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Global surface ocean phytoplankton community structure determined from co-variability in phytoplankton pigment concentrations

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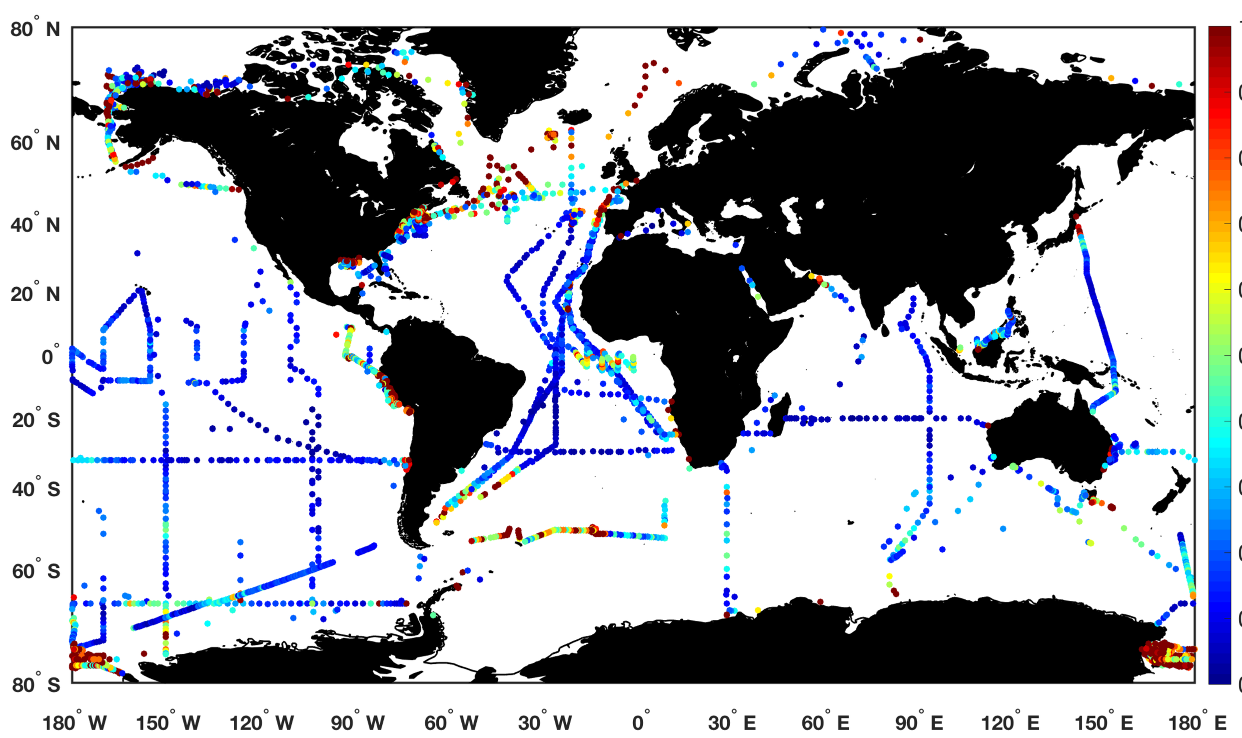
Research Goals

- Describe the global distribution and co-variability of phytoplankton pigments
- Use **associations between groups of phytoplankton pigments** to distinguish between groups of phytoplankton
- Explore the global patterns of groups and size classes of phytoplankton based on the results of **clustering, EOF, and network analyses** on varying spatial scales

Data & Methods

Data summary:

