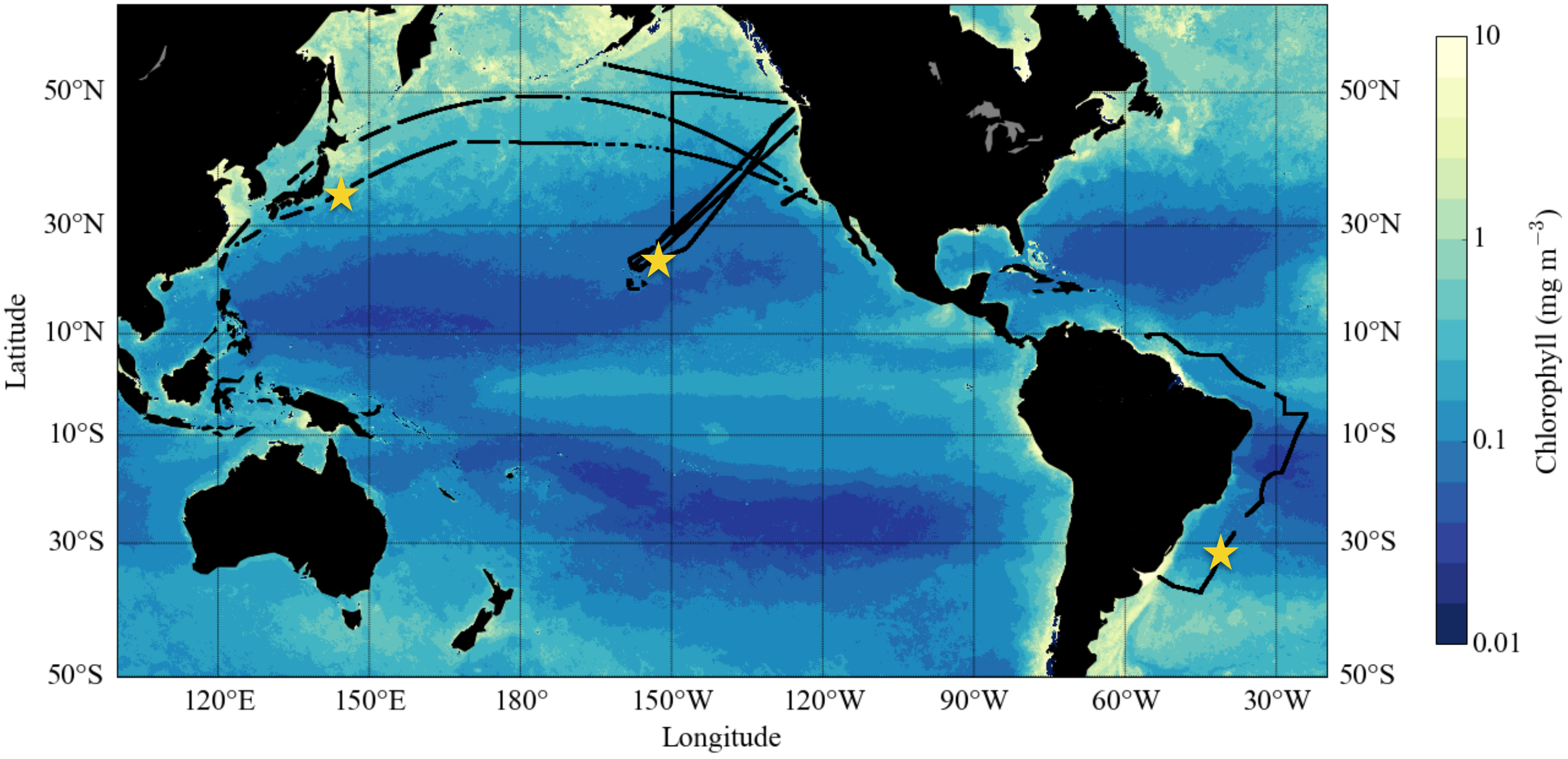
1. SeaFlow underway cytometer
2. Community structure at (some) fronts
3. Overall impact of fronts

