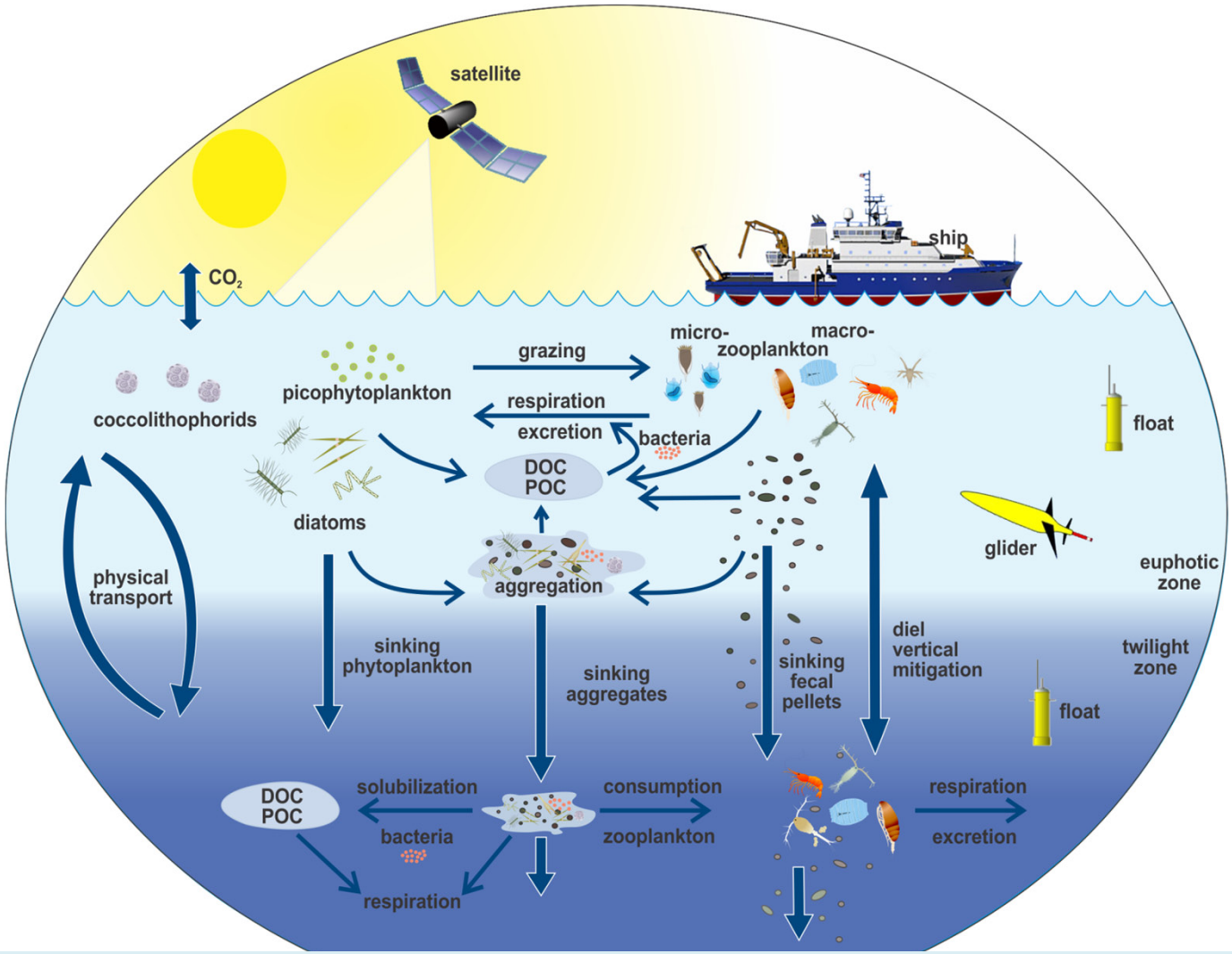
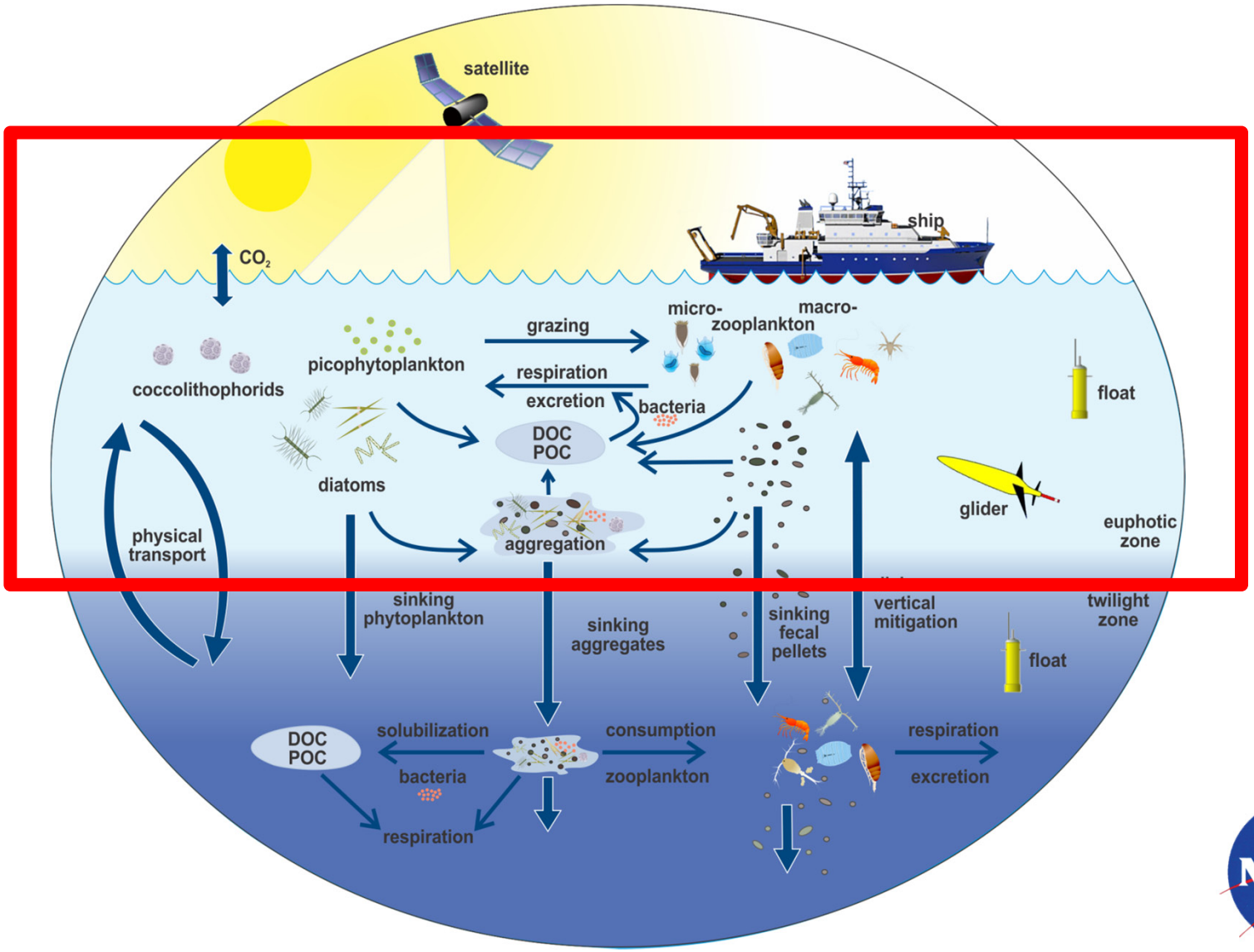
EXport Processes in the Ocean from RemoTe Sensing (EXPORTS): Science Question 1