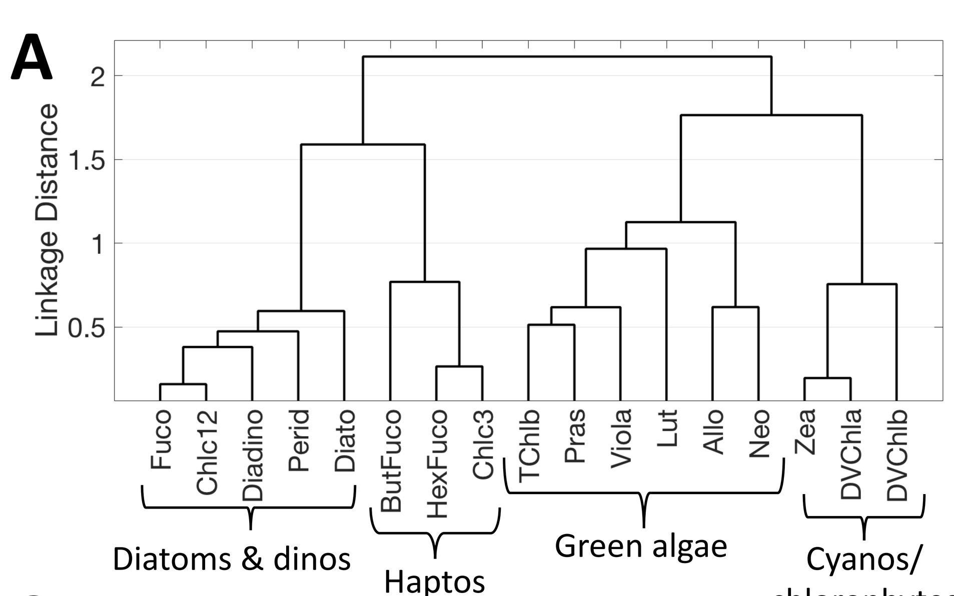
- **4,124** distinct data points from **40+** cruises in **5** major ocean basins
- **6** labs performed analysis: Horn Point, NASA GSFC, LOV, CSIRO, AWI, DiTullio



Methods:

- All pigment values below NASA GSFC detection limit set to zero; pigments normalized to total chlorophyll-*a* concentration for all analyses
- Hierarchical cluster analysis using correlation distance & Ward's linkage
- Optimized coefficients for diagnostic pigment analysis (Vidussi, Uitz): weighted sum of 7 pigments to equal total chlorophyll-*a* concentration
- Empirical orthogonal function analysis

A



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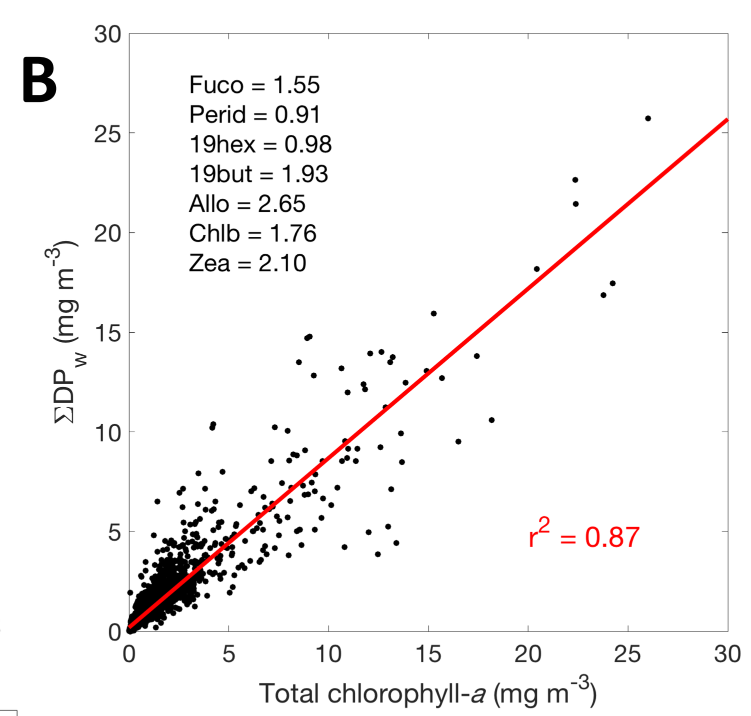