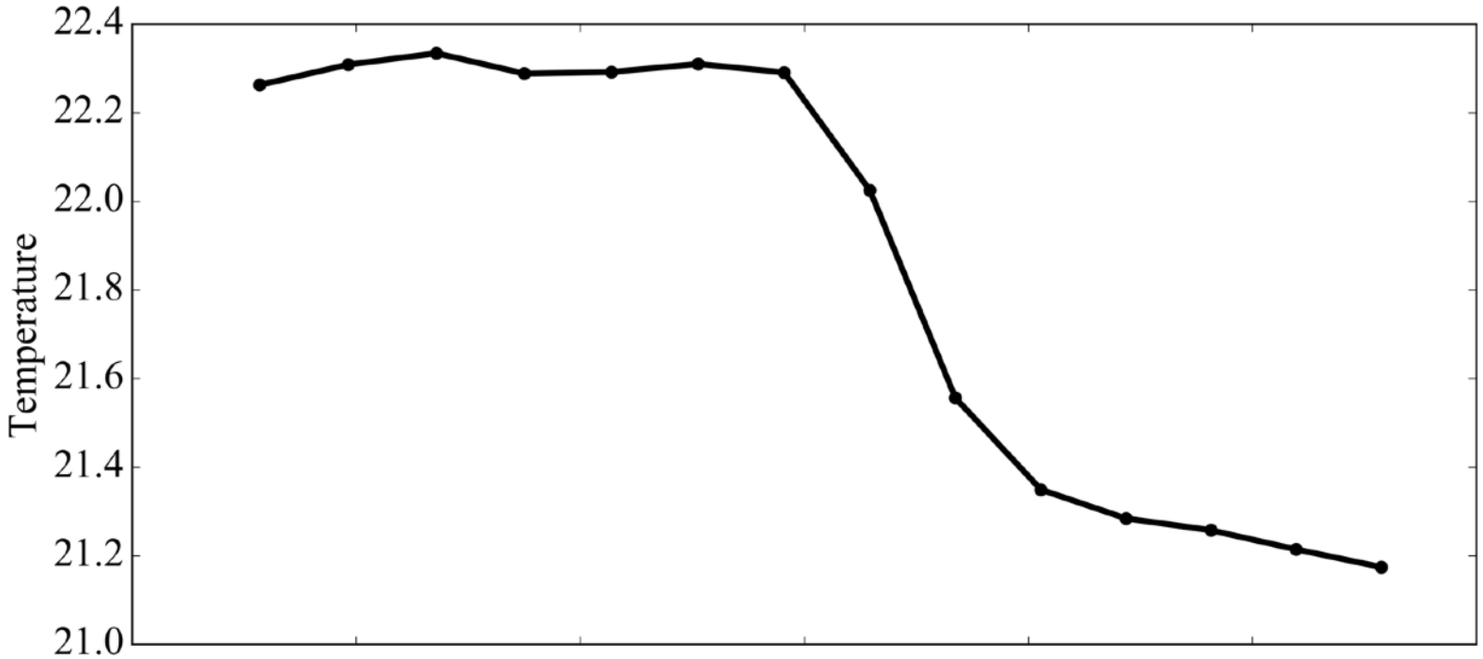
Identifying fronts from underway data

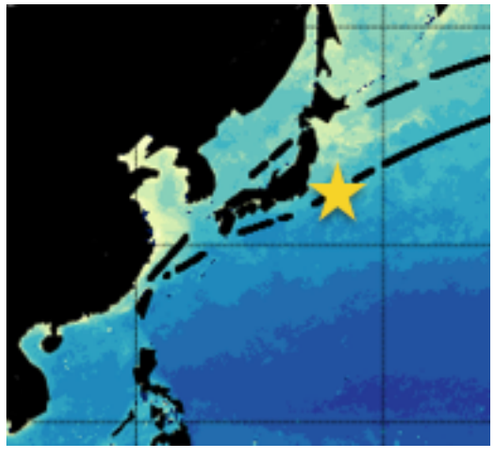


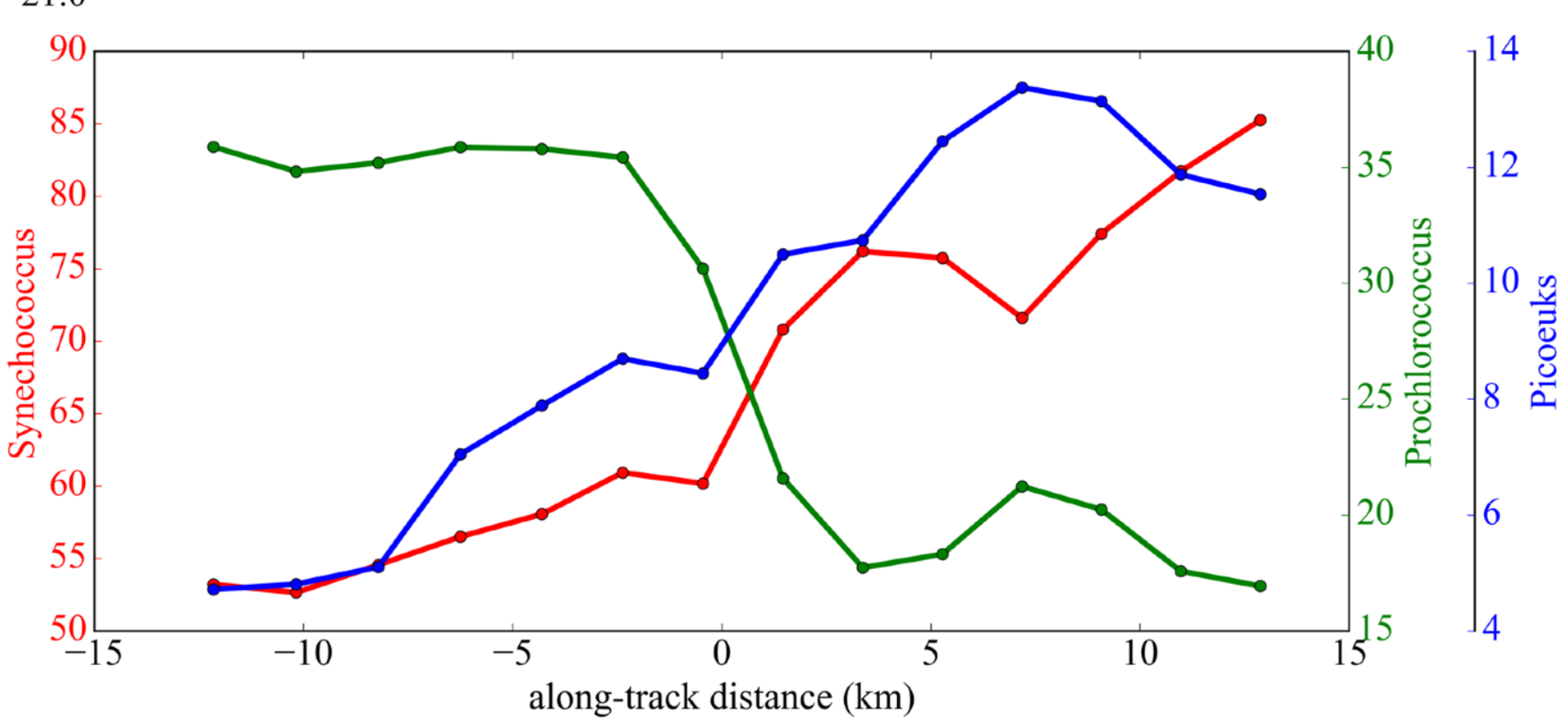
data collected in May 2015 aboard the R/V Kilo Moana

