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Nutrient supply does play a role on the structure of marine picophytoplankton communities

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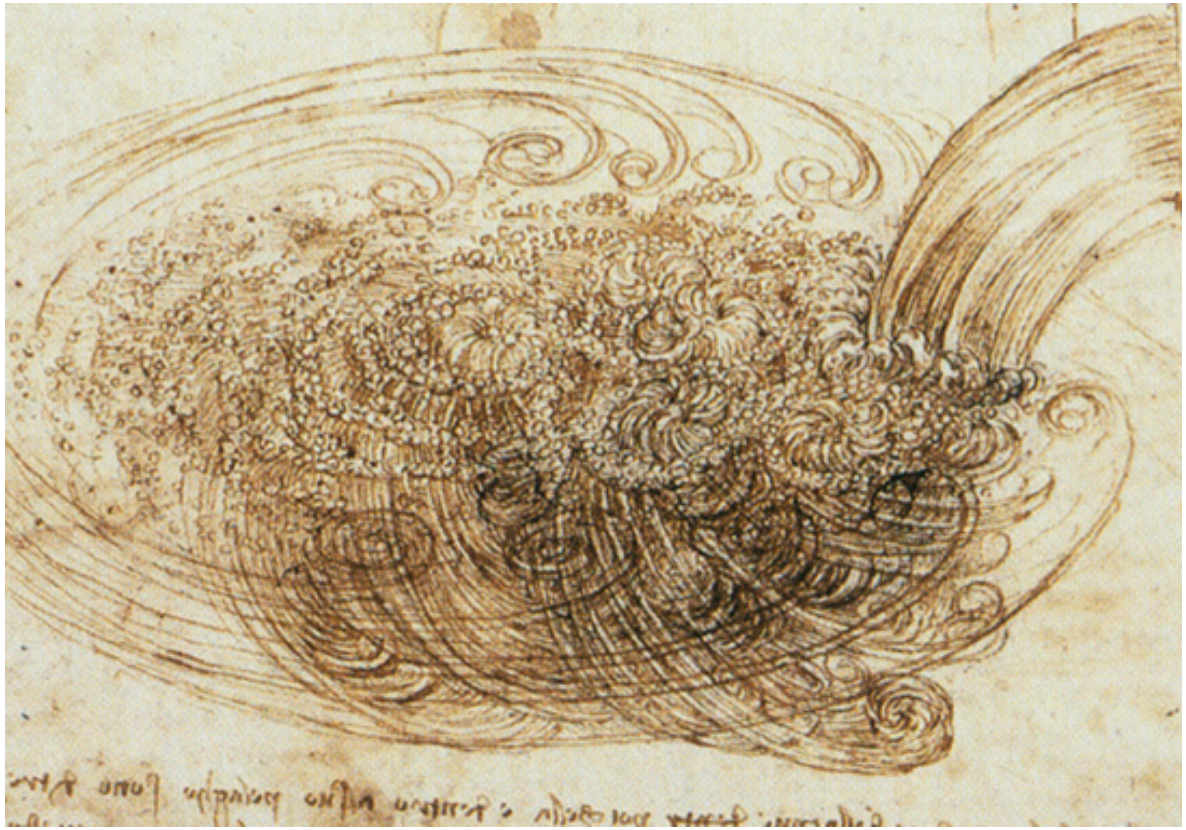
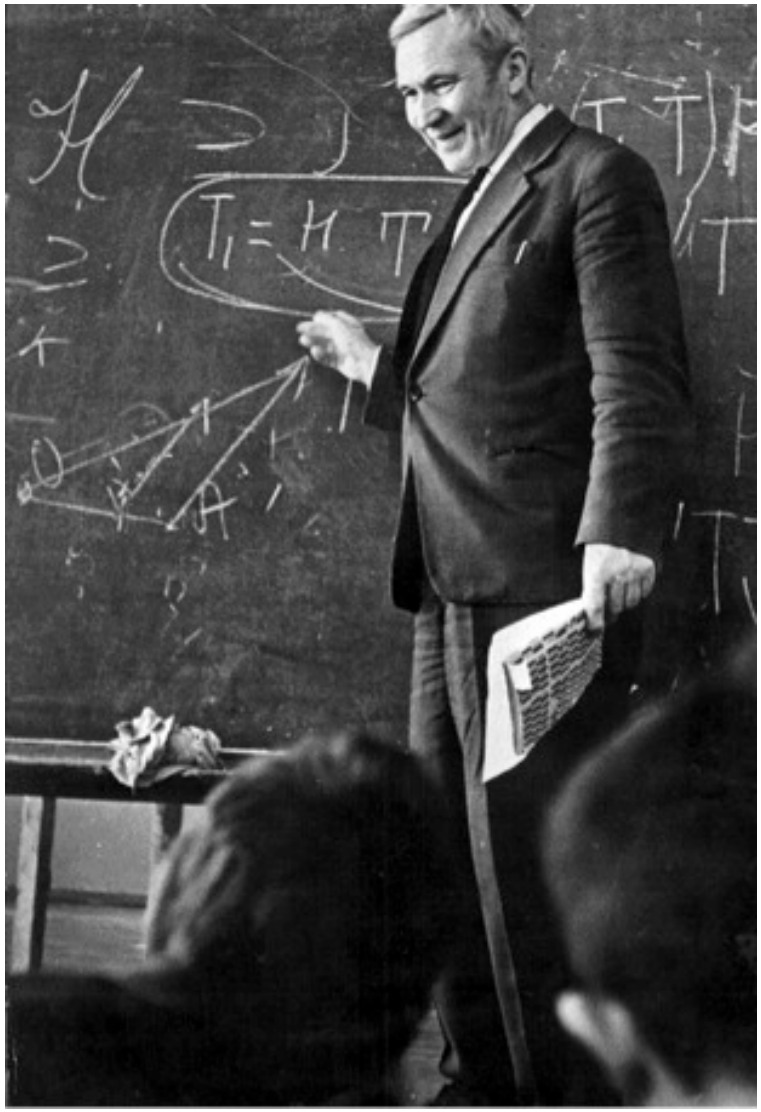
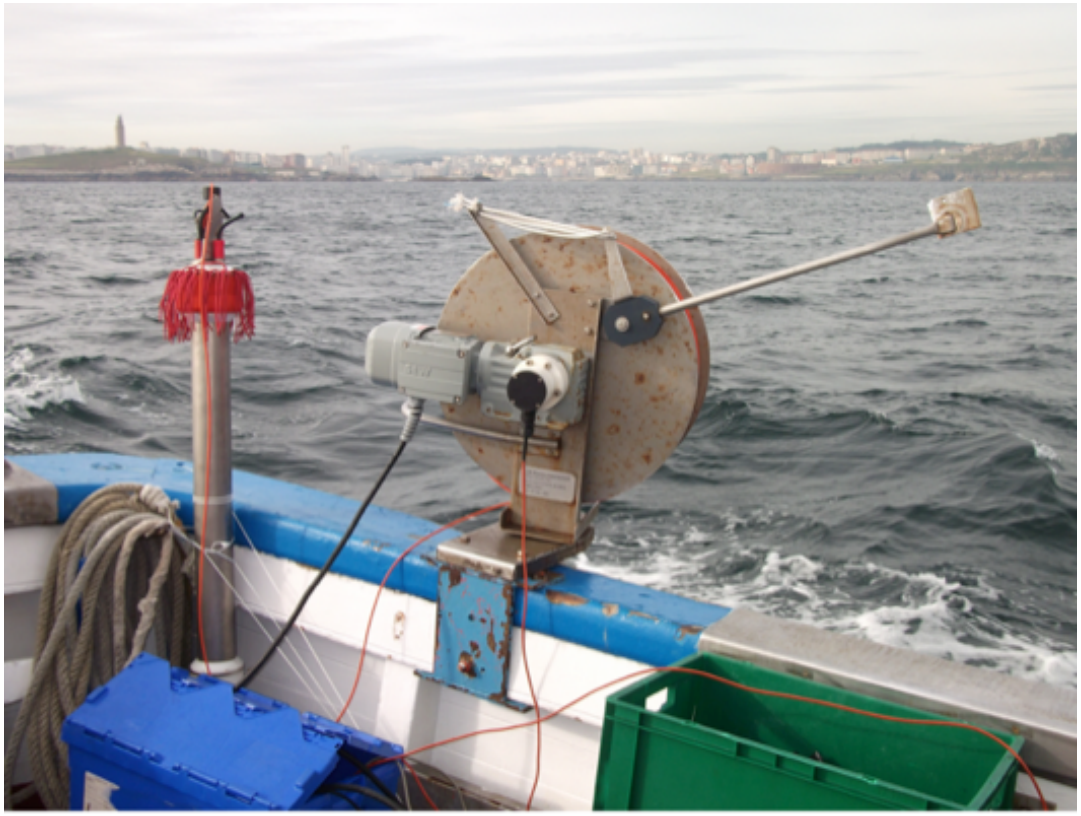
Sketch of turbulent flow by Leonardo da Vinci



