The Role of Autotrophic Biomass in Marine Particulate Organic Carbon

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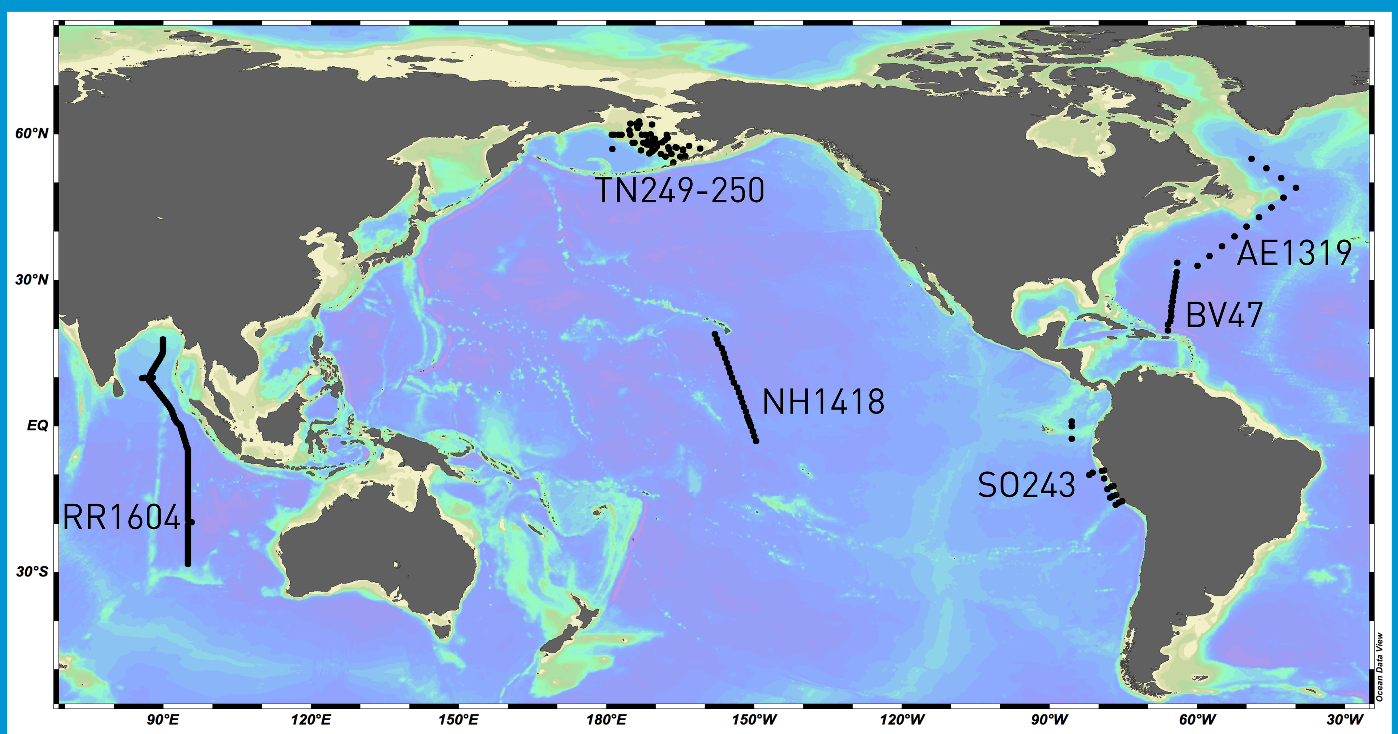
Introduction