Examples of frontal underway data

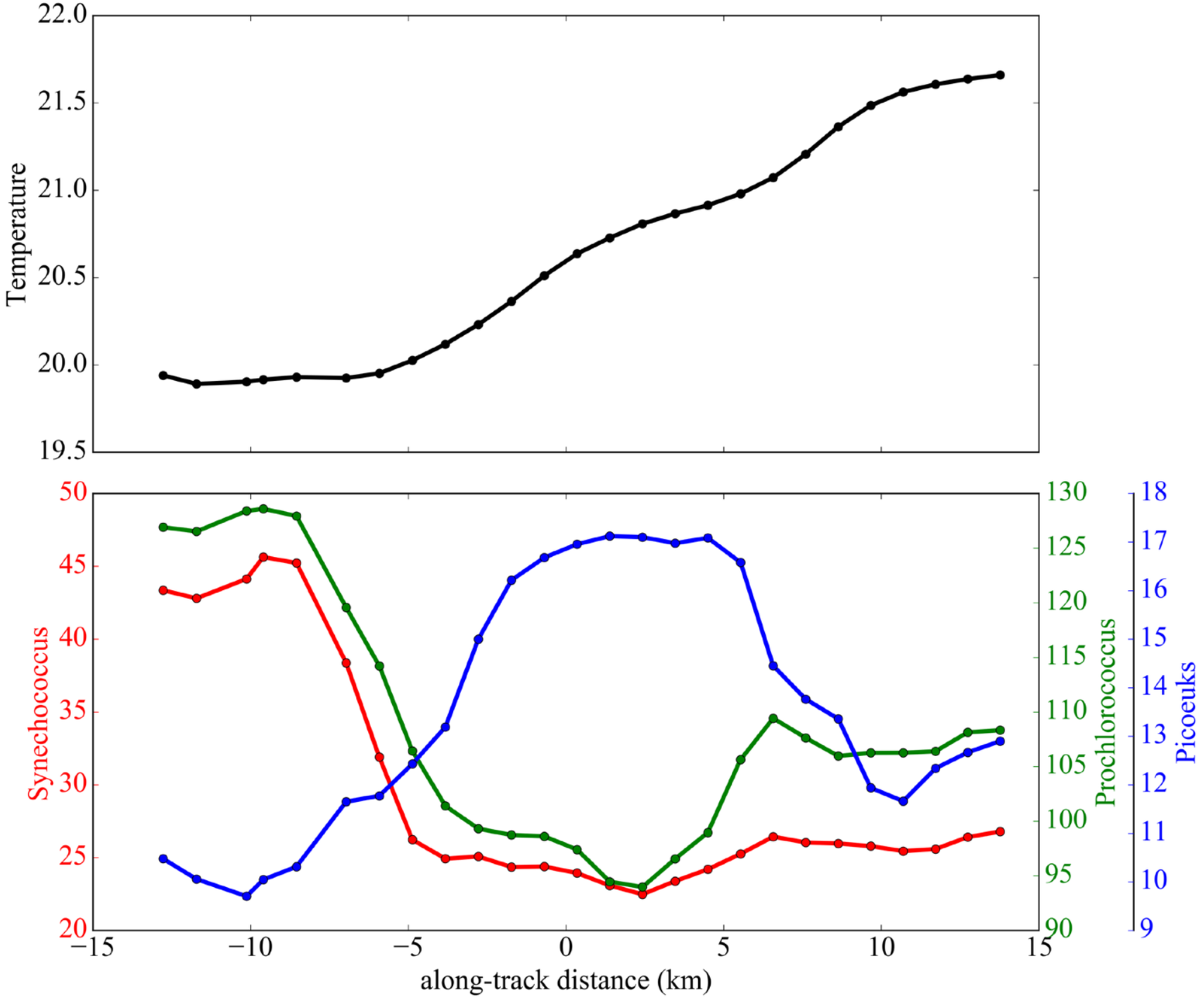


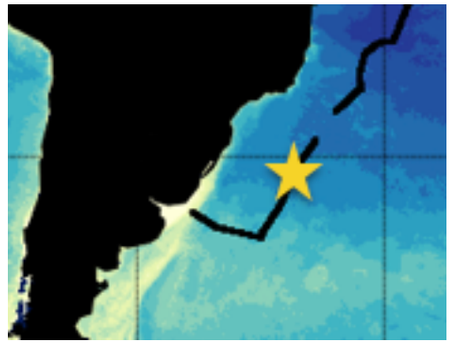






abundance unit: 10^6 cells/L





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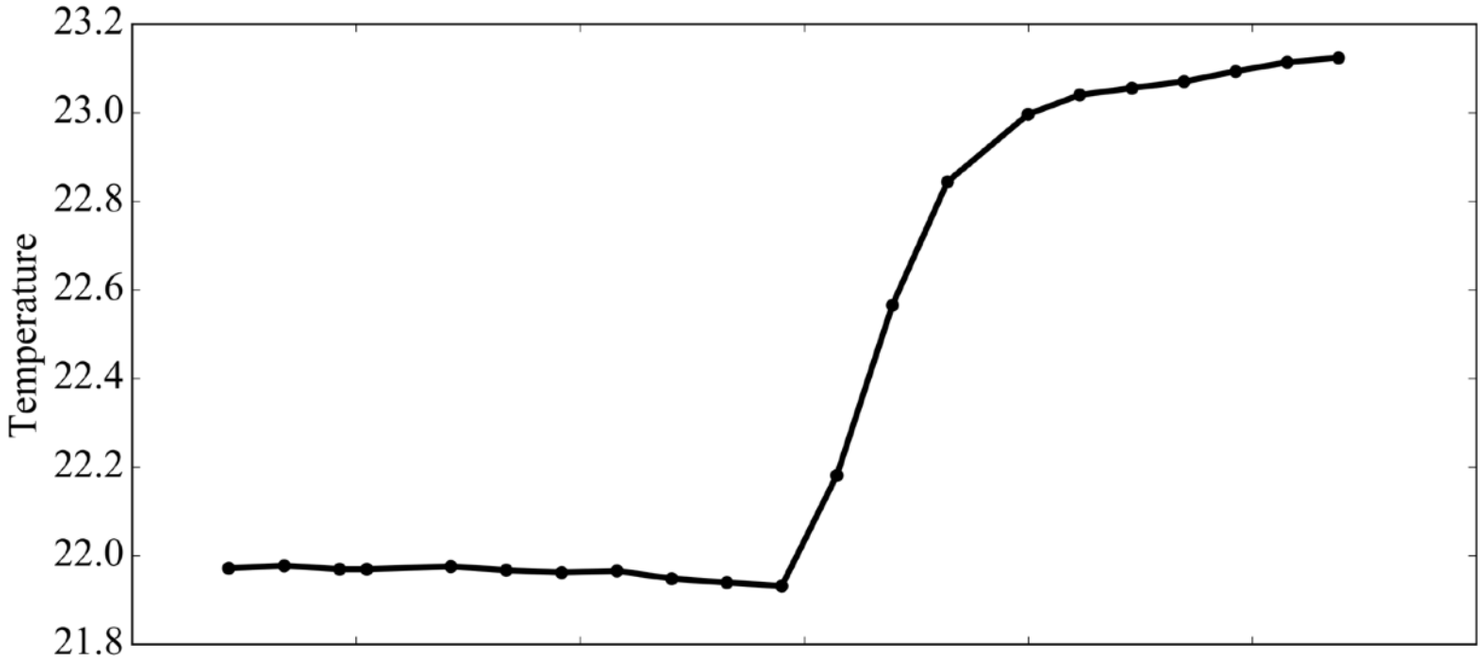
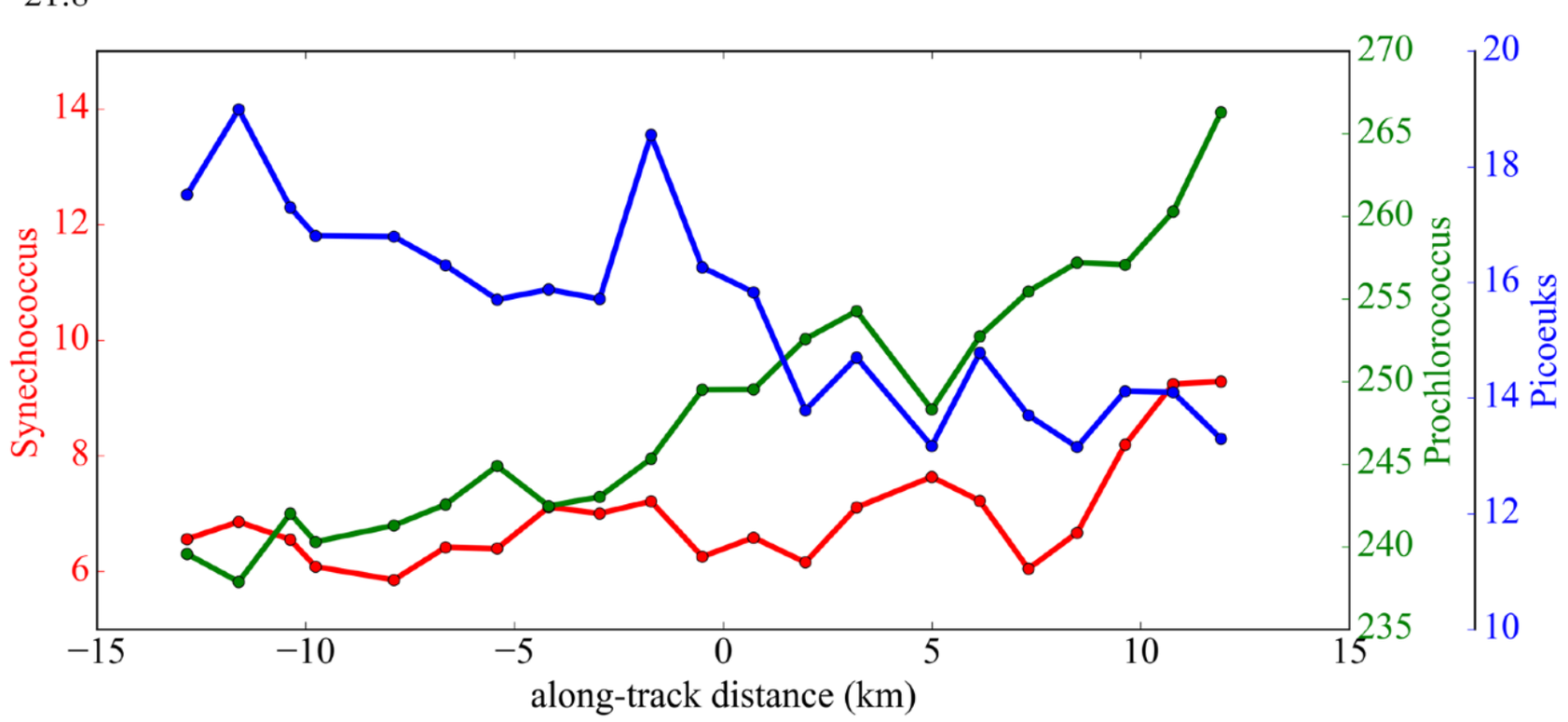
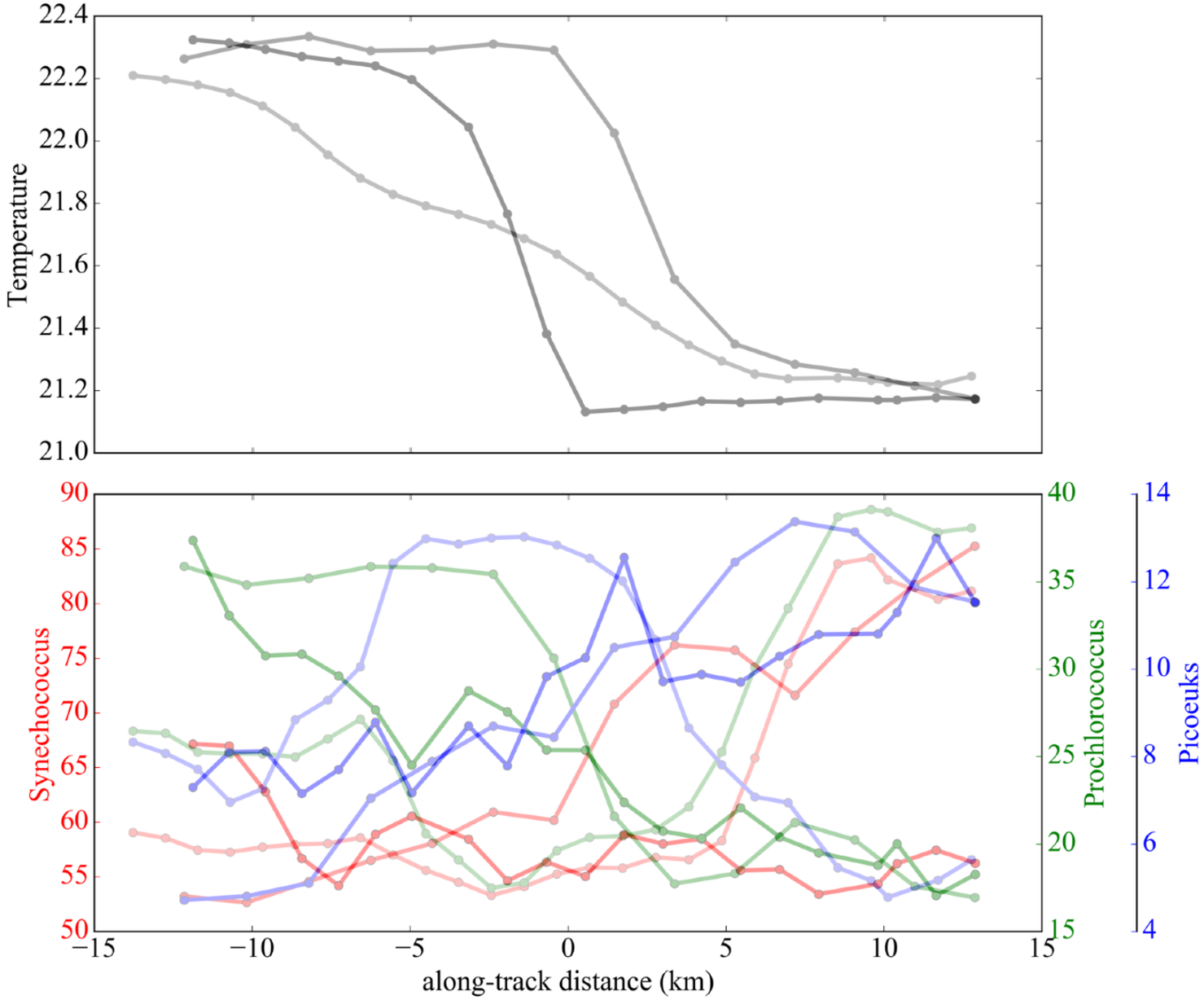