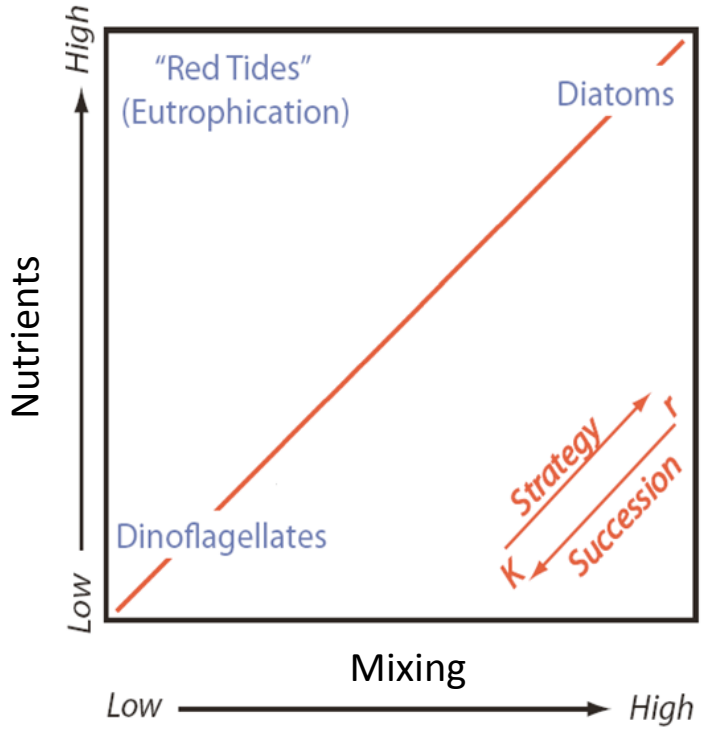
Andrey Nikolaevich Kolmogorov (1903-1987)



Microstructure turbulence profiler on board RV Lura (NW Spain)