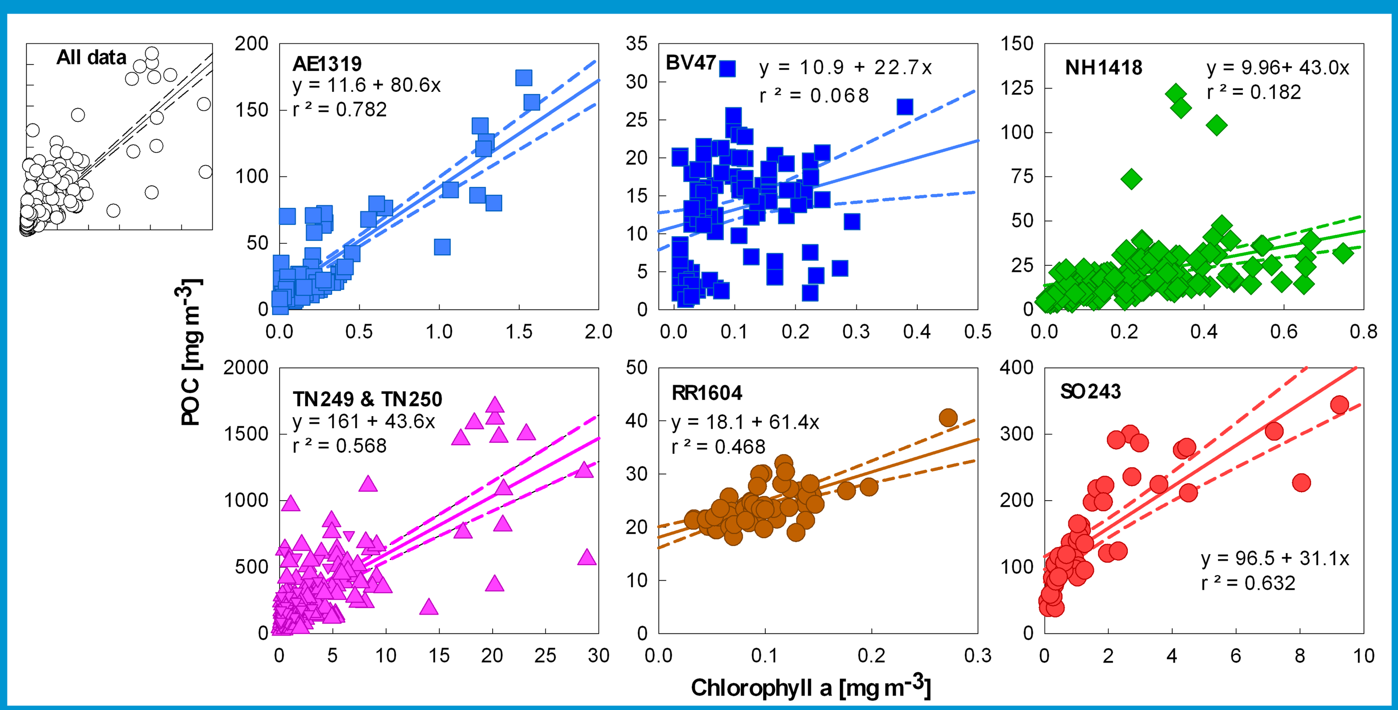
Global oceanic food web models commonly use chlorophyll estimates, standardized conversions to carbon (C), and allometric scaling of biomass to model net primary productivity. Estimates of each component (i.e. chlorophyll *a*, particulate organic carbon (POC), and cell volume) and their ratios are subject to pronounced variability, and thus uncertainty. Marine POC is comprised of heterotrophic bacteria, micro-zooplankton, detritus and phytoplankton, which vary geographically in their relative abundance. The C density of cells and C-to-chlorophyll relationships are confounded by a lack of knowledge of whether chlorophyll concentrations scale with biomass, or are a result of photoacclimation processes. To better constrain the relationships between ecosystem C components, we reanalyzed data from cruise transects to major ocean basins in the North Atlantic, tropicalPacific, and eastern Indian Oceans, along with the high nutrient Bering Sea and Peruvian upwelling zone.