abundance unit: 10^6 cells/L

Different fronts tell different stories

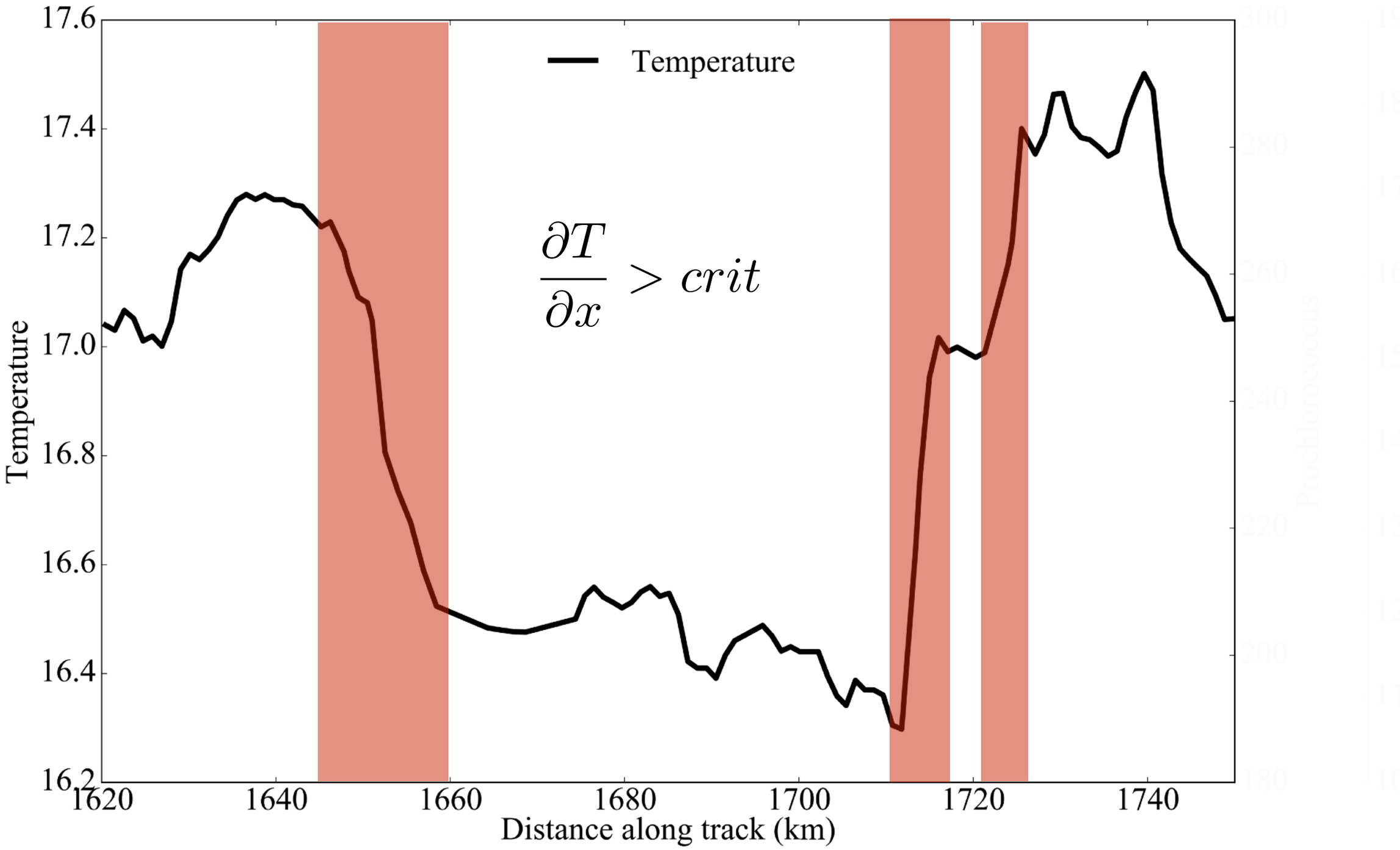


How can we distill this to find the overall impact of frontal systems on the phytoplankton community?