Revisiting the mandala of Margalef (1978)



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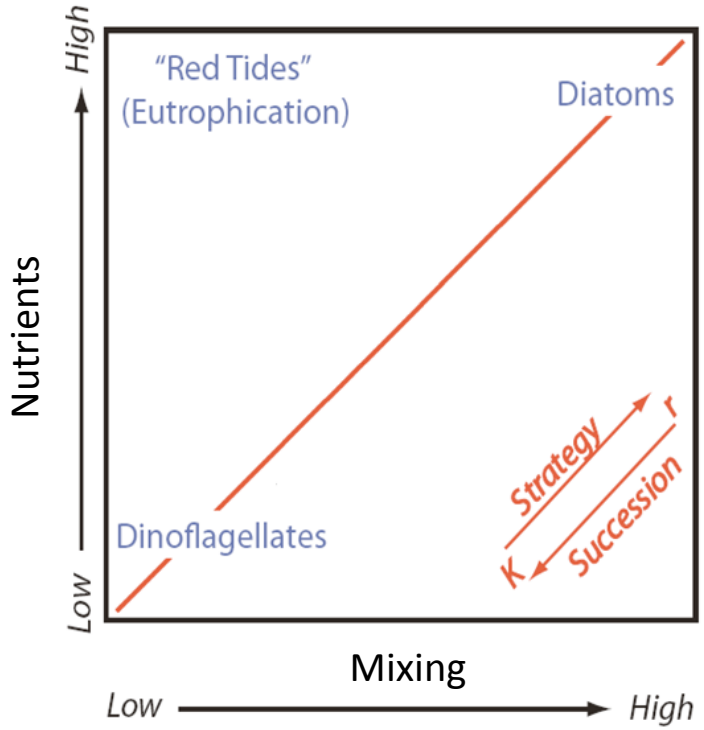
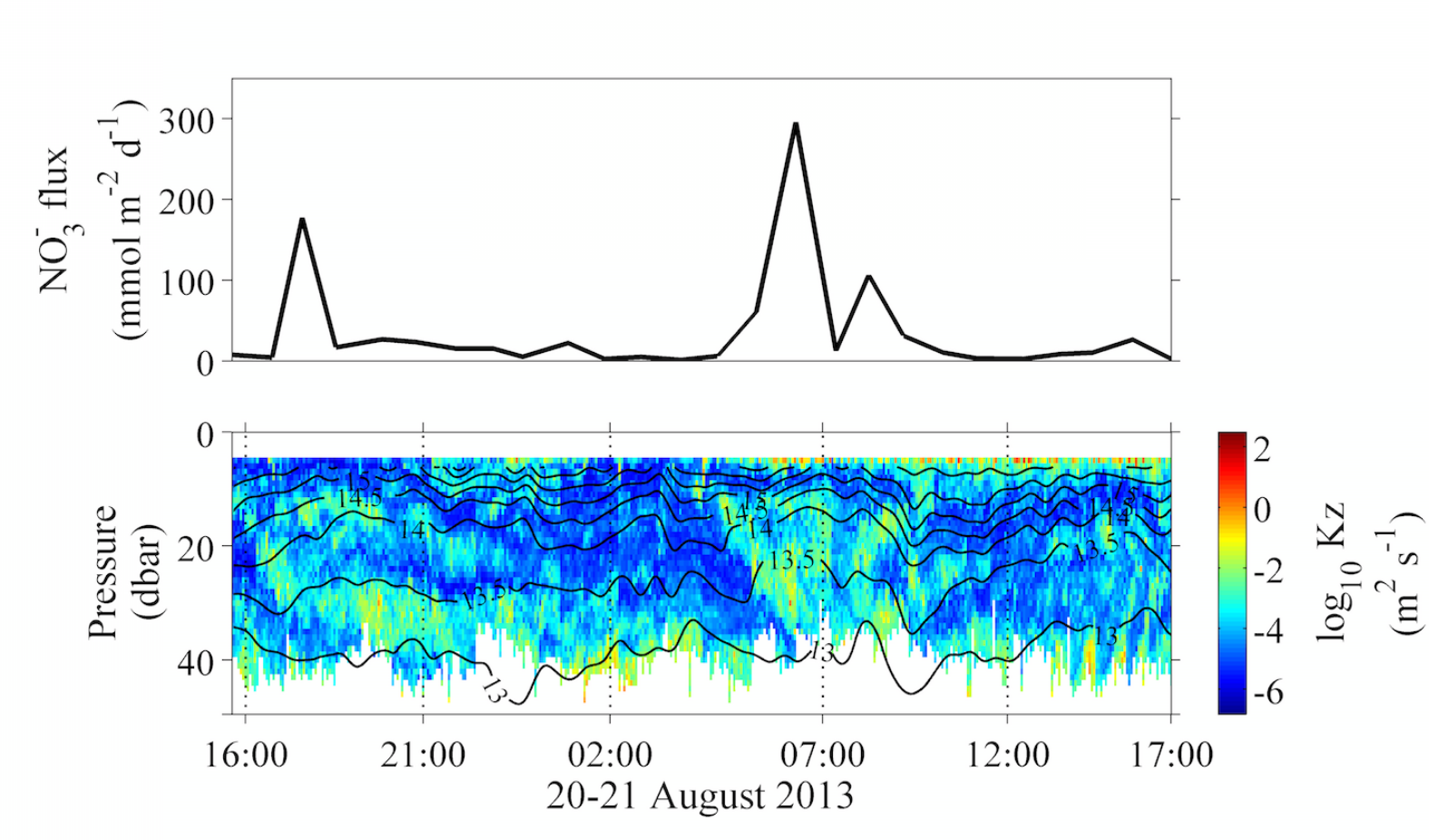