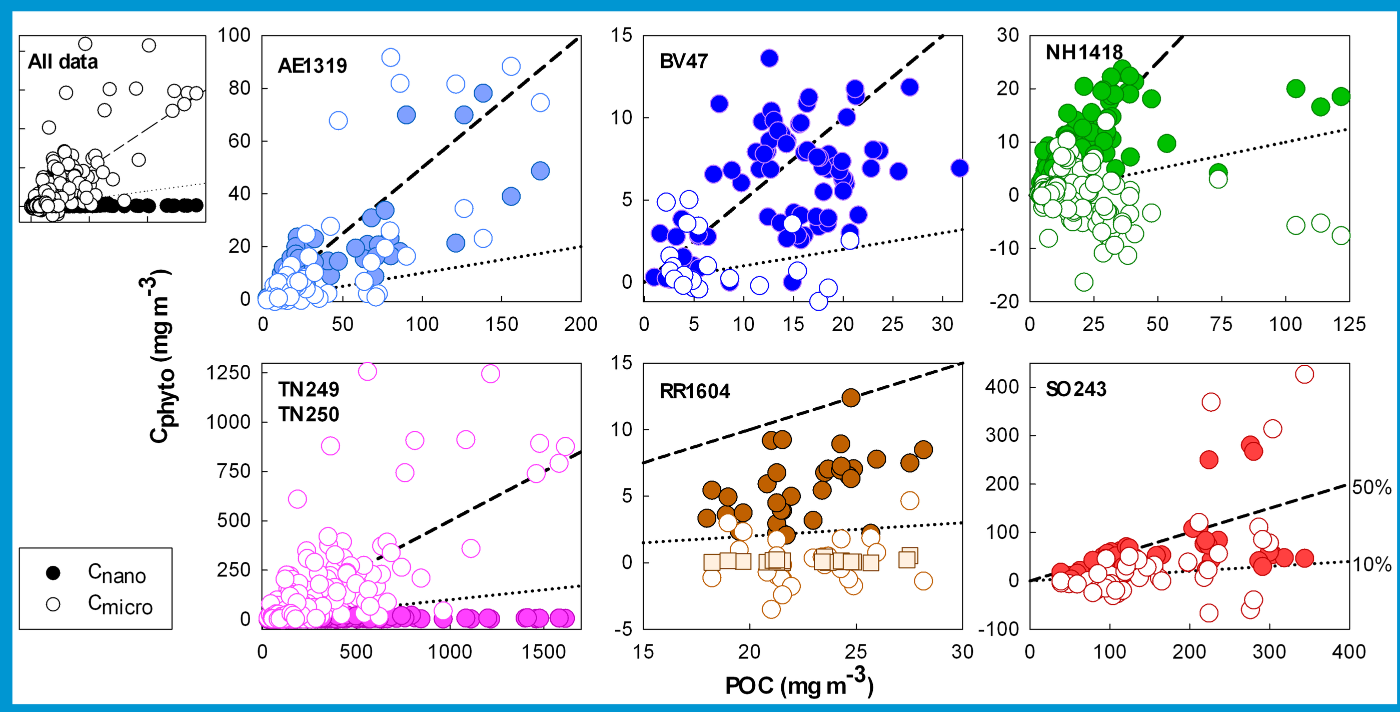
Station Map. AE1319 (Sep 2013), BV47 (Oct 2012), SO243 (Oct 2015), NH1418 (Oct 2014), RR1604 (Apr 2016), TN249 (May 2010) and TN250 (Jun 2010).

Methods

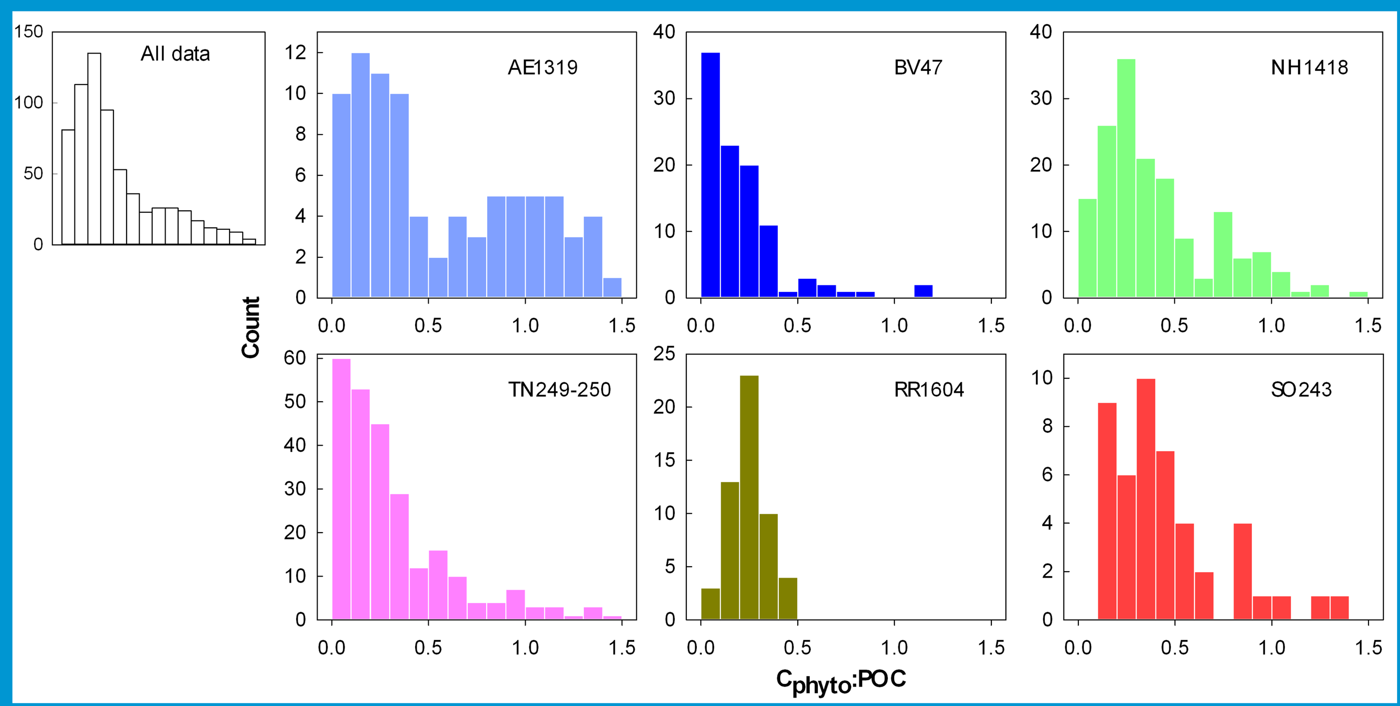
On each cruise, samples for POC, PON, POP, nutrients and chlorophyll *a* were taken in the surface 200 m and analyzed with standard techniques. Flow cytometry cell counts were performed on fixed samples, and C $cell^{-1}$ determined using empirical relationships described by Casey et al. (2013), which was used to calculate the biomass of of nanoplankton (<20um; Cnano).