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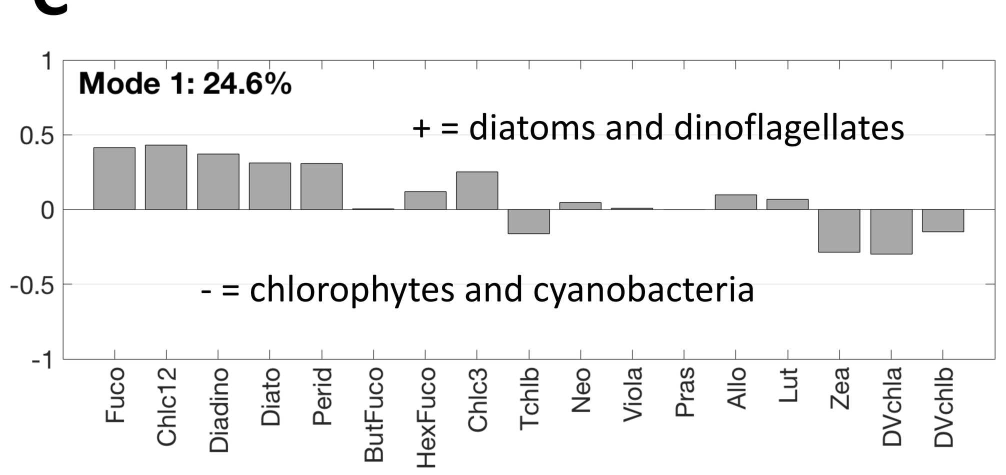
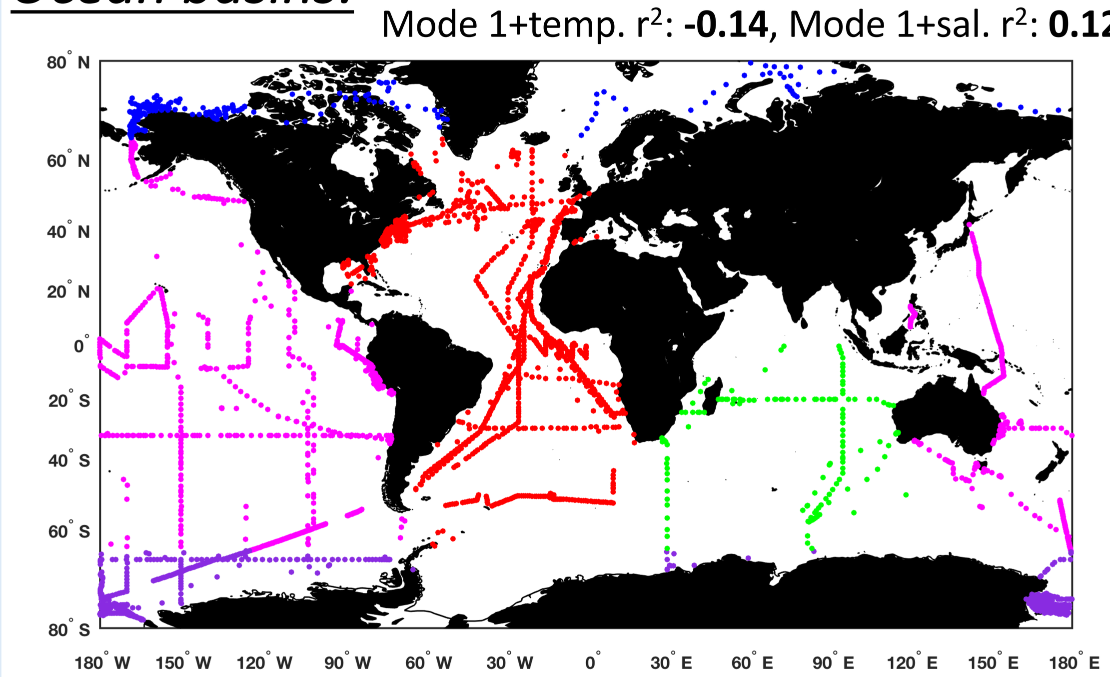