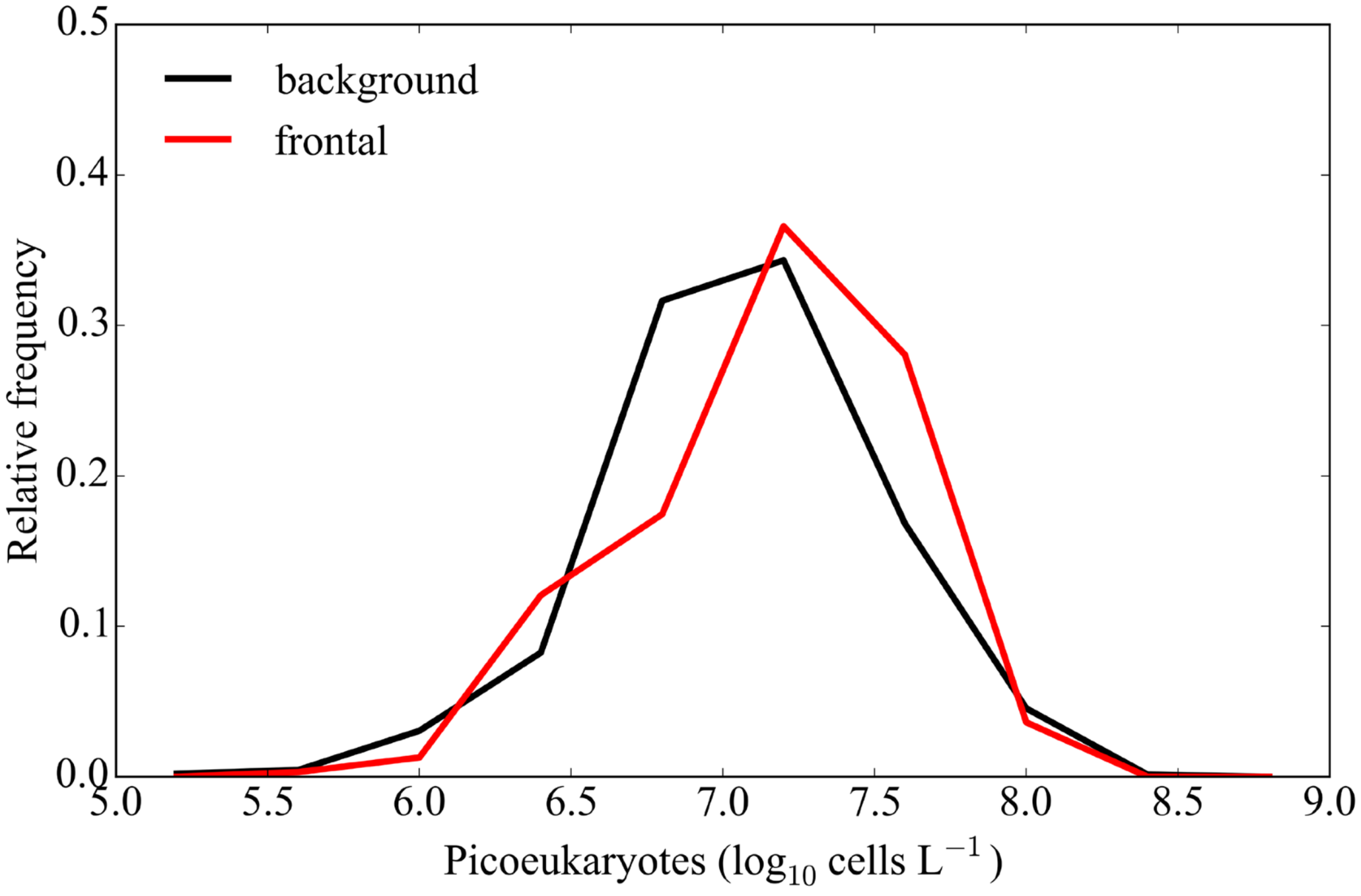
1. SeaFlow underway cytometer
2. Community structure at (some) fronts
3. Overall impact of fronts