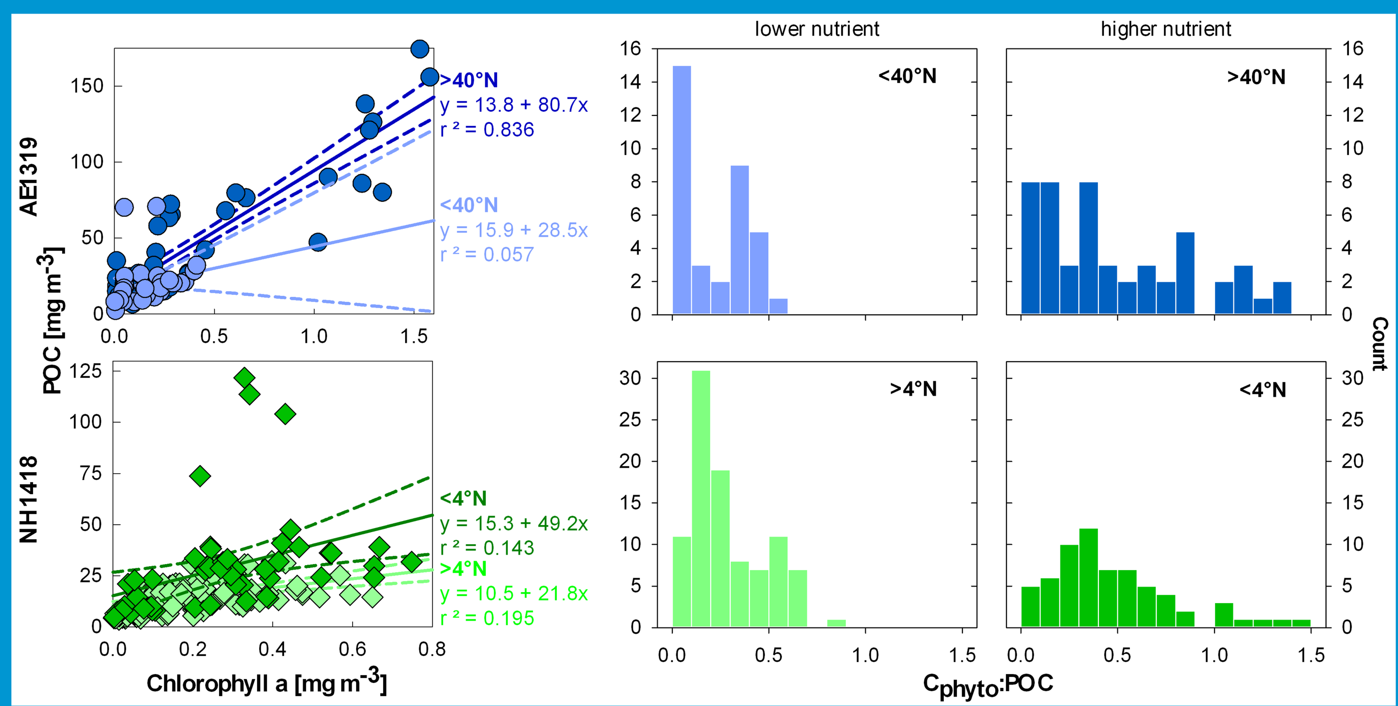
POC to chlorophyll relationships were used to derive total autotrophic biomass (Cphyto), and Cnano was subtracted to estimate large autotroph biomass (Cmicro).