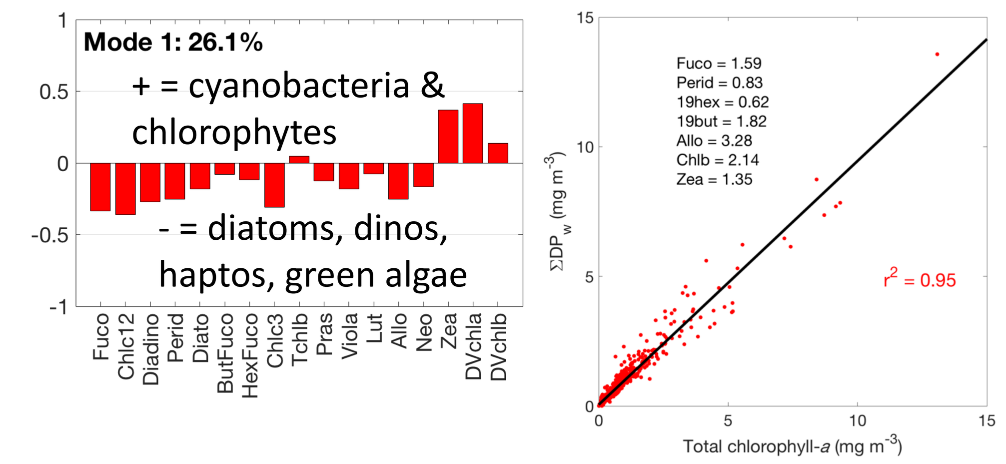
(A) Hierarchical clustering analysis results. **(B)** Mode 1 of empirical orthogonal function analysis: loadings show the strength of the correlation between each pigment and Mode 1. Sum of first six modes explains 72% of total variance in the dataset. **(C)** Re-optimized diagnostic pigment analysis.

Results of Cluster, EOF, and DPA Analyses on Varying Spatial Scales

Ocean basins: Variance explained by EOF modes 1-6: **72.19%**
Mode 1+temp. r^2: **-0.14**, Mode 1+sal. r^2: **0.12**

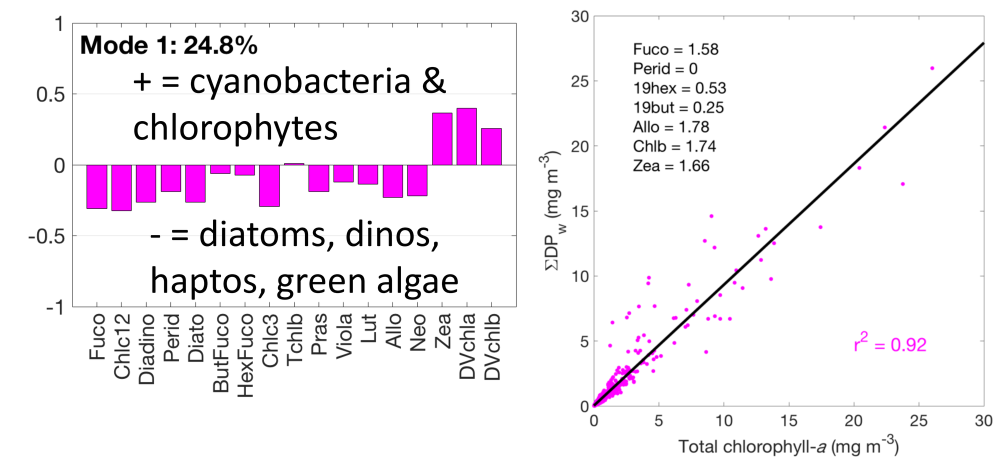


Atlantic



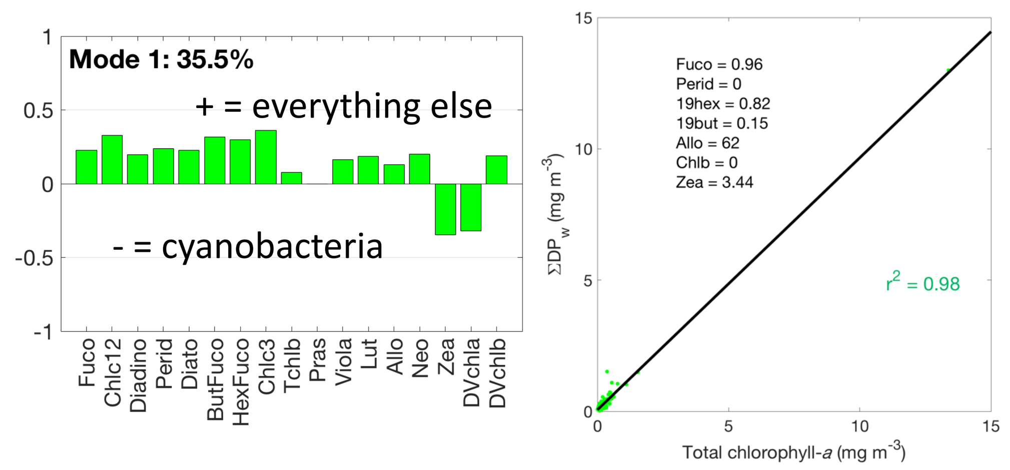
Variance explained by modes 1-6: **71.24%**
Mode 1+temp. r^2 = **0.008**, Mode 1+sal. r^2 = **0.52**