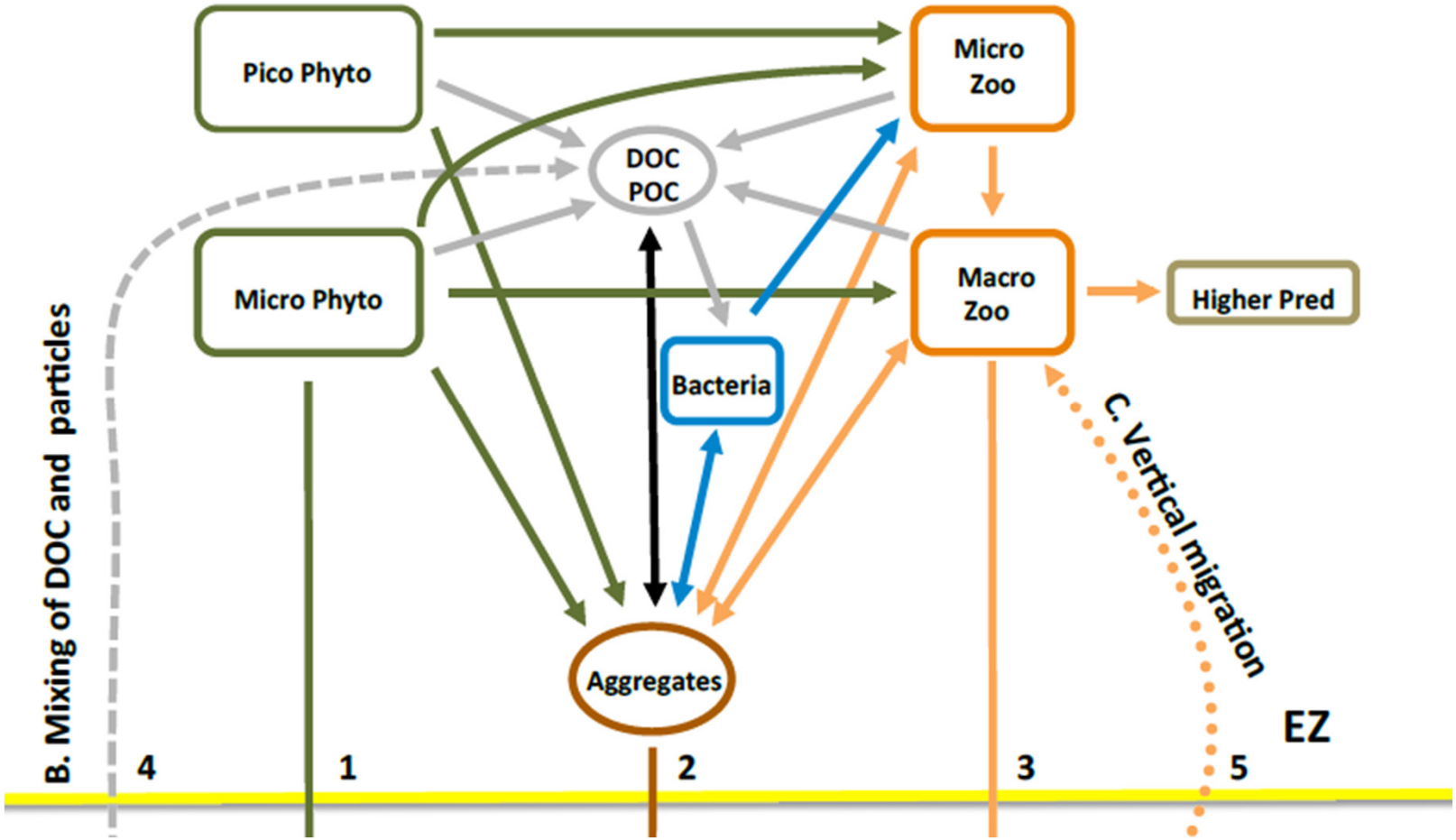


Mary Jane Perry – University of Maine – 25 July 2016

SQ1 - How do upper ocean ecosystem characteristics determine vertical transfer of organic matter from the surface ocean?



- How does plankton community structure regulate export from the surface ocean?
- How do the 5 pathways that drive export vary with plankton community structure?
- What controls aggregation / disaggregation of exported organic particles and how are these controls influenced by plankton community composition?
- How do physical and ecological processes act to export organic matter?



Sinking of 1) intact cells, 2) aggregates, 3) zooP by-products

4) vertical sub-mesoscale advection of DOC & POC

5) transport of organics via migrating zooplankton

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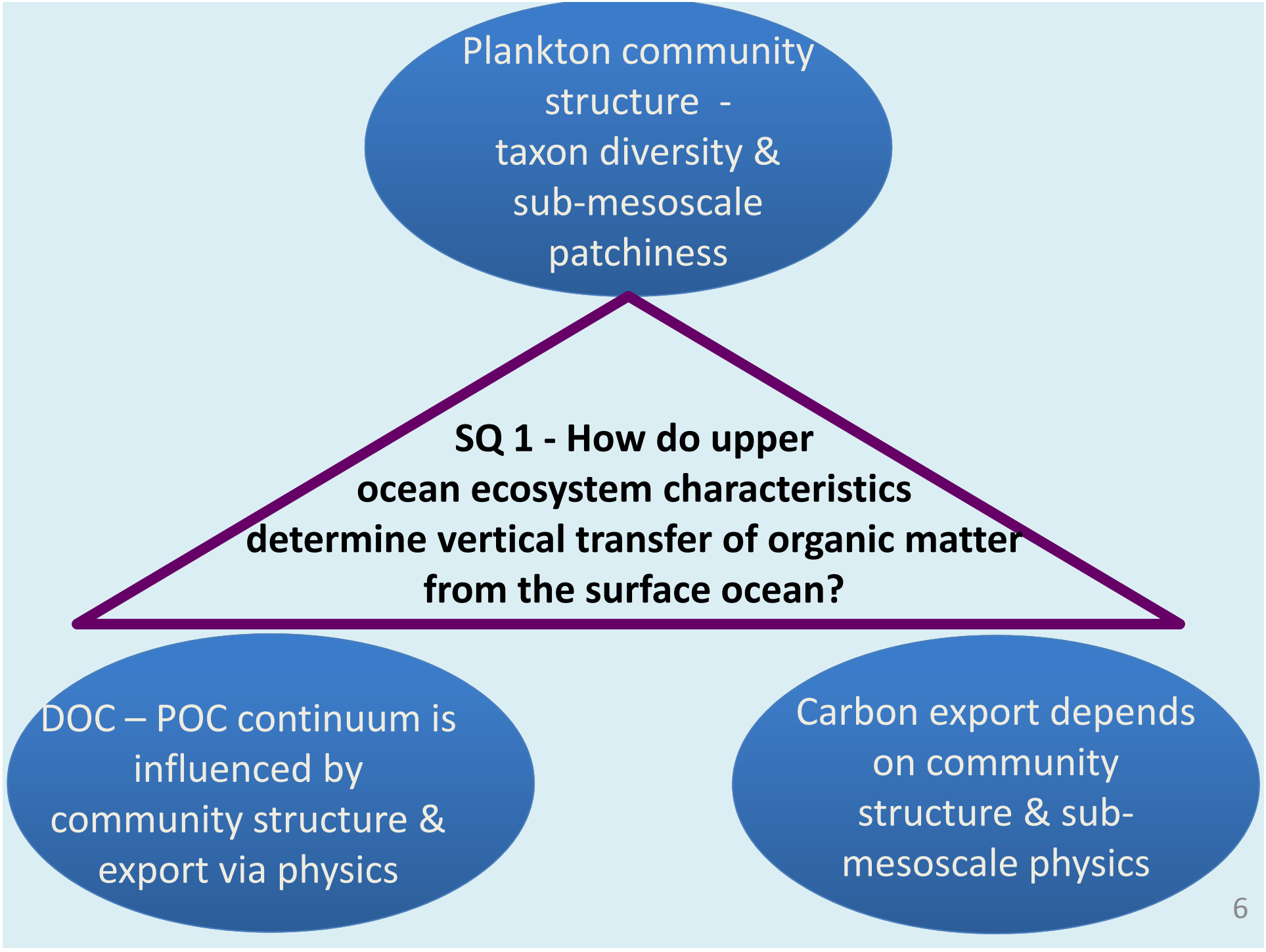
Plankton community structure - taxon diversity & sub-mesoscale patchiness
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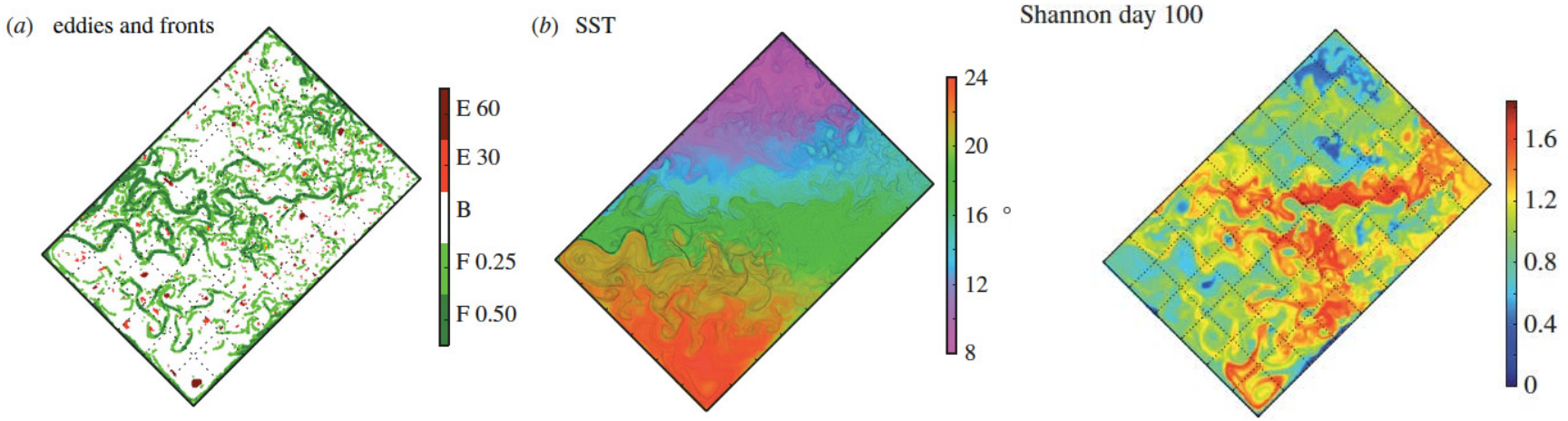
Carbon export depends on community structure & sub-mesoscale physics

Phytoplankton community structure – what creates and maintains taxonomic diversity?

Fronts & Eddies SST Shannon diversity

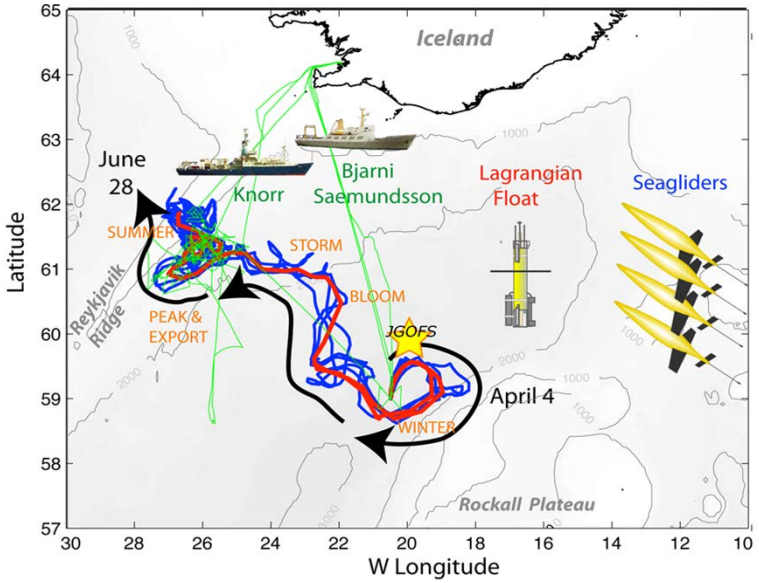


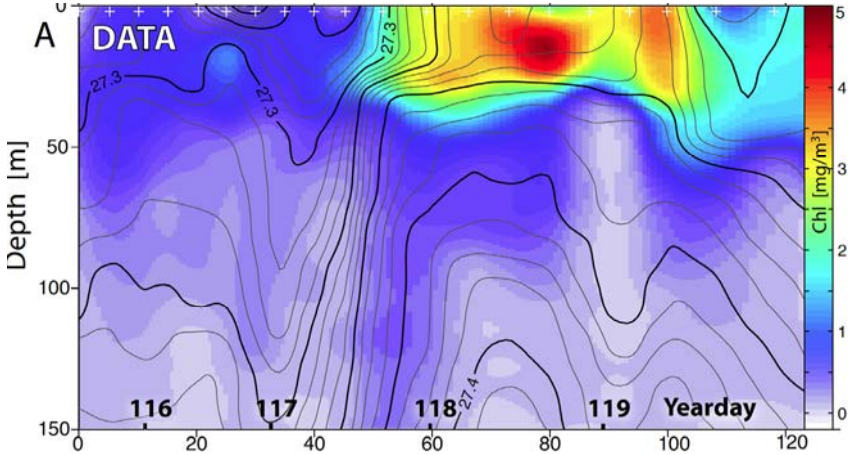
Levy et al. 2015. J. R. Soc. Interface 12