Methodological difficulties to quantify mixing (Kz) in the field

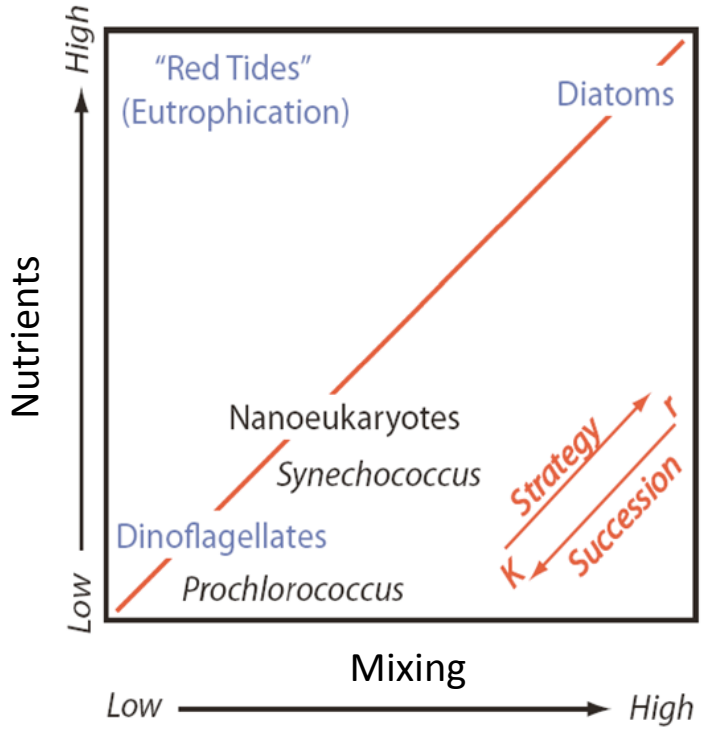
Internal wave mixing and nutrient supply on the shelf off Ría de Vigo (NW Spain)



Villamaña-Rodríguez et al (in prep.)

Mixing and stratification: related but not the same

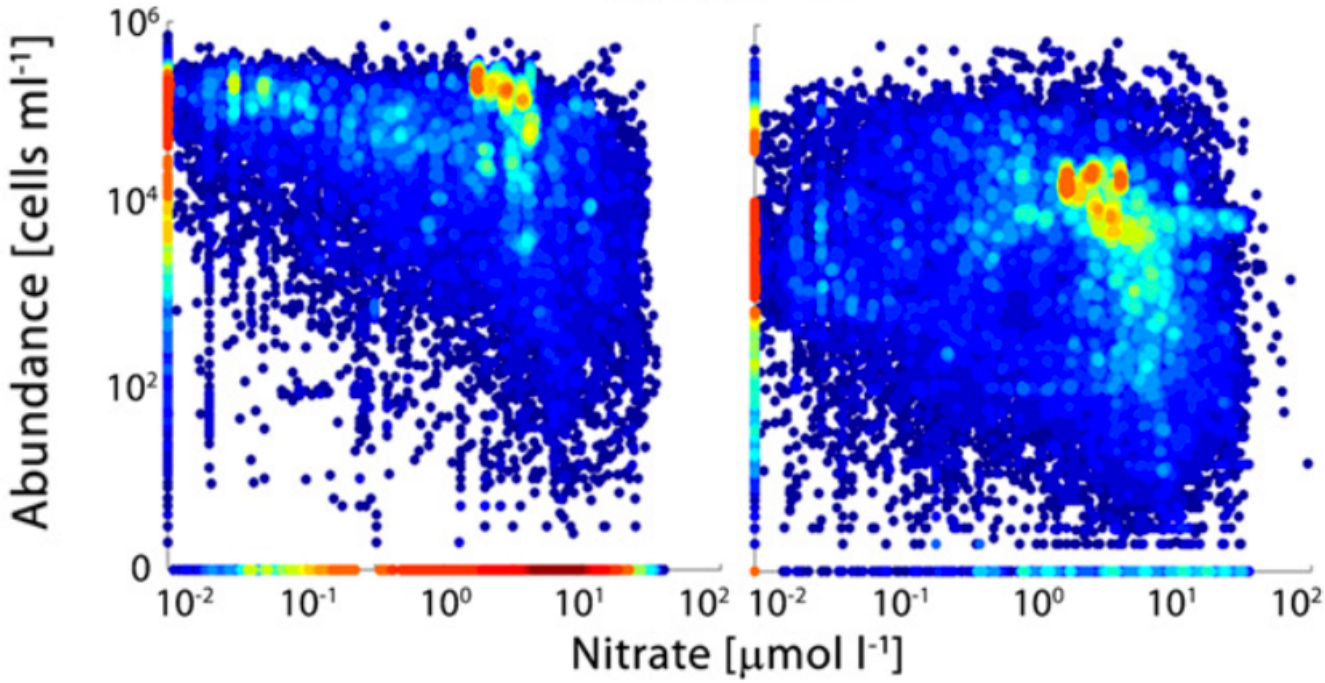
Revisiting the mandala of Margalef (1978)



The smaller-size picophytoplankton groups were not included in the original diagram

Picoplankton (~<2 μm) often dominate primary production, and recent studies suggest a significant contribution to carbon export (Richardson and Jackson, 2007; Guidi et al, 2016)