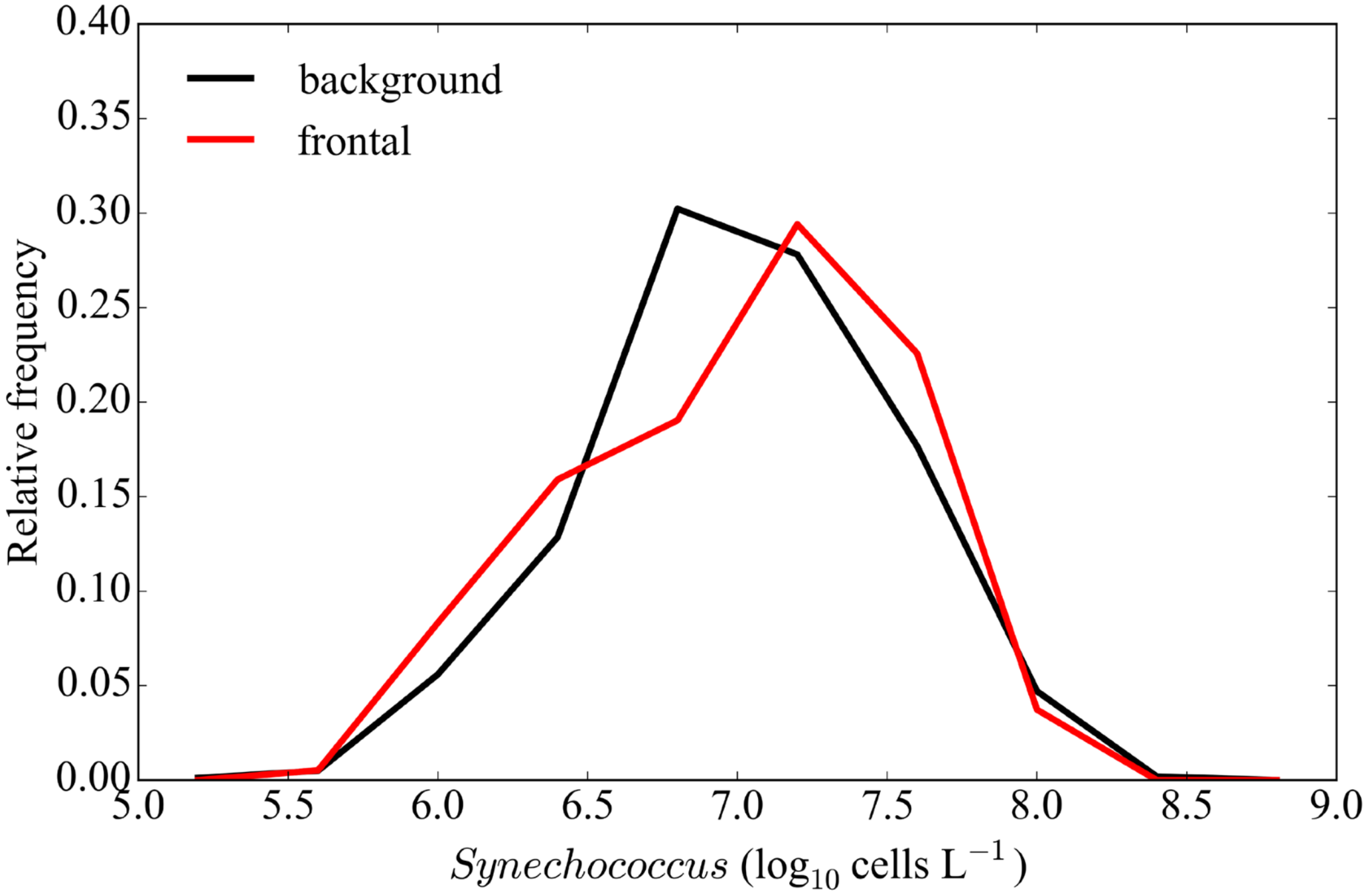
Identifying fronts from underway data

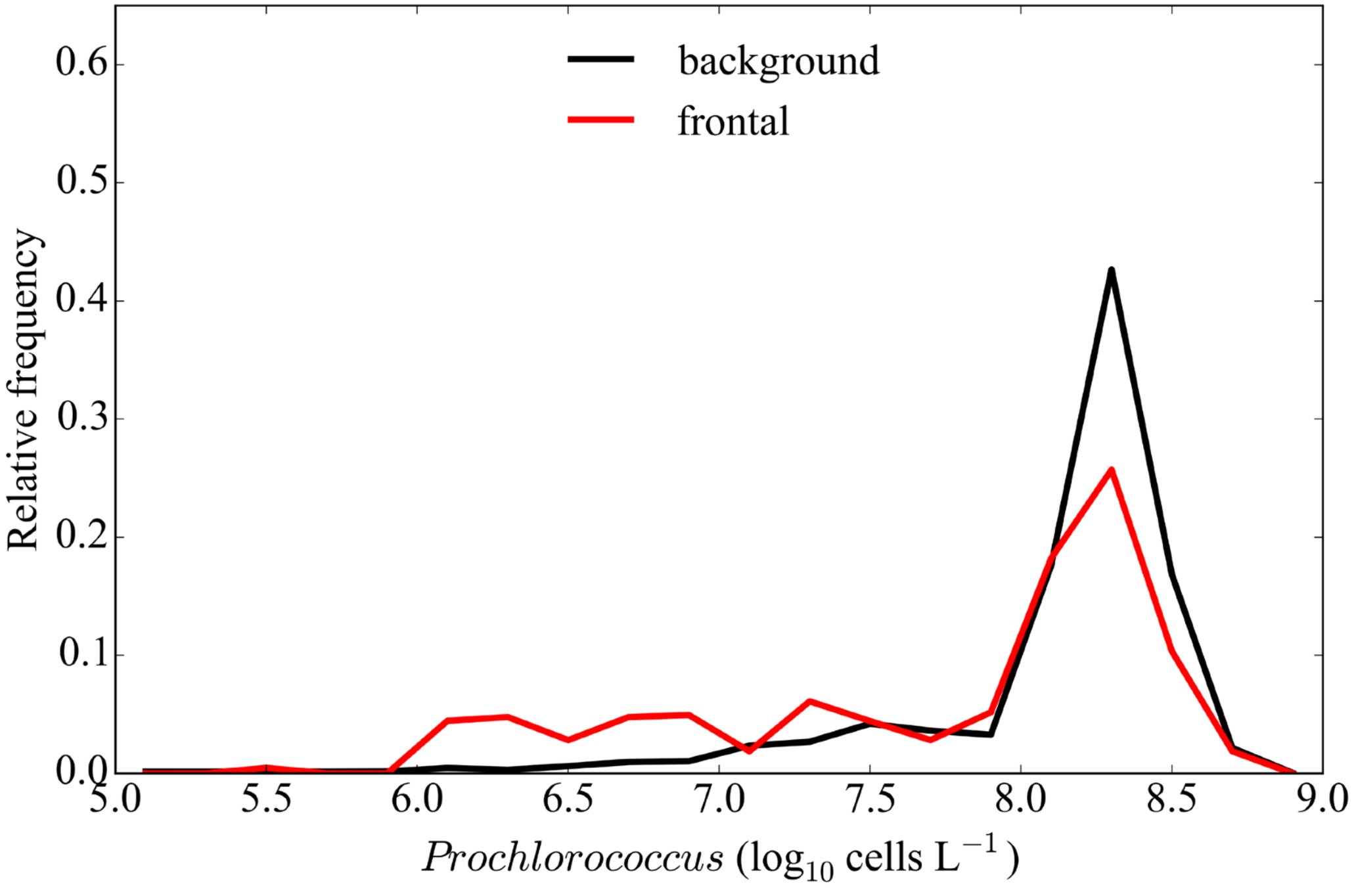
Split data into "fronts" vs. "background"



data collected in May 2015 aboard the R/V Kilo Moana


background
frontal
0.5
0.4
0.3
0.2
0.1
0.0
Relative frequency
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Picoeukaryotes (log10 cells L−1)


background
frontal
Relative frequency
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Synechococcus ($\log_{10}$ cells L^{-1})


background
frontal
Relative frequency
0.0
0.1
0.2
0.3
0.4
0.5
0.6
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Prochlorococcus ($\log_{10}$ cells L^{-1})