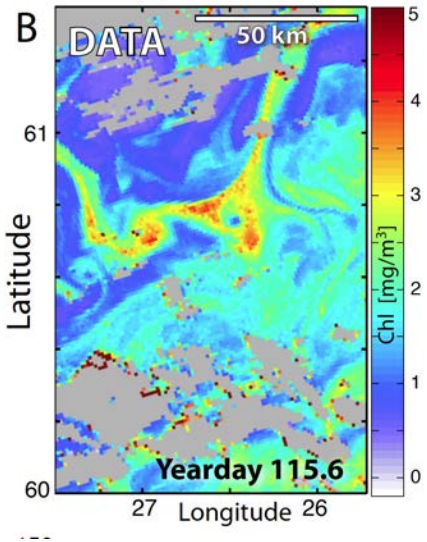
Small-scale diversity set by:

1) large-scale environmental conditions set broad phytoplankton biogeography
2) horizontal stirring dynamically distorts large-scale niches
3) biological and ecological responses on timescales of fronts & eddies

Recent papers with various approaches to assessing submesoscale phytoplankton diversity from NAB2008

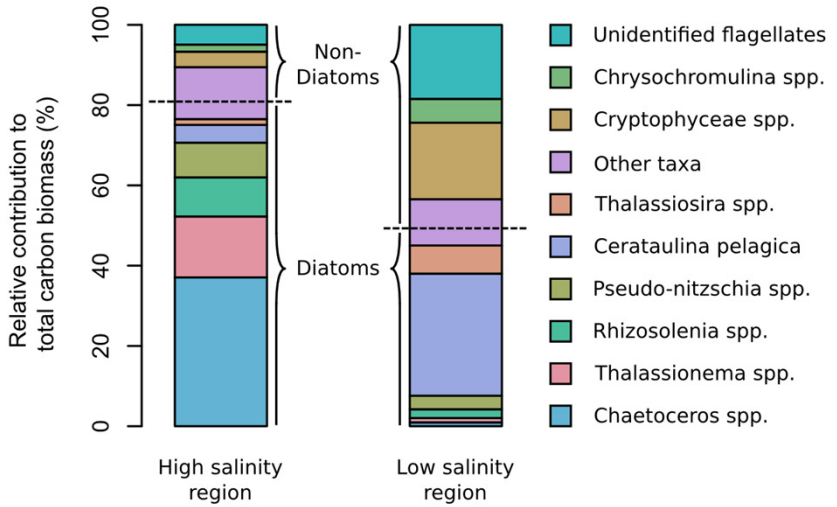


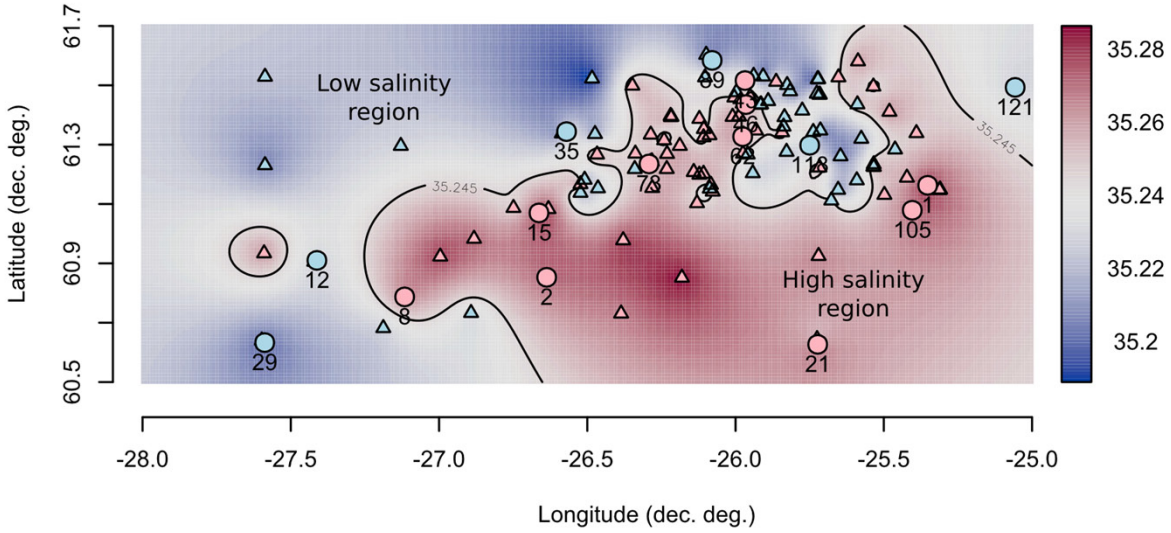


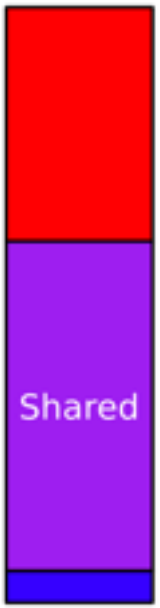


Mahadevan el al. 2012. Science 337:54

Phytoplankton community structure in NAB 2008 – submesoscale frontal structure controls α and β diversity







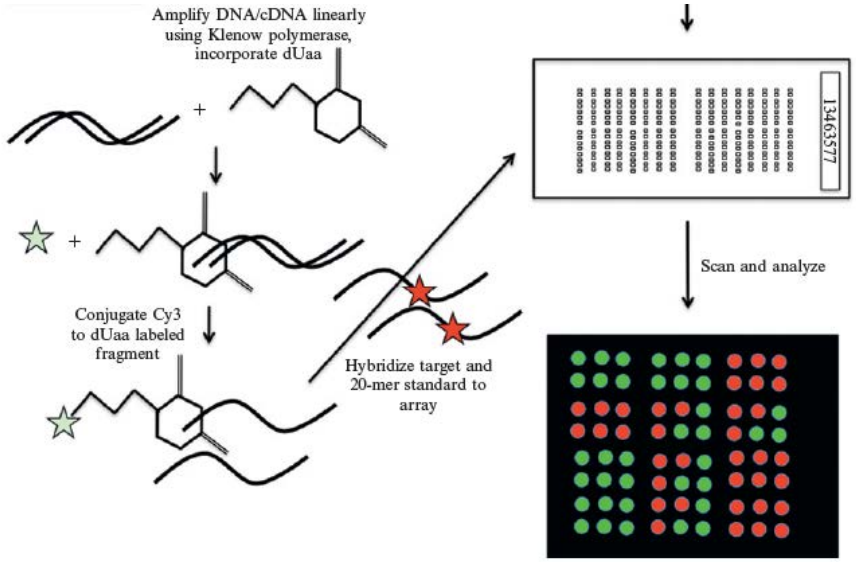
22 taxa in high salinity only

31 taxa in both water masses

3 taxa in low salinity only

Mousing et al., in press, J. Ecology

A different view of phytoplankton submesoscale diversity assessed by functional gene microarrays

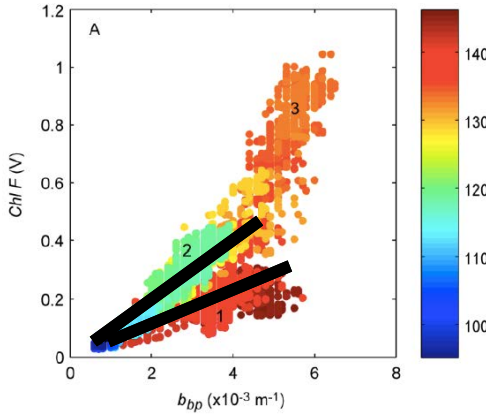


Ward and van Oostende. 2016. J. Plankton Res. doi: 10.1093/plankt/fbw043

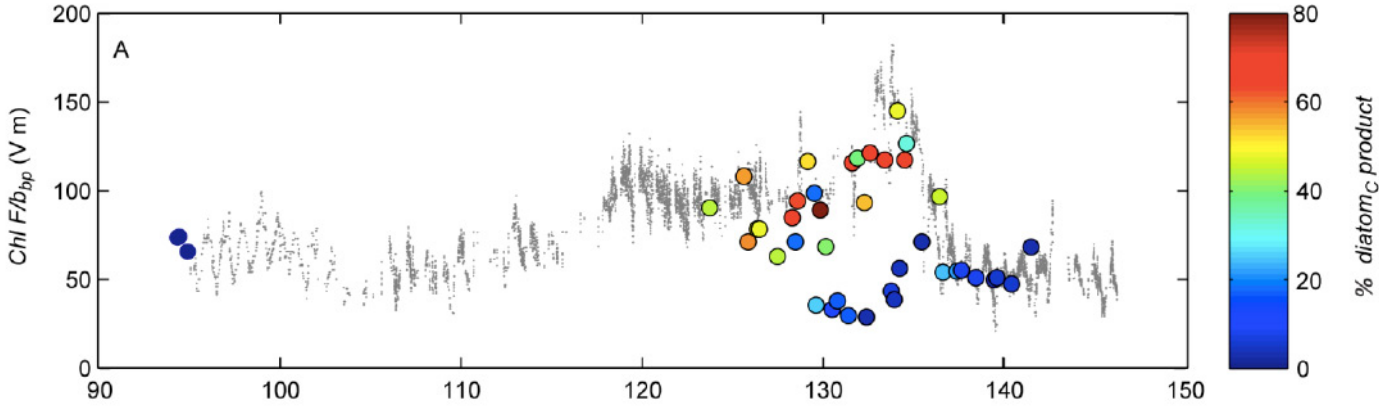
A few archetypes dominated, showing T/S patterns distinct from the other archetypes, suggesting that a few species dominate against a background of high diversity.