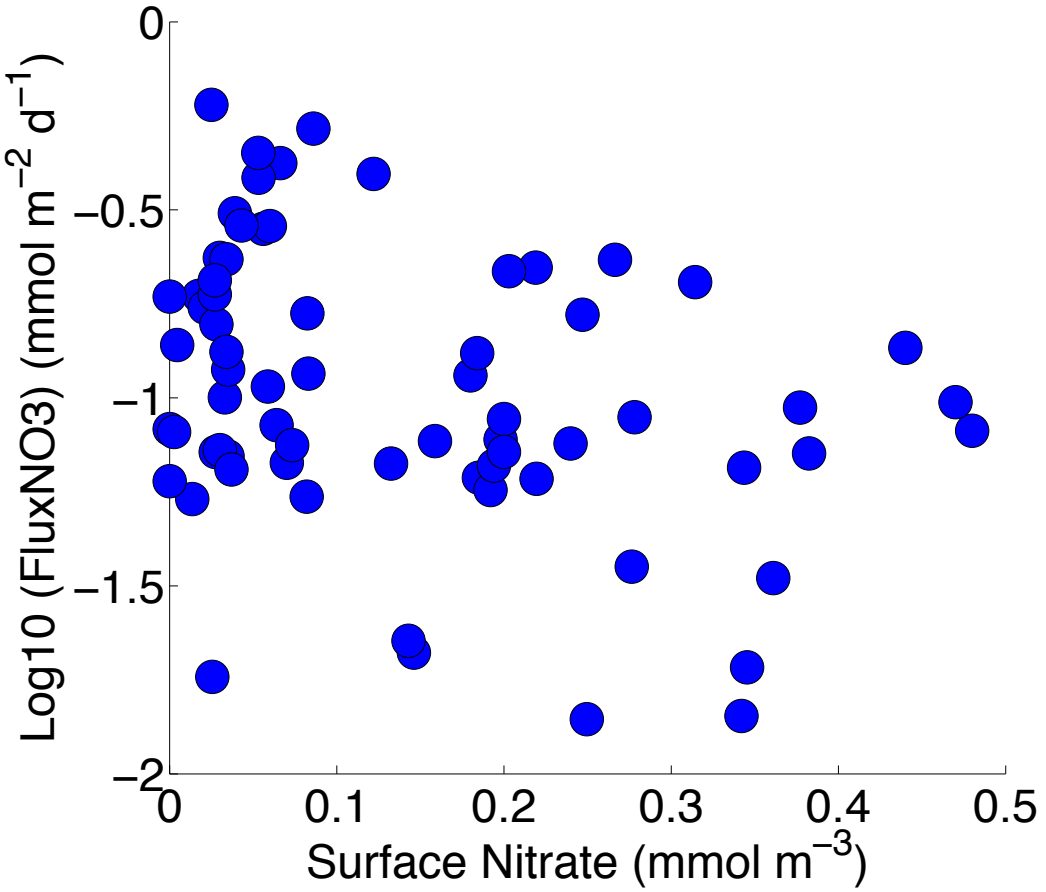
Control factors on *Prochlorococcus* and *Synechococcus* regional distributions



Flombaum et al. (2013, PNAS)

No relationship between nutrients concentration and cell abundance

Nitrate flux versus surface nitrate in oligotrophic regions



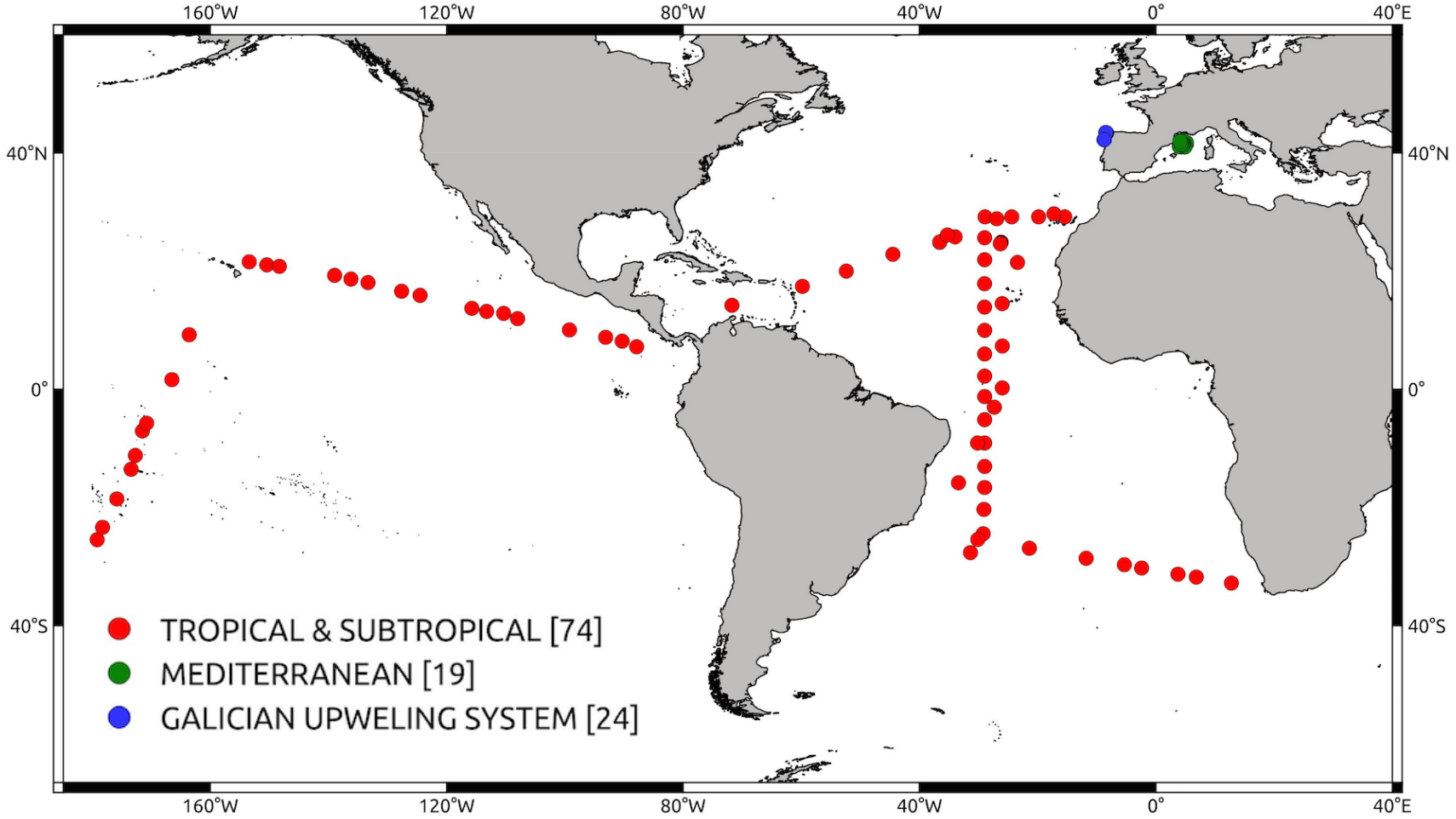
Mouriño-Carballido et al. (2011, L&O)