Picophytoplankton diversity

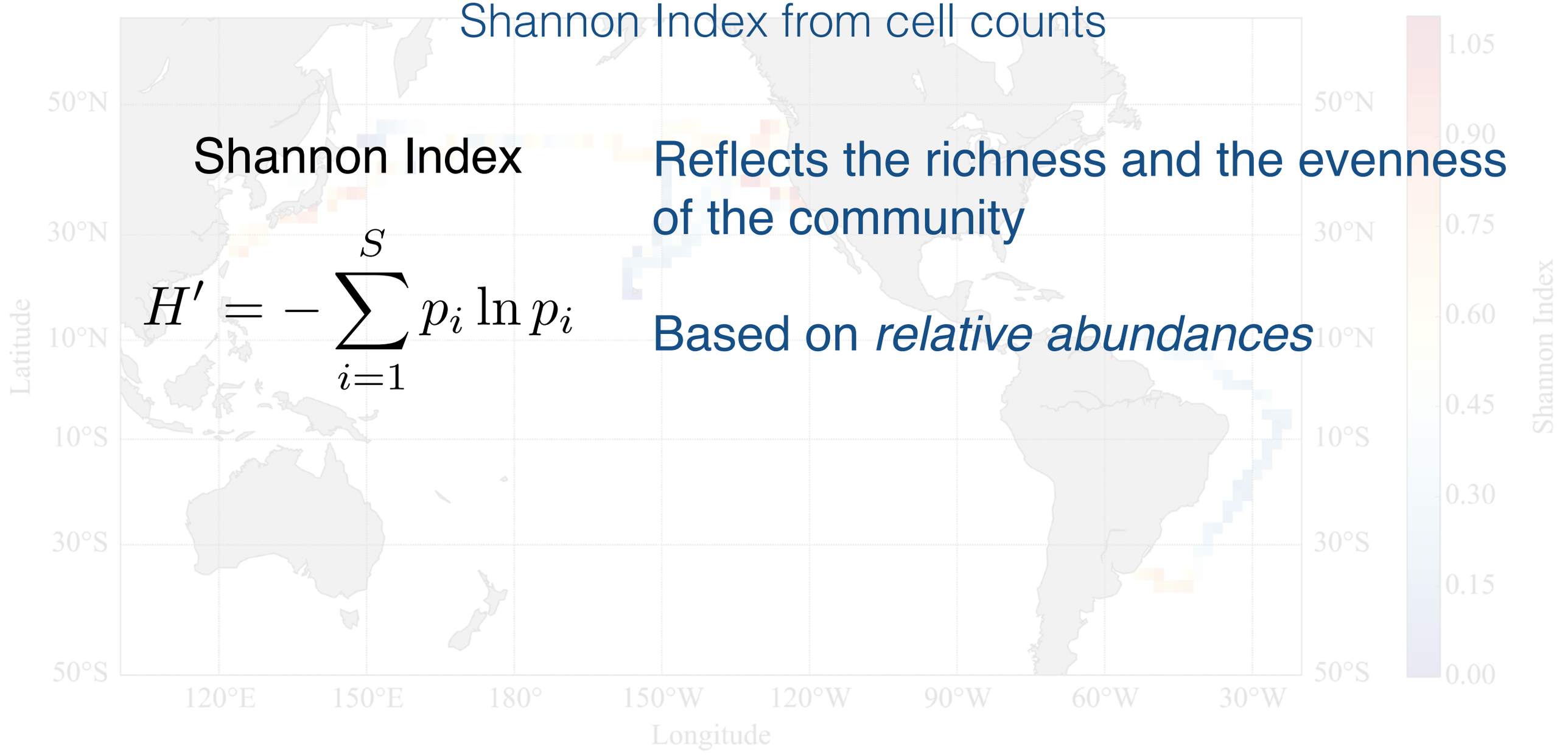
Shannon Index from cell counts

Shannon Index

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Reflects the richness and the evenness of the community

Based on *relative abundances*



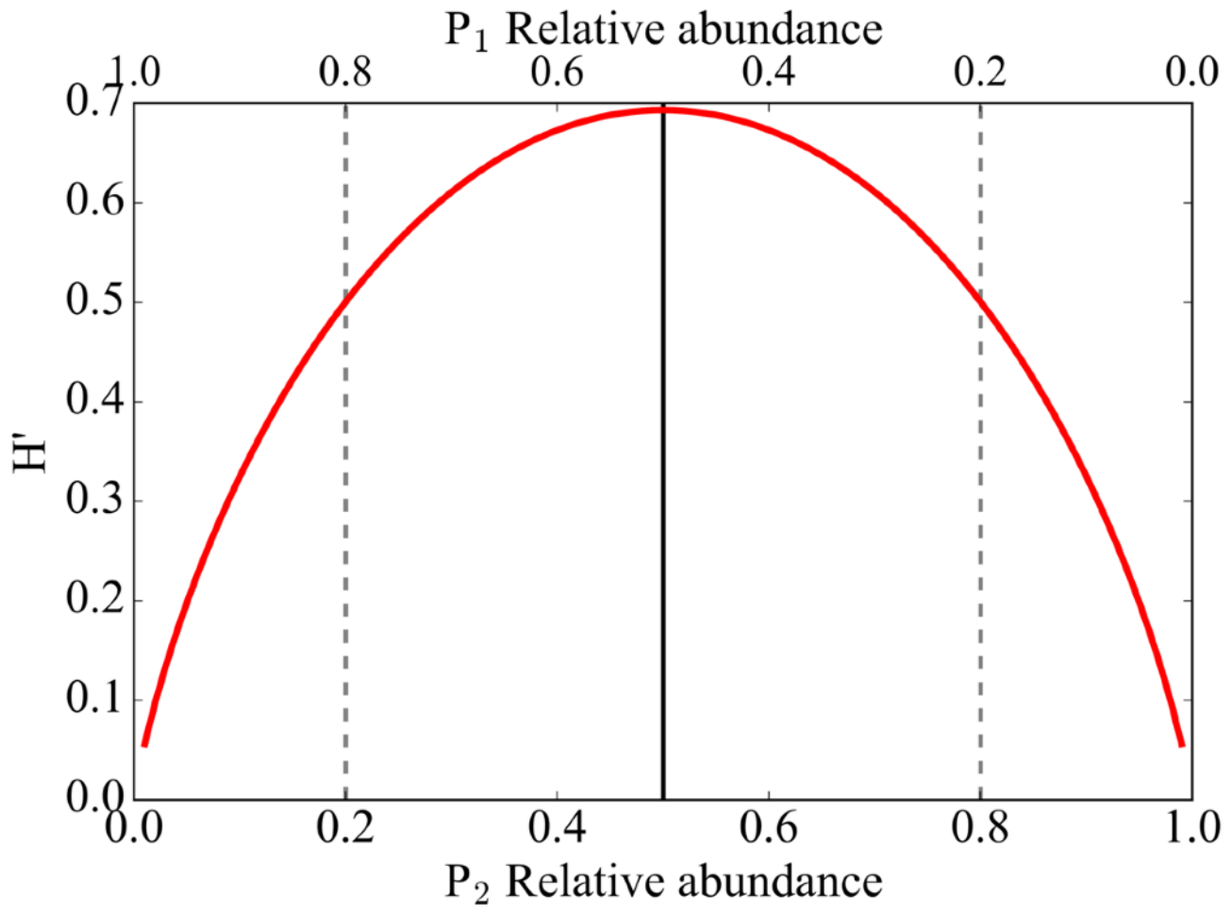
Picophytoplankton diversity from SeaFlow