Remaining challenge to relate function to known species.

Meeting the challenge to scale–up point measures of phytoplankton diversity to larger scales

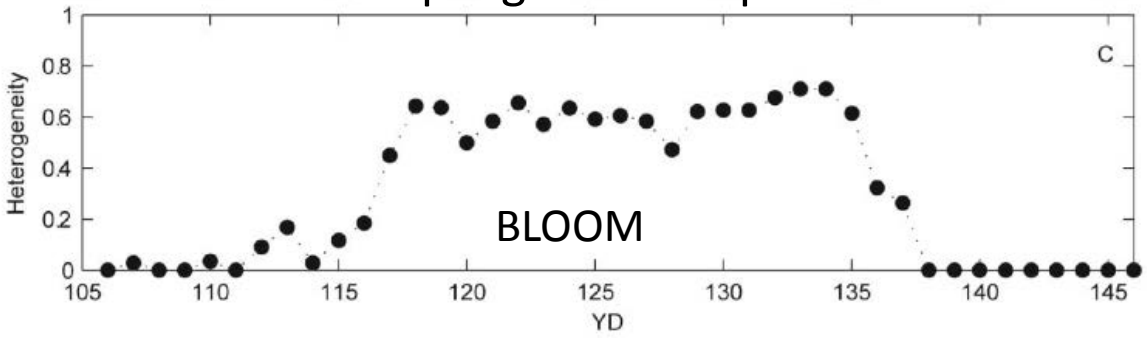


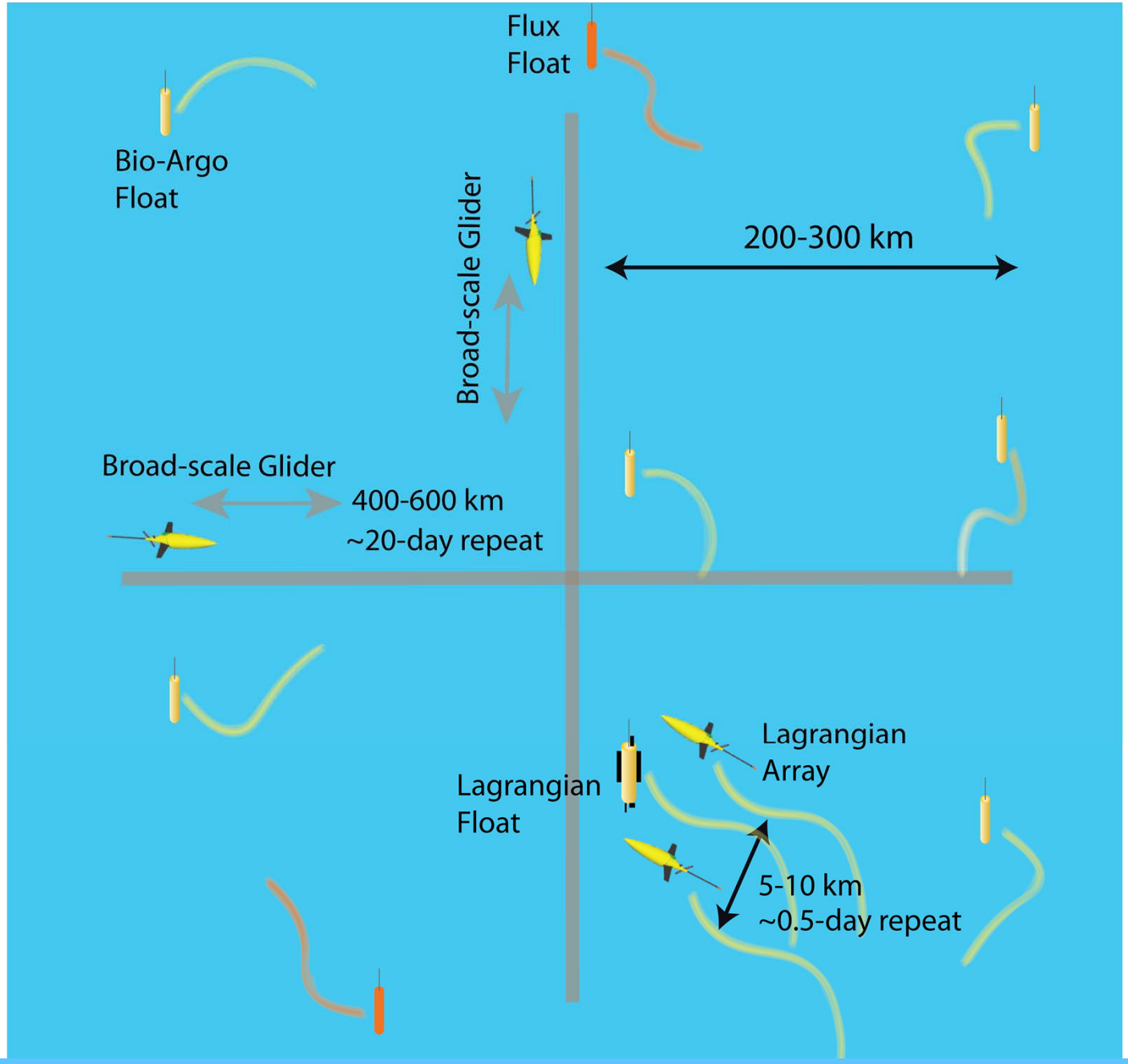
Lagrangian float in patch & ship in/out of patch



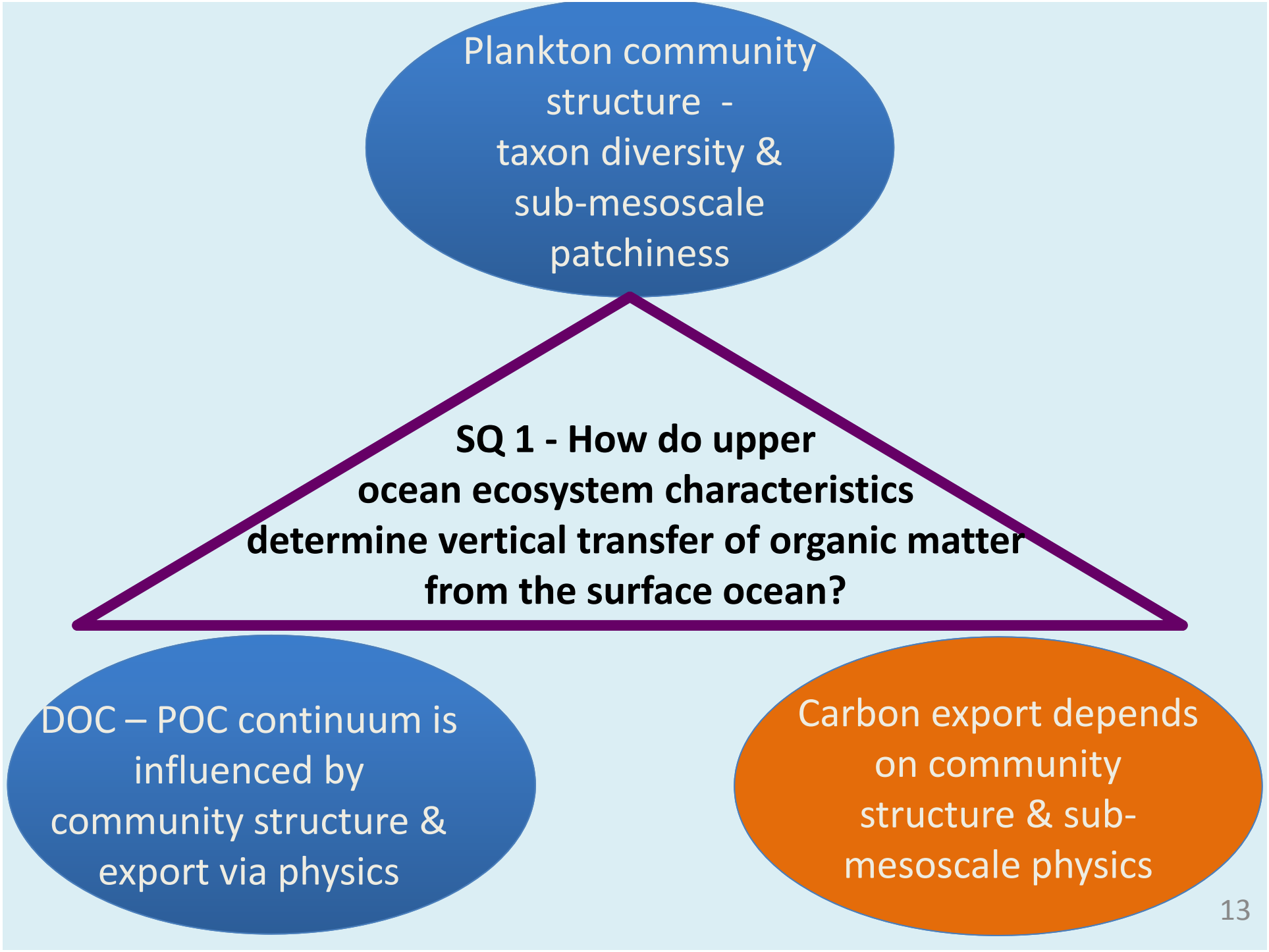
Cetinic et al. 2015. Biogeosciences 12: 2179