The variability in nutrient concentrations can be disconnected from changes in nutrient supply

Our hypothesis

The Margalef's mandala also applies within the picoplankton size-class

Data set of microstructure turbulence and picoplankton properties (2006-2013)



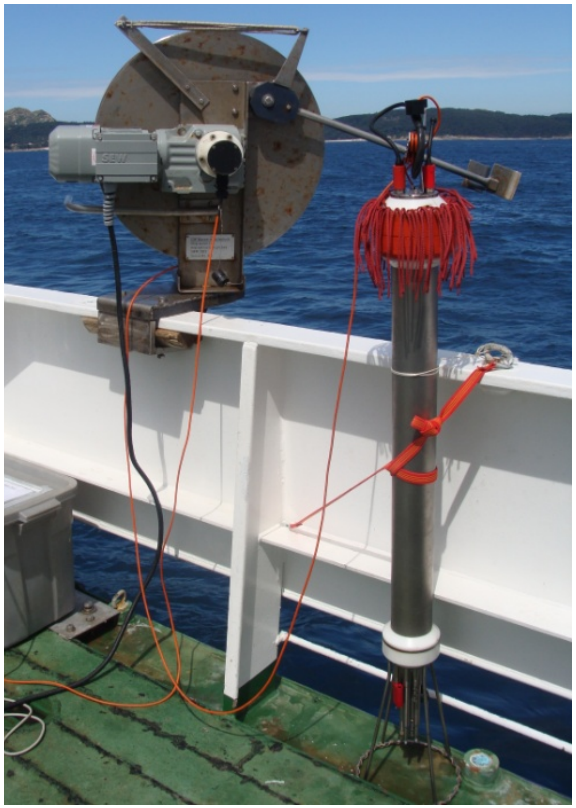
<u>117 Stations</u>:

- Microturbulence (MST profiler, 0-200 m)
- Nitrate concentration (0-200 m)
- Picoplankton abundance and cell properties (Flow cytometry, photic layer) →

Prochlorococcus
Synechococcus
Small picoEuk

How did we quantify vertical mixing (Kz)?

MSS (Micro-Structure-Turbulence) profiler



ISW Wassermesstechnik (http://www.ISW-Wasser.com)

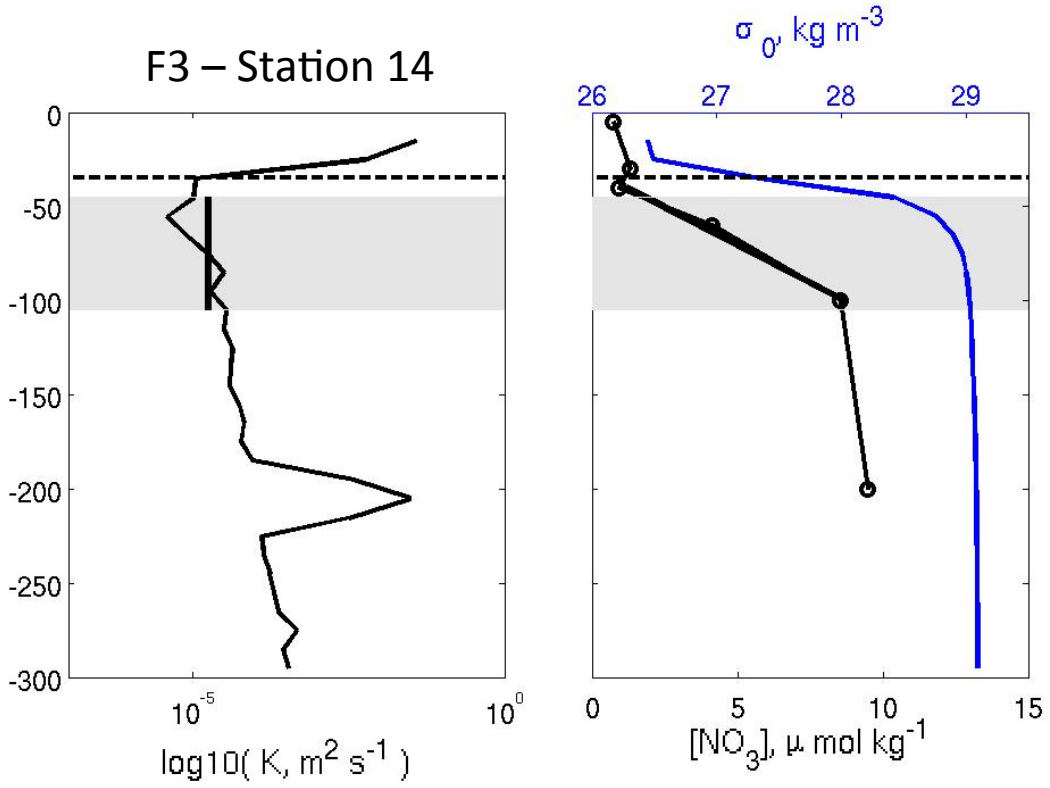
Vertical diffusivity (Kz):