Pacific



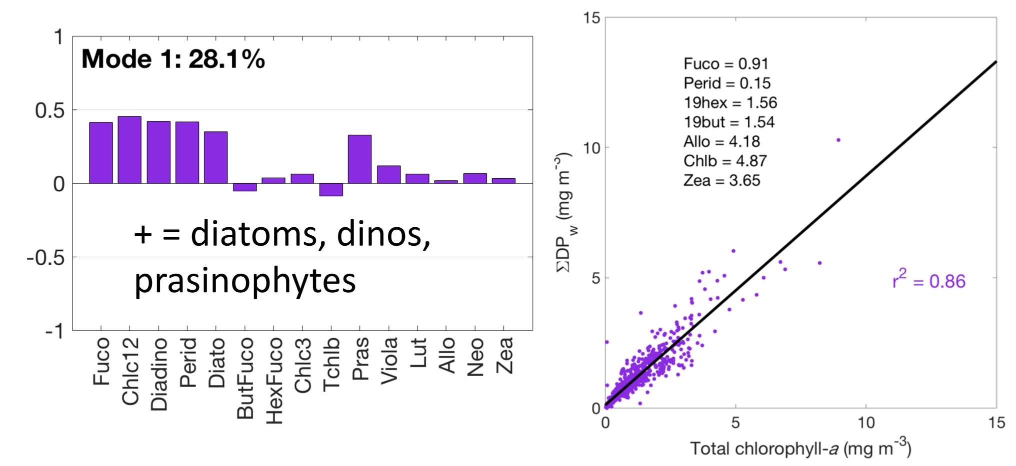
Variance explained by modes 1-6: **77.36%**
Mode 1+temp. r^2 = **-0.21**, Mode 1+sal. r^2 = **0.34**

Indian



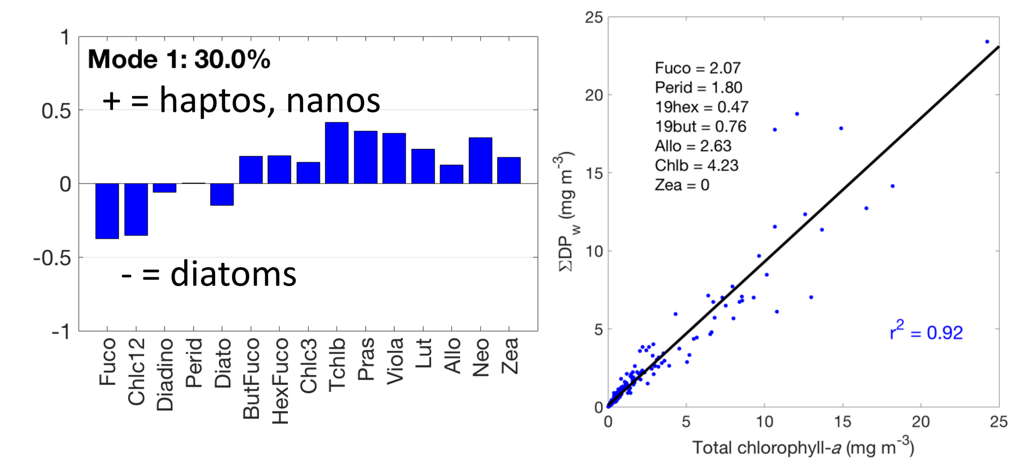
Variance explained by modes 1-6: **81.77%**
Mode 1+temp. r^2 = **-0.17**, Mode 1+sal. r^2 = **-0.61**

Southern



Variance explained by modes 1-6: **79.93%**
Mode 1+temp. r^2 = **0.06**, Mode 1+sal. r^2 = **0.30**