Heterogeneity index applied to four gliders sampling different patches





Proposed observing system to meet scaling challenge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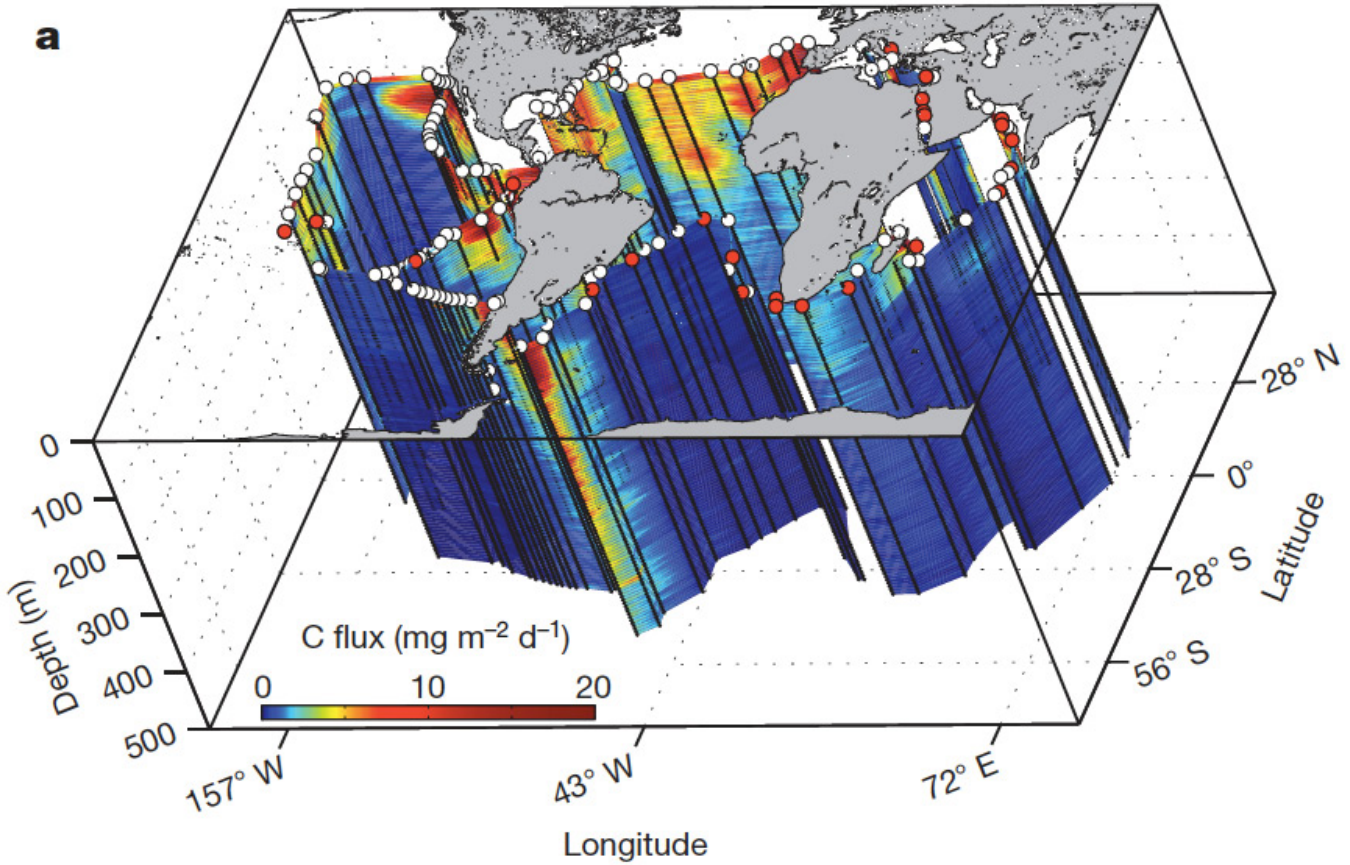
Export control by upper ocean plankton community

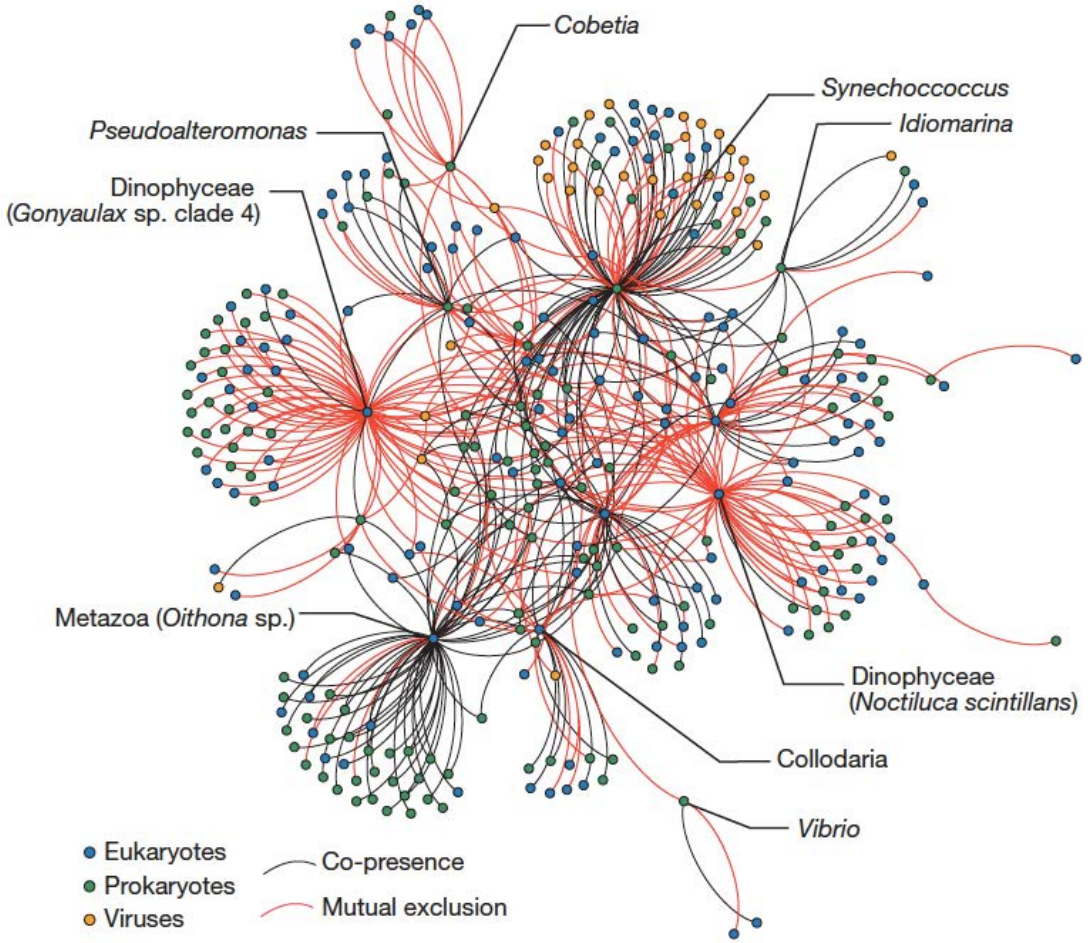
TARA Expedition in subtropical oligotrophic ocean shows carbon export at 150 m estimated from particle size distribution & abundance from underwater vision profiler (UVP).



Guidi et al. 2016
Nature 532: 465

Export control by upper ocean plankton community

Integrated plankton community subnetworks were built from genetic profiling of eukaryote, prokaryotes and viruses.

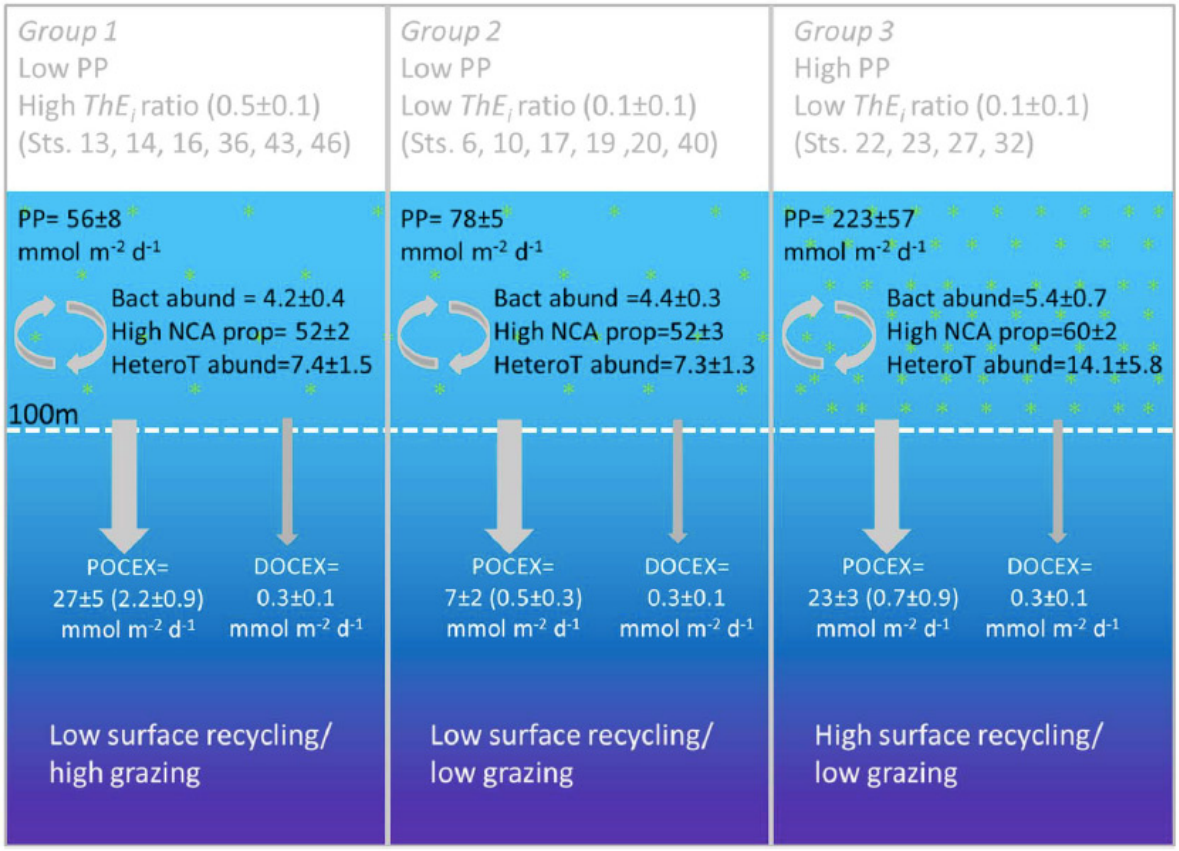


Shows importance of community, not just particle size. Opens new questions for role of viruses and small particles in carbon export.