$$Kz = 0.2\frac{\varepsilon}{N^2}$$ Osborn (1980)

ε Dissipation rate of turbulent kinetic energy

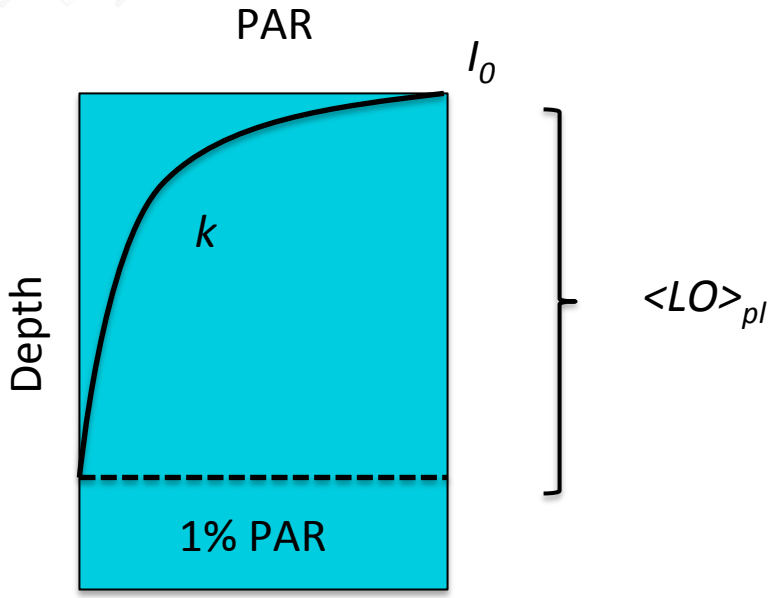
N Brünt Väissälä frequency

How did we calculate the diffusive transport of nitrate across the nutricline?



$$Flux_{nut} = \langle K_z \rangle \frac{d\,[nut]}{dz}$$

How did we calculate light availability (LA)?



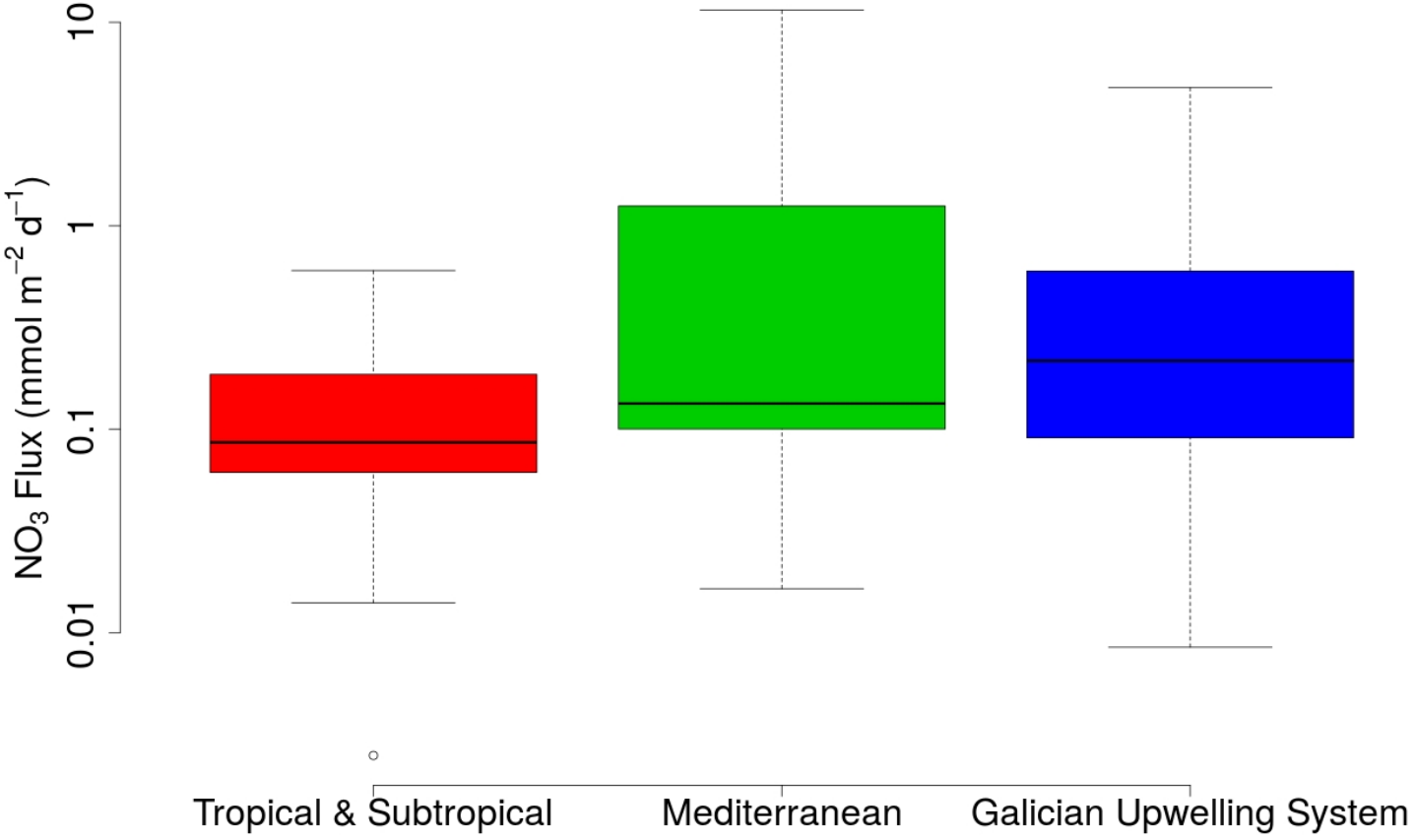
$$LA = \frac{I_0}{k \cdot <LO>_{pl}} (1 - \exp^{-k \cdot <LO>_{pl}})$$