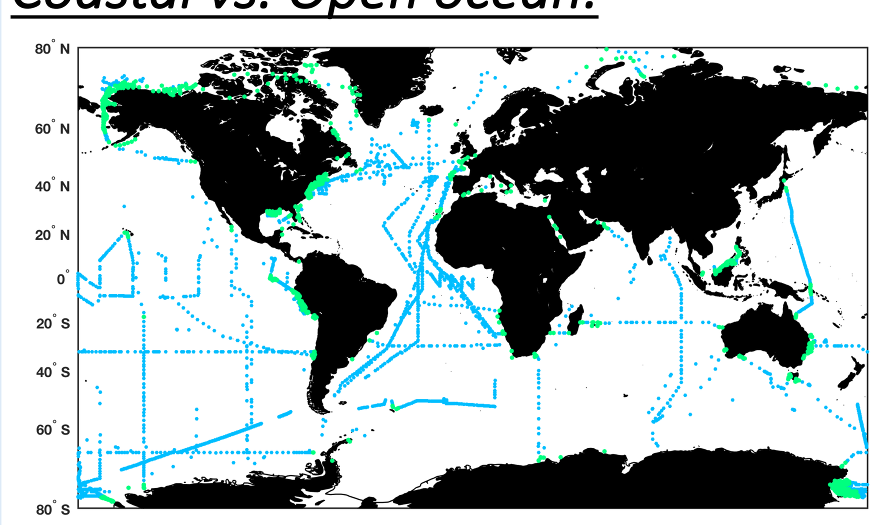
Arctic

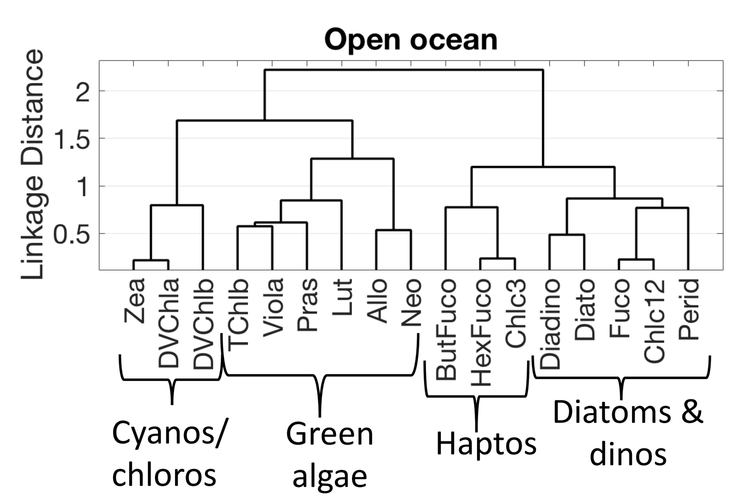


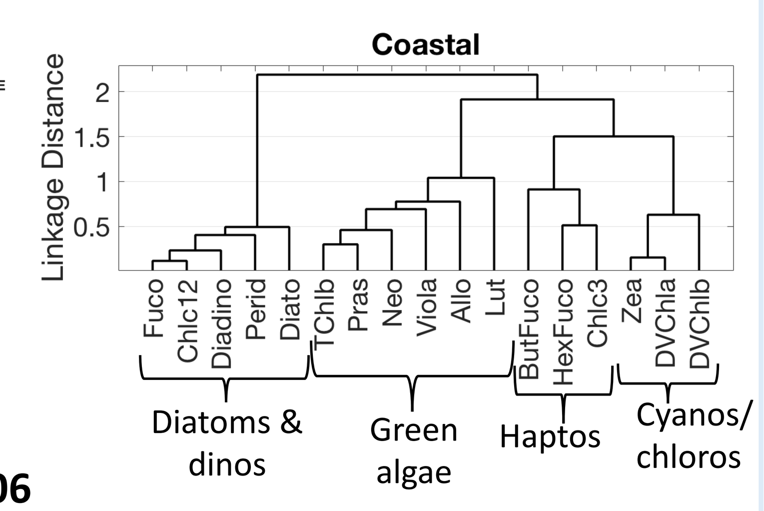
Variance explained by modes 1-6: **82.93%**
Mode 1+temp. r^2 = **0.21**, Mode 1+sal. r^2 = **0.0009**

Mode 1 of EOF analysis generally more highly correlated with salinity than with temperature: water mass seems to dictate pigment assemblage.