Guidi et al. 2016
Nature 532: 465

Export control by upper ocean plankton community

Understanding the pathways are critical to resolving inverse relationship between NPP and export flux in Southern Ocean.

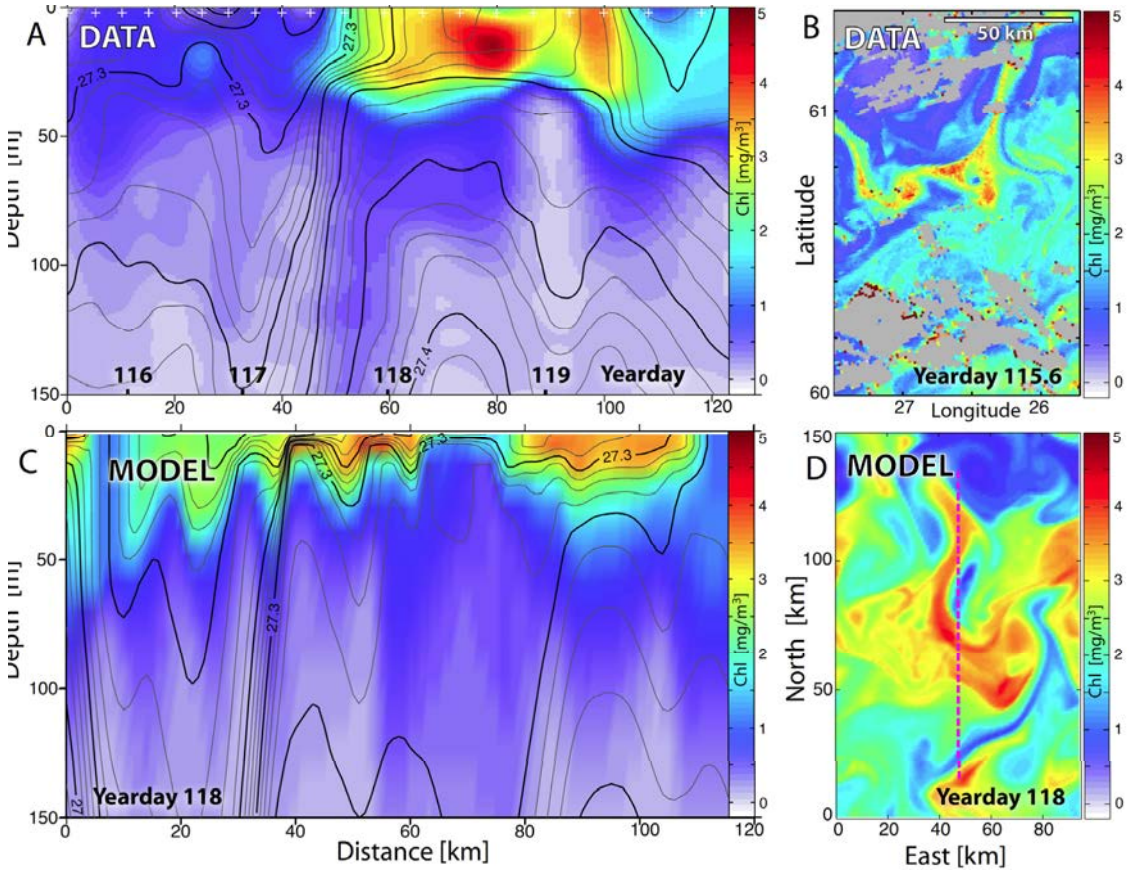


Conclusions:
Zooplankton export of fecal pellets and surface microbial recycling regulate export.
But how does quality of DOC control recycling?

Le Moigne et al. 2016. GRL 10.1002/2016GL068480

Export control by upper ocean plankton community and submesoscale physics

In subpolar N.A., patchy bloom due to patchy stratification at initiation.



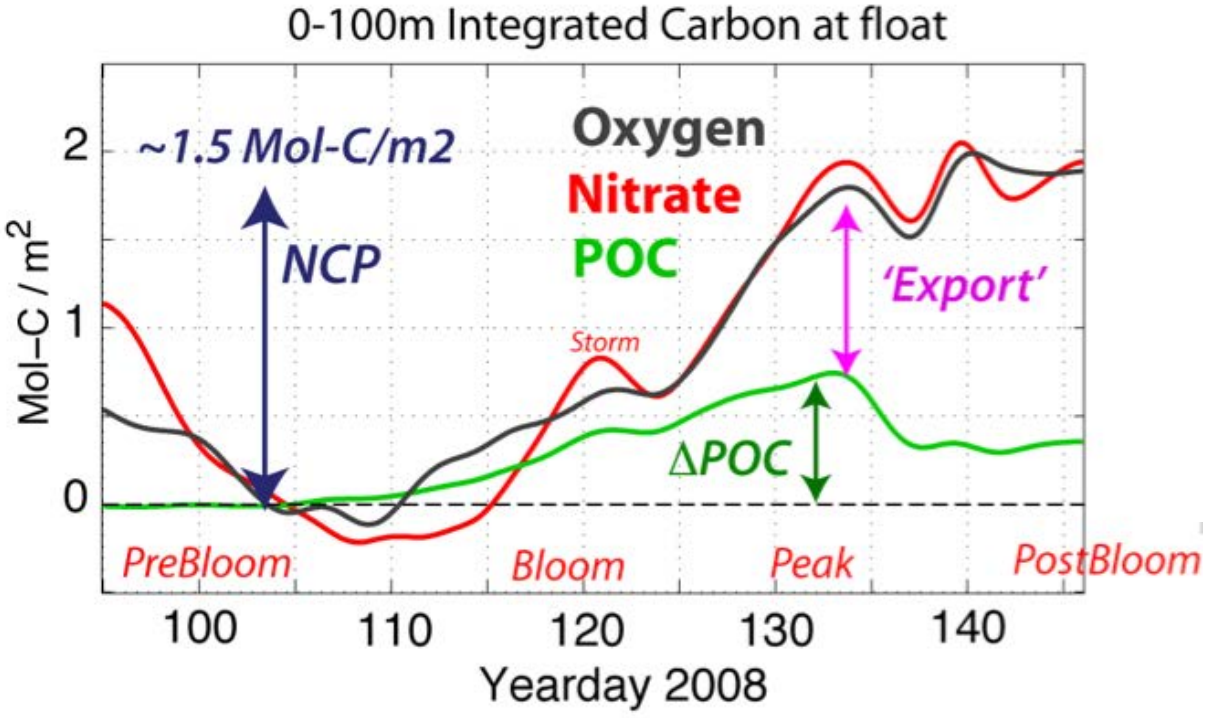
Mahadevan el al. 2012. Science 337:54

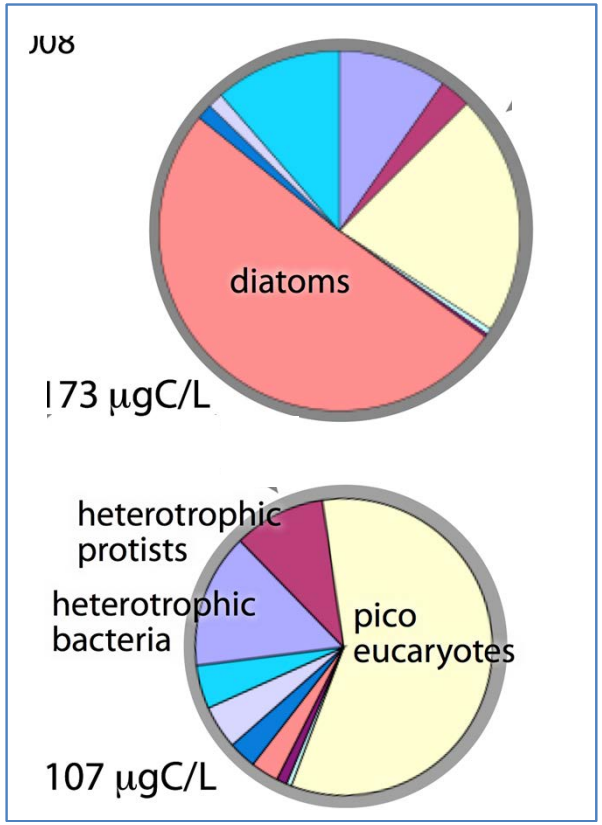
Patchy bloom is also patchy in export ➔ scaling challenge

Lagrangian float followed evolution of a patch, diagnosing export:

– diatom bloom exported ~ 12% standing stock of POC/day

– recycling community exported ~ 2% standing stock of POC/day.