Biomass partitioning between Cnano (filled circles) and Cmicro (open circles) as a function of total POC. 10% and 50% lines provided for reference. Squares in RR1604 plot are semi-empirical Cmicro derived from FlowCAM analysis (C $cell^{-1}$ from Menden-Deuer &Lessard (2000)).



Distributions of autotrophic biomass to total particulate organic carbon. Mean and standard deviation of all data = 0.381 ± 0.375; median = 0.257. Inter- and intra-cruise variability likely due to nutrient availability and diversity, and the interaction between the two.



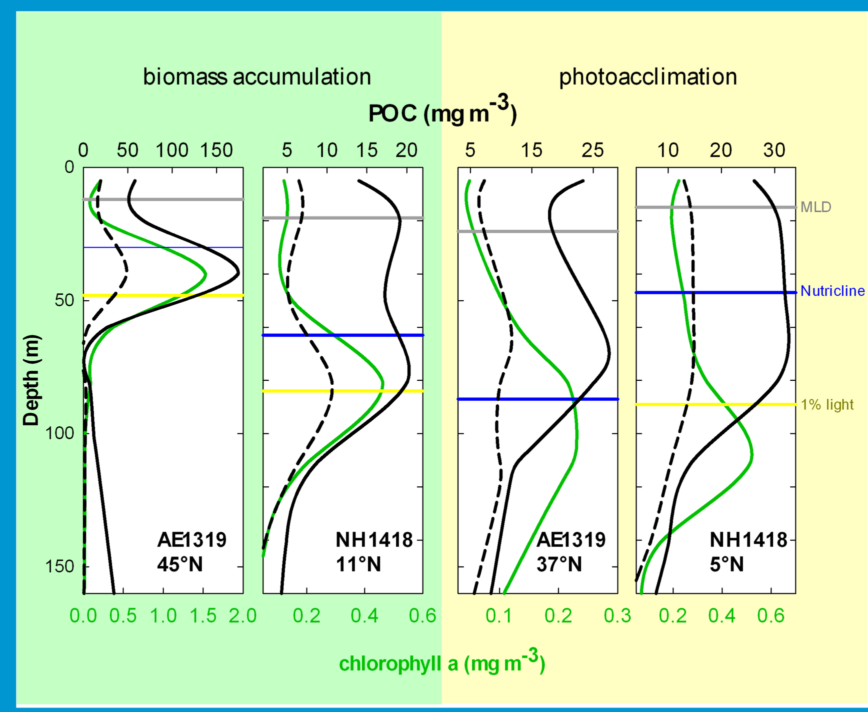
Re-analysis of Cphyto:POC distribution using modified linear regressions of POC to chlorophyll (left panels), distinguished by high and low nutrient regions of the AE1319 and NH1418 transects.