Shannon Index from cell counts

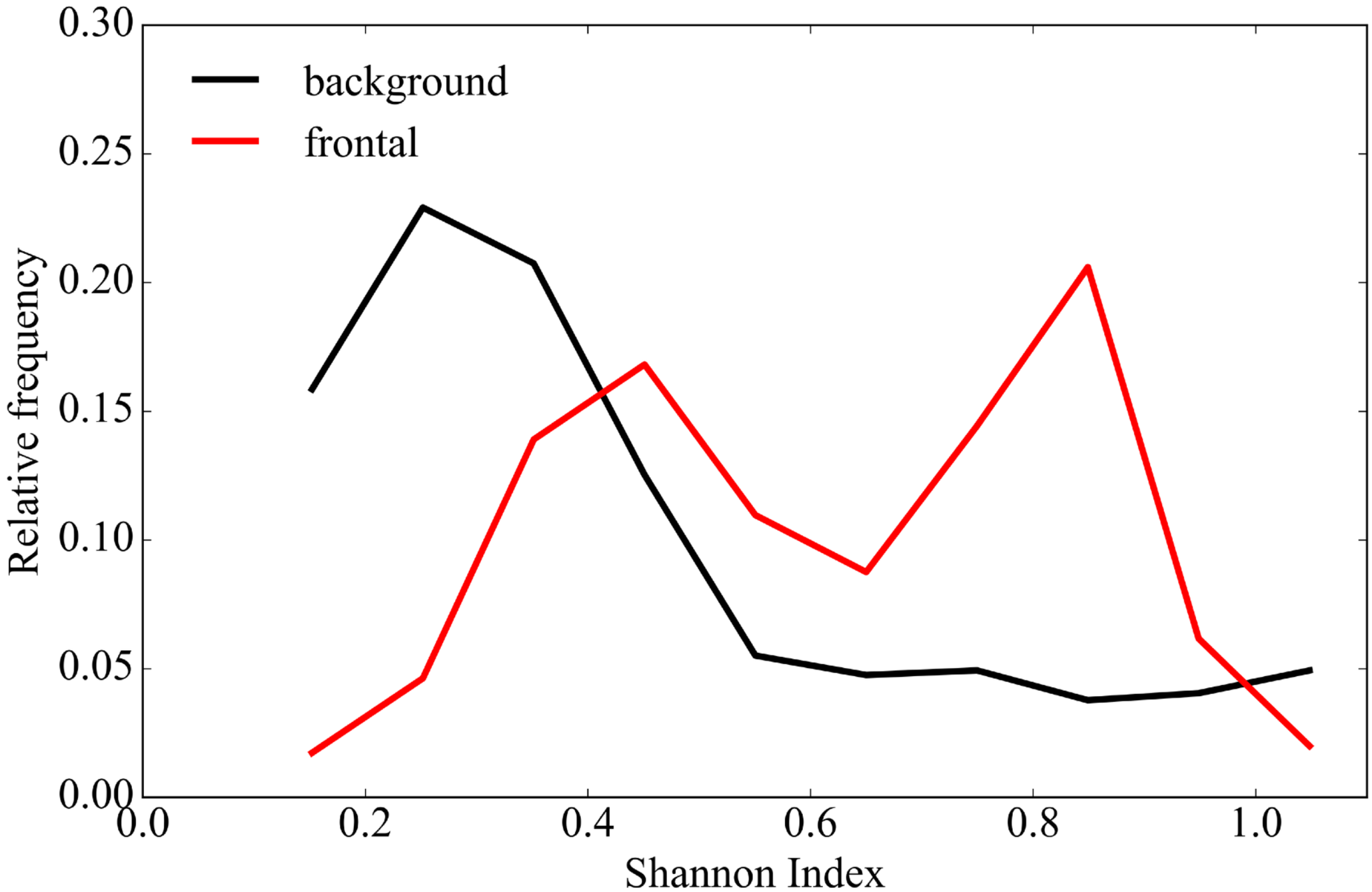
Shannon Index

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Maximized for richest *and* most evenly distributed population



Shannon Index is significantly enhanced at fronts



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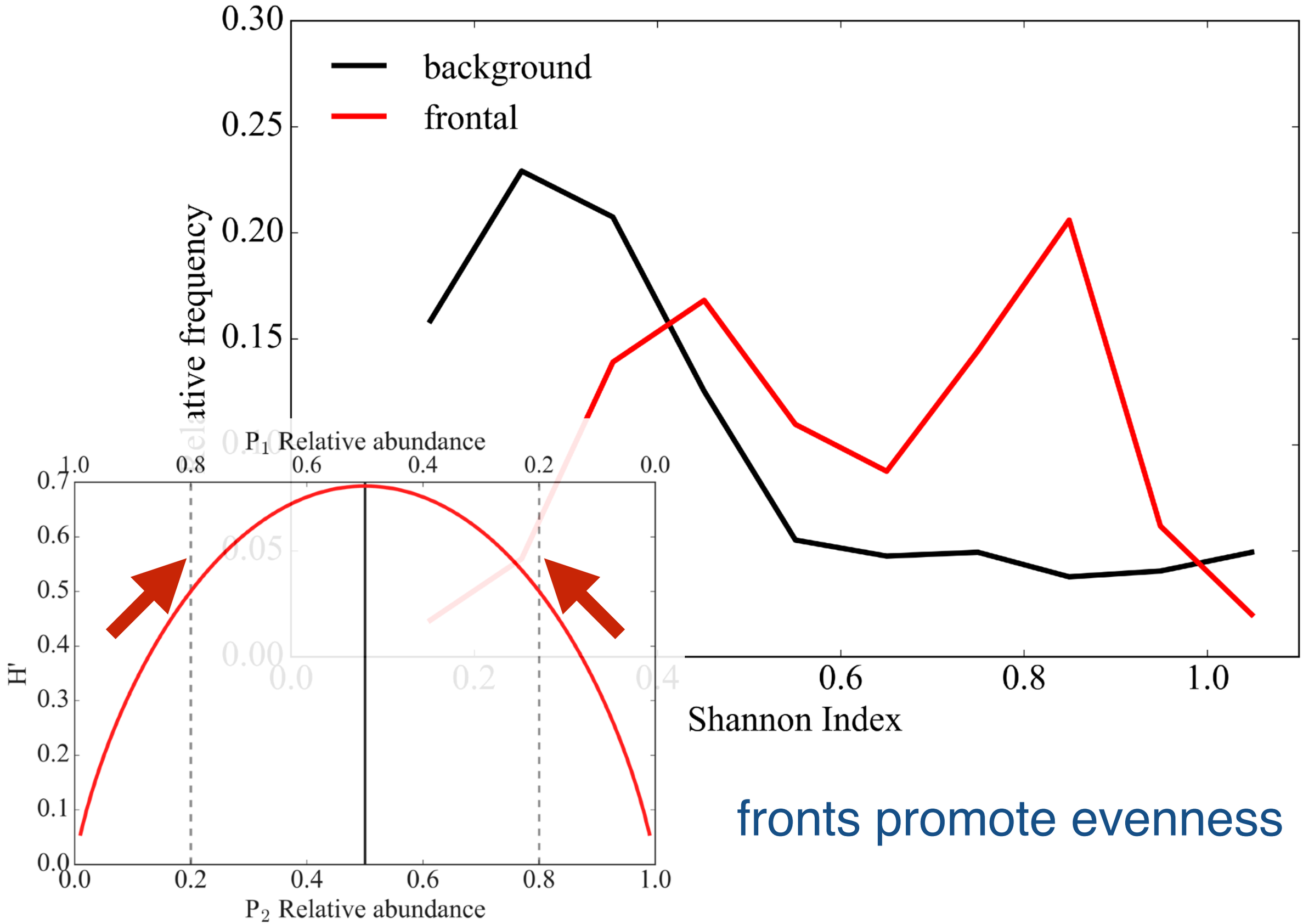
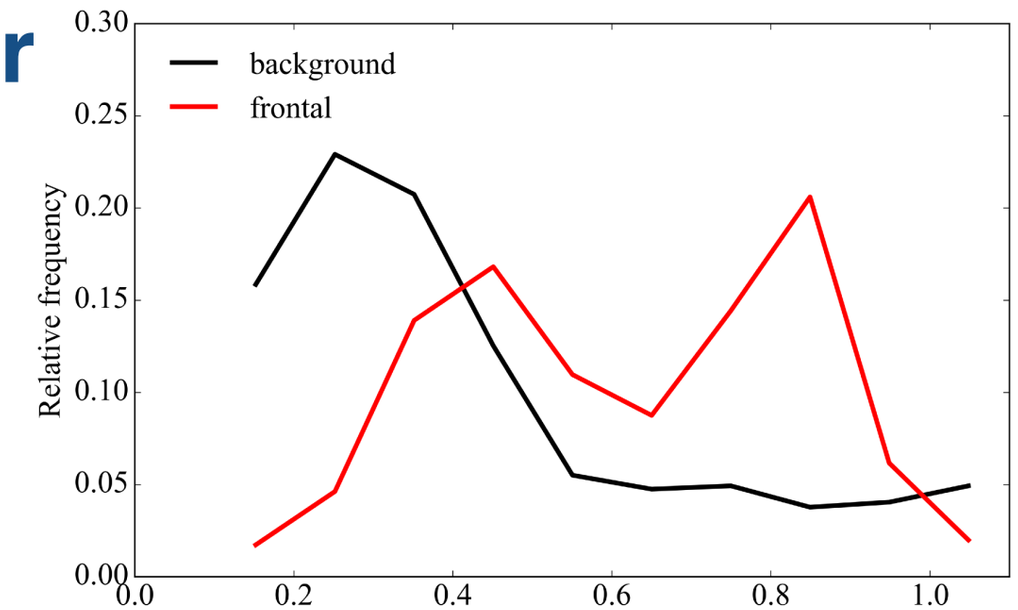


fronts promote evenness

Concluding thoughts

Submesoscales do support higher diversity (evenness)

Stirring vs. biological response?
Probably both…



High resolution, taxonomically resolved observations are a challenge. Vertical structure?

Biomass is cool but how about rates? And community function?

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