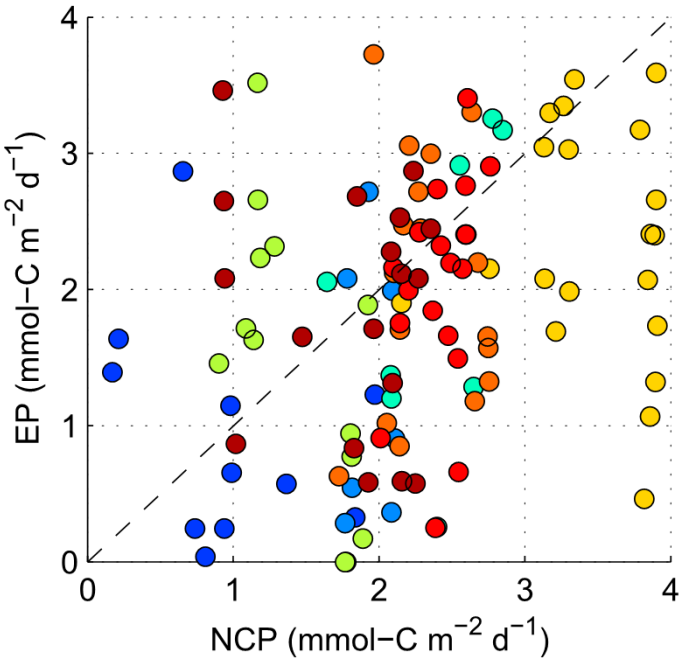


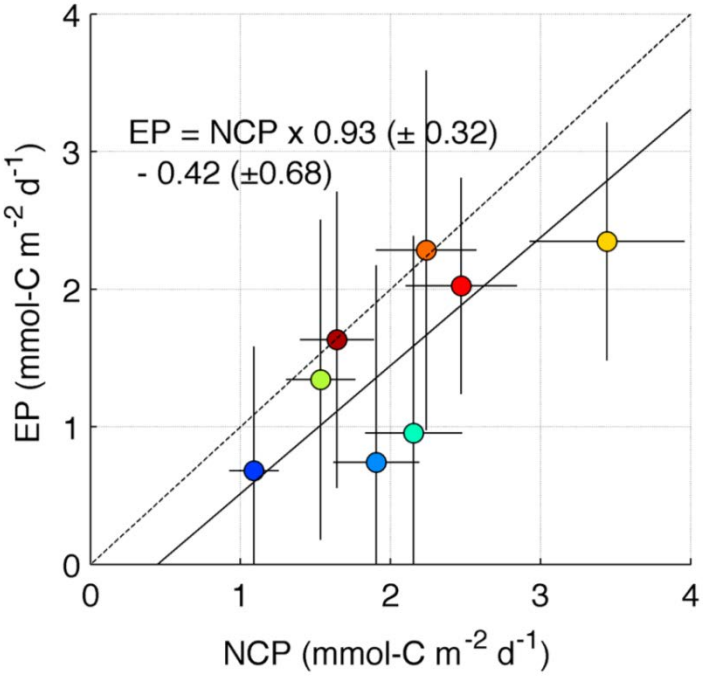
D'Asaro et al. unpub.,

Alkire et al., 2012, Cetinic et al. 2015

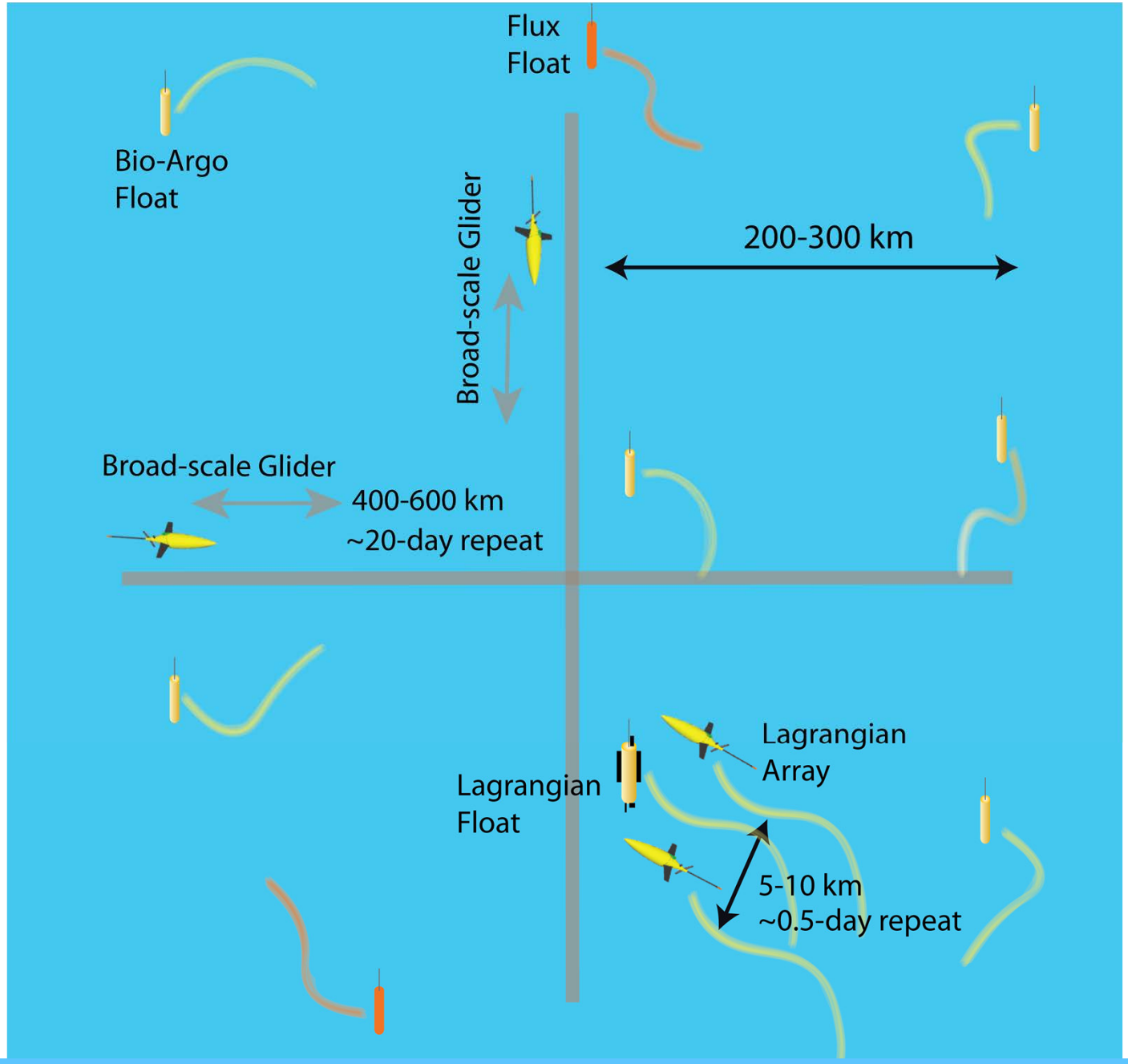
Sampling is key to resolving imbalances in relationship between NCP and Export Production

Individual measurements vs. values averaged over 30-40 km transects





Estapa et al. 2015. BGC 10.1002/2014GB004913



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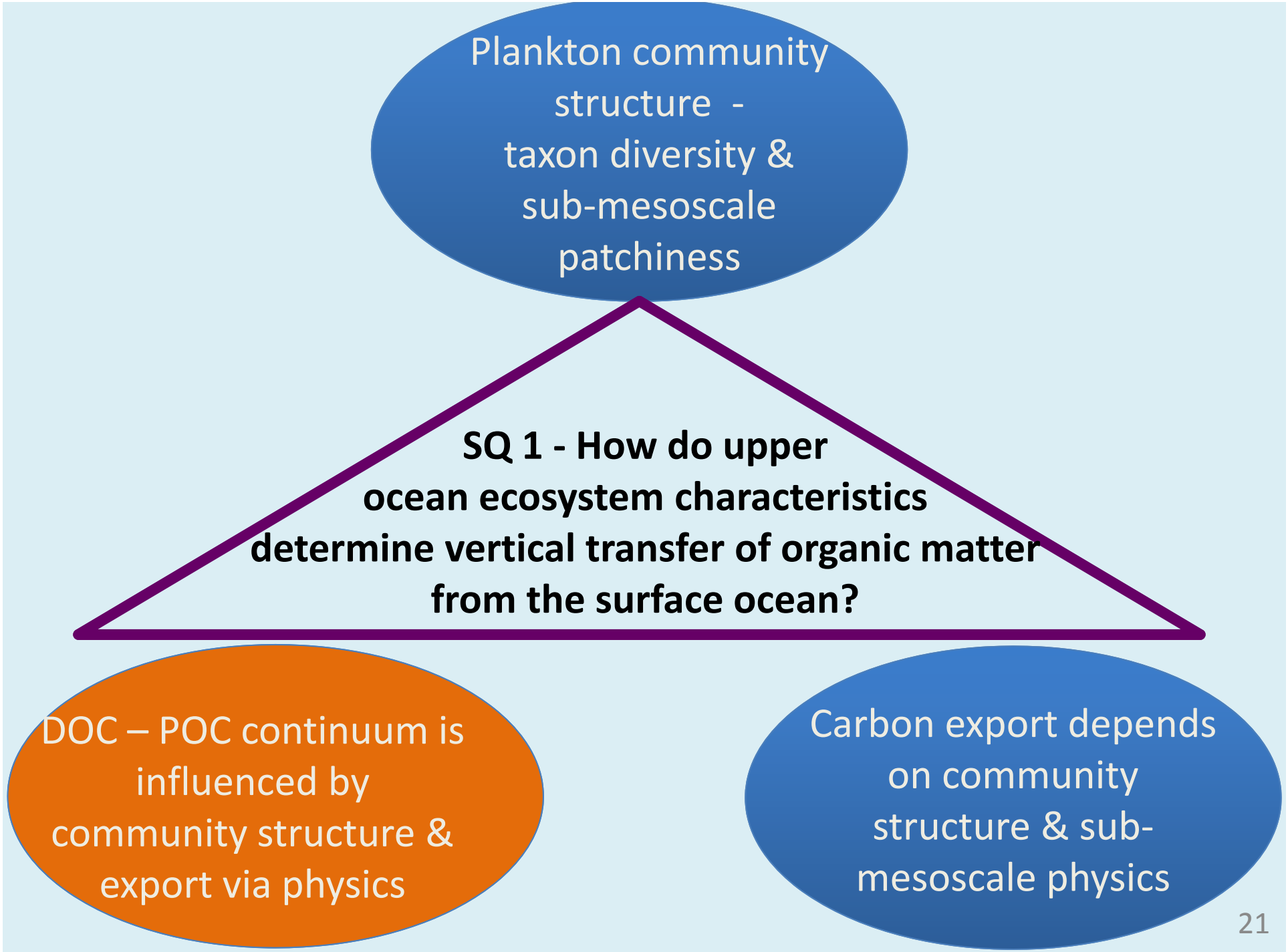
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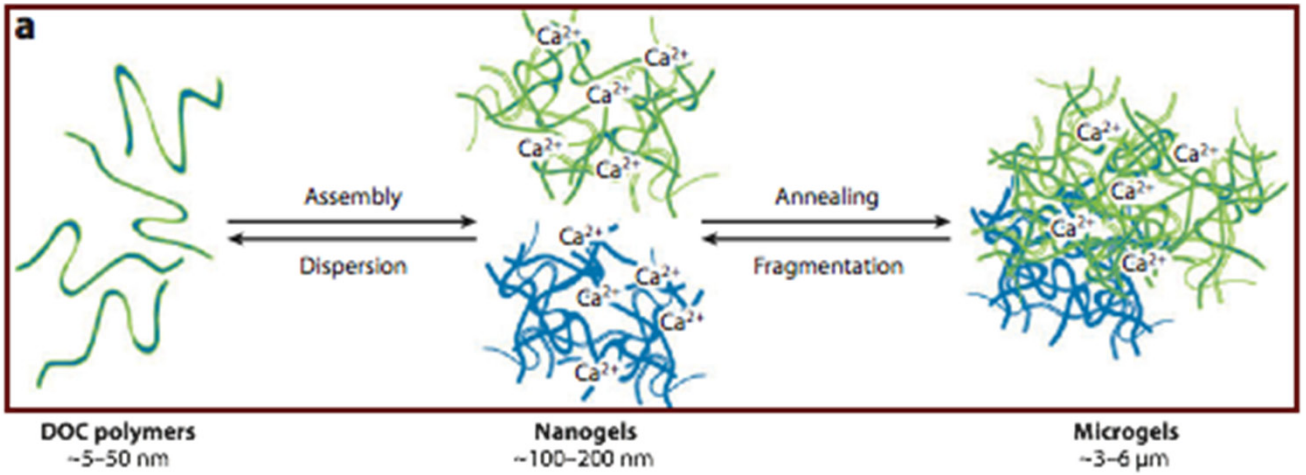
DOC – POC continuum is influenced by community structure