References

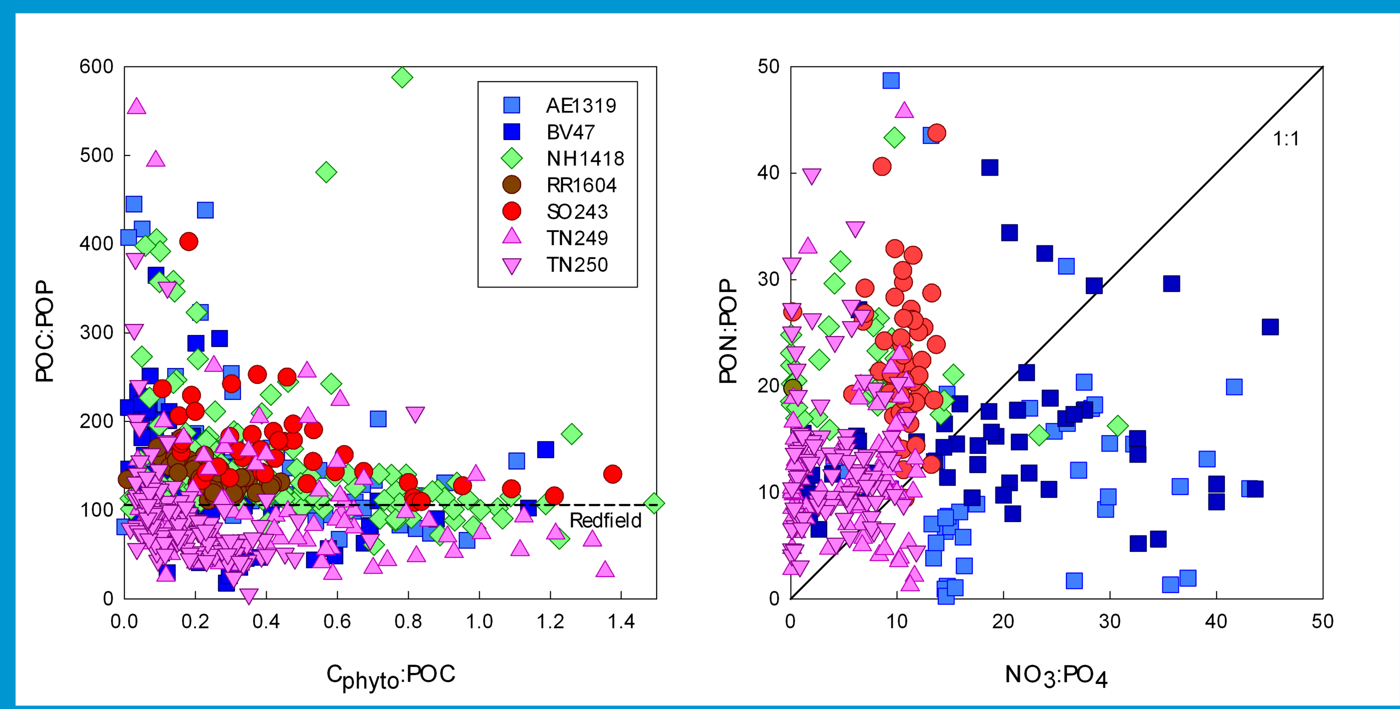
Casey JR, Aucan JP, Goldberg SR, Lomas MW (2013) Changes in partitioning of carbon amongst photosynthetic pico- and nano-plankton groups in the Sargasso Sea in response to changes in the North Atlantic Oscillation. *Deep-Sea Res Pt II* 93: 58-70.

Menden-Deuer S & Lessard EJ (2000) Carbon to volume relationships for dinoflagellates, diatoms, and other protist plankton. *Limnol Oceanogr* 45: 569-579.

Depth profiles of select stations representing different relationships of chlorophyll (green line), POC (solid black line), and Cnano (dashed black line).



Allometric C relationships from Menden-Deuer & Lessard (2000) describe the slope of C-to-volume for diatoms (m=0.81) and other protists (m=0.94), but have less robust representation of nanoplankton, which dominate the vast oligotrophic oceans and have fundamentally different C-to-volume relationships (m=0.43; Lomas & Baer, unpub.). Future work using the current data set will analyze how diversity of phytoplankton groups (e.g. cyanobacteria, eukaryotes) impact biogeochemical signatures and cycling.



Stoichiometric relationships show that low Cphyto:POC (low-nutrient, cyanobacteria dominate) correlates with high POC:POP. Dissolved and particulate N:P have no consistent pattern, maybe due to lack of detectable nutrients in ocean surface.

Conclusions

- Autotrophic biomass (Cphyto) makes up a significant portion of total POC. It is variable but constrained.
- High- and low-nutrient regimes have definitive biomass signatures.
- Carbon-to-chlorophyll relationships are problematic. There is a need to improve capture of large (>20 μm) phytoplankton biomass (e.g. FlowCAM).
- Diversity likely correlates to bulk particle stoichiometry.

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