$$LO = (\varepsilon N^{-3})^{1/2}.$$

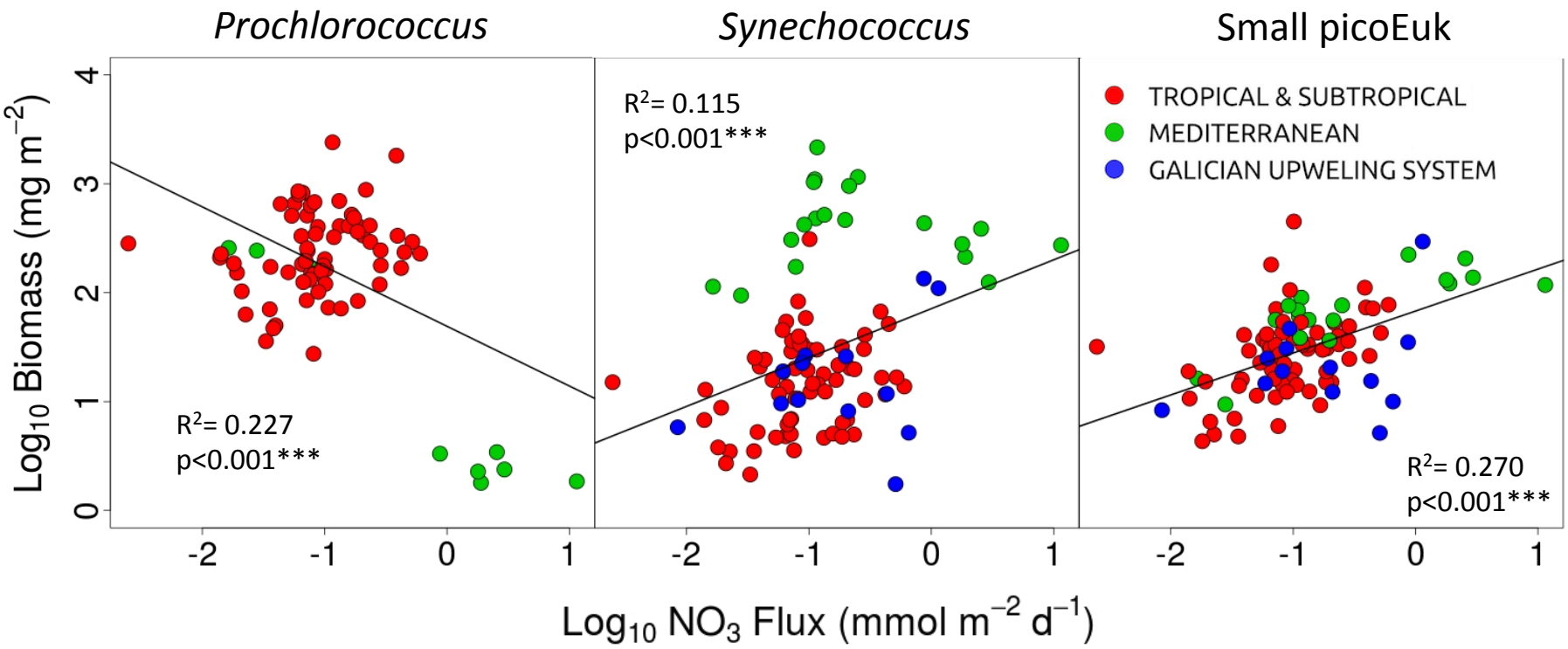
I_0	Surface PAR (Photosynthetic Active radiation)
k	Light Extintion Coefficient
$<LO>_{pl}$	Averaged photic layer Osmidoz Scale
ε	Dissipation rate of turbulent kinetic energy
N	Brünt Väissälä frequency

What did we find…?

Variability in nitrate diffusive fluxes