Talk on the continuum by Monica Orellana this afternoon.

DOC gel size is a function of species, composition of DOC, time for gel assembly, grazing and other disassembly mechanisms.

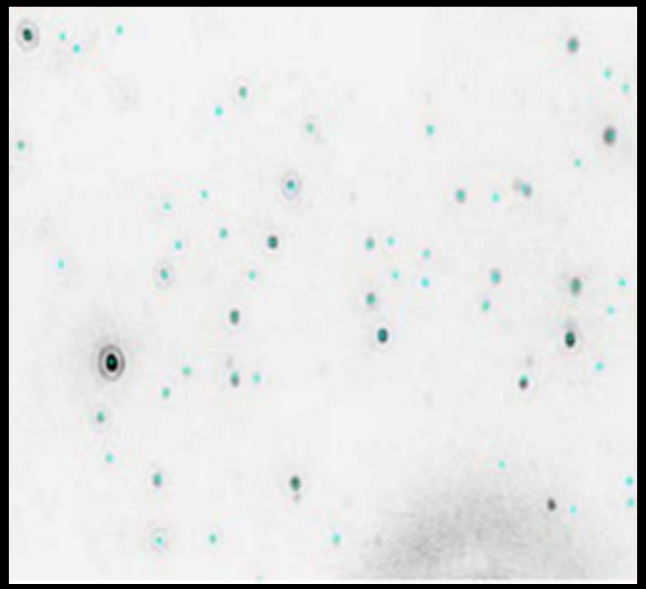


Verdugo, 2012. Ann. Rev. Mar. Sci, 4:375

DOC – POC continuum is influenced by phytoplankton community structure — and metabolic state.

Southern Ocean diatom community produces larger gels

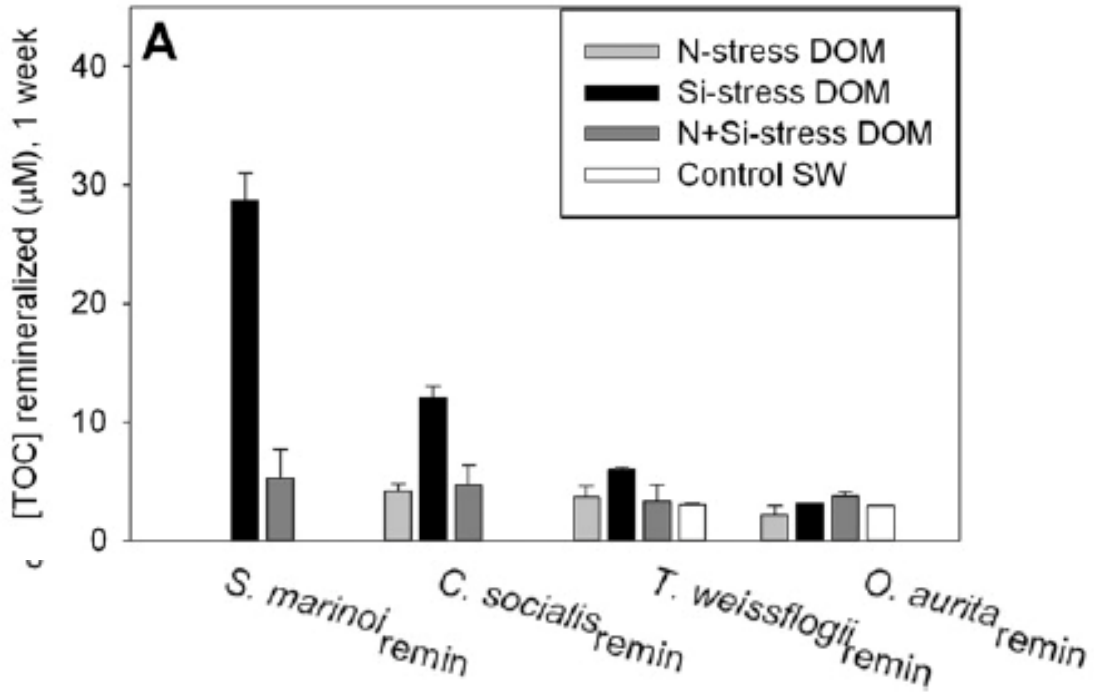
Prokaryote community produces smaller gels



Orellana, unpub.

Time scale of TOC availability is influenced by phytoplankton community structure and metabolic state.

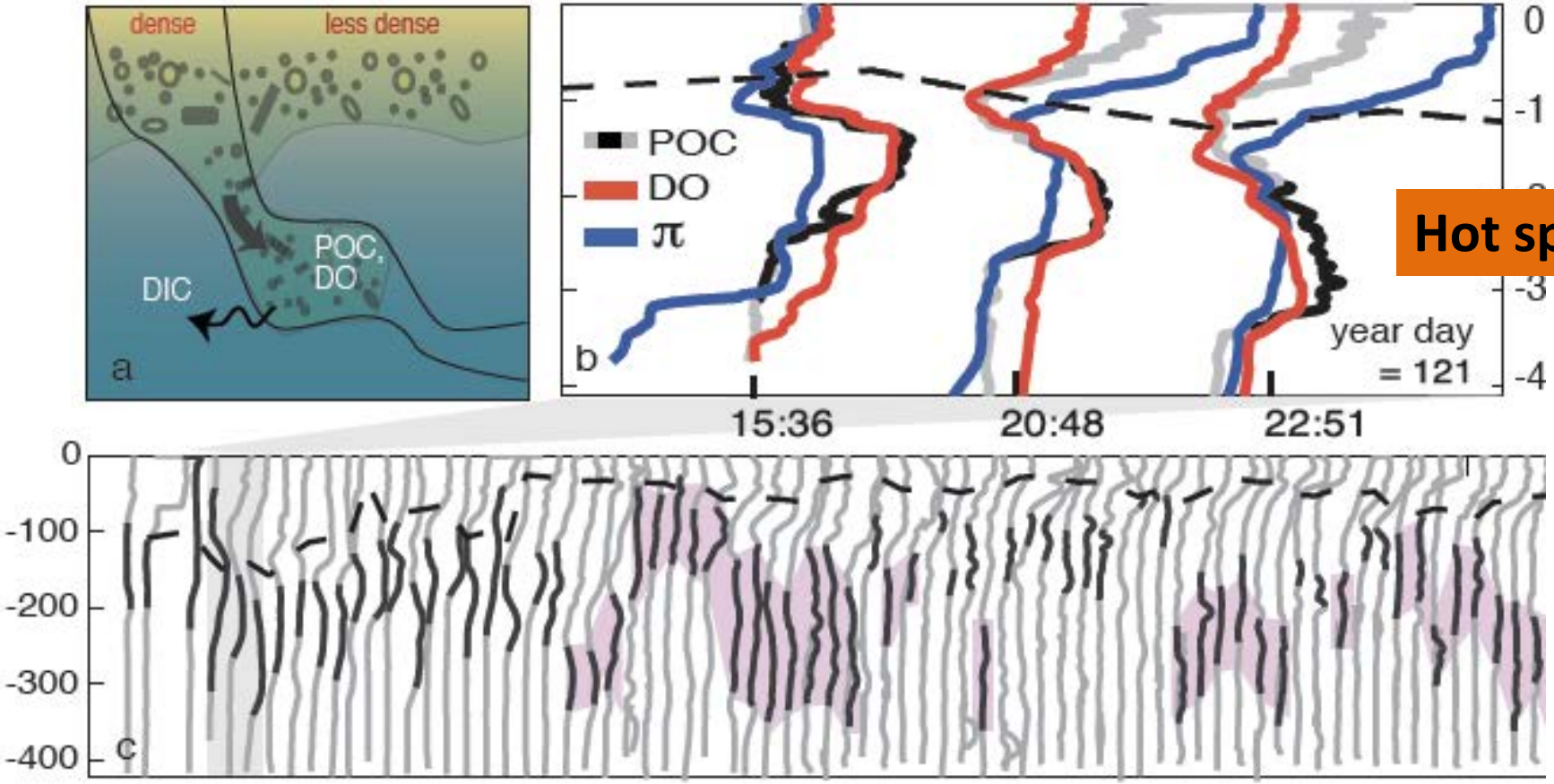
Si limitation of diatoms enhances short-term TOC recycling while diatom species composition influences long-term TOC persistence and potential for physical export.



Wear et al. 2015. Mar. Chem. 177:335

Lab study with four diatom species

What are the consequences of submesoscale subduction of DOC and POC on short time and small space scales?



Hot spots?

Omand et al. 2015. Science 348: 222

EXPORTS: Science question 2 – Adrian Martin