Coastal vs. Open ocean:







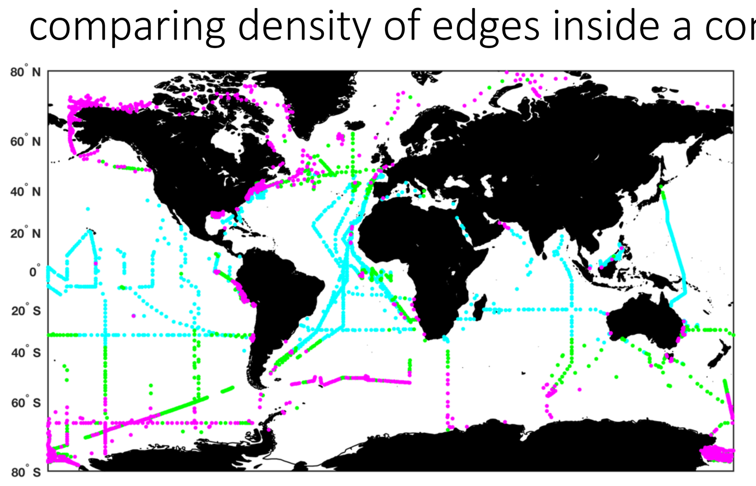
Coastal (within 100 km. of coastline):
Variance explained by modes 1-6 = **75.67%**
Mode 1+temp. r^2 = **-0.24**, Mode 1+sal. r^2 = **0.008**

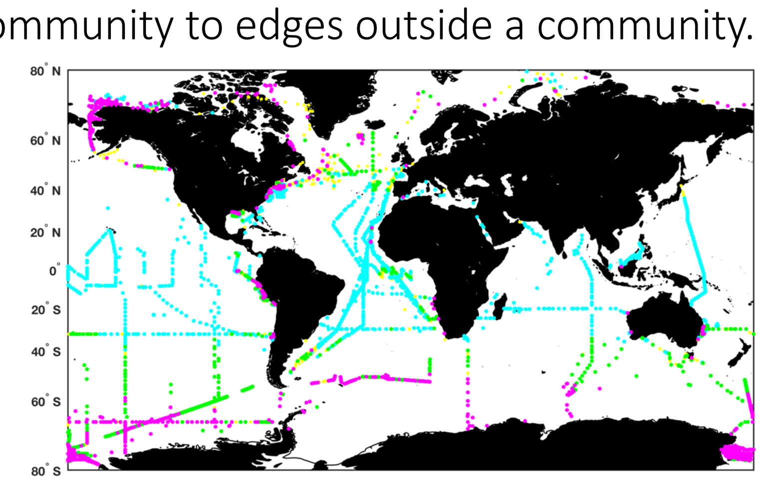
Open ocean:
Variance explained by modes 1-6 = **70.96%**
Mode 1+temp. r^2 = **-0.48**, Mode 1+sal. r^2 = **-0.06**

Blooms in coast dominated by micros; blooms in open ocean dominated by picos.

Preliminary network results:

Generalized Louvain network for community detection: groups nodes by comparing density of edges inside a community to edges outside a community.





Louvain network results: Algorithm balances speed with performance. 3 communities detected based on the modularity of the weighted correlation adjacency matrix, $a_{ij} = |corrcoef(x_i,x_j)|^{\beta}$

Optimized diagnostic pigment analysis: Phytoplankton size classes as a fraction of chl-*a* where pink >50% micro, green >50% nano, cyan >50% pico, and yellow = multiple groups but no dominant group.

Lucas G. S. Jeub, Marya Bazzi, Inderjit S. Jutla and Peter J. Mucha, "A generalized Louvain method for community detection implemented in MATLAB," http://netwiki.amath.unc.edu/GenLouvain (2016).

Conclusion & Future Work

- **Size emerges as a dominant source of variation** in the assemblage of phytoplankton pigments across all analyses (cluster, EOF, DPA, and networks) on both global and basin/coastal scales
- Plan to determine local communities within global dataset of pigments using **random walks**
- Compare **other phytoplankton community metrics** (absorption, genomics, IFCB imagery, etc.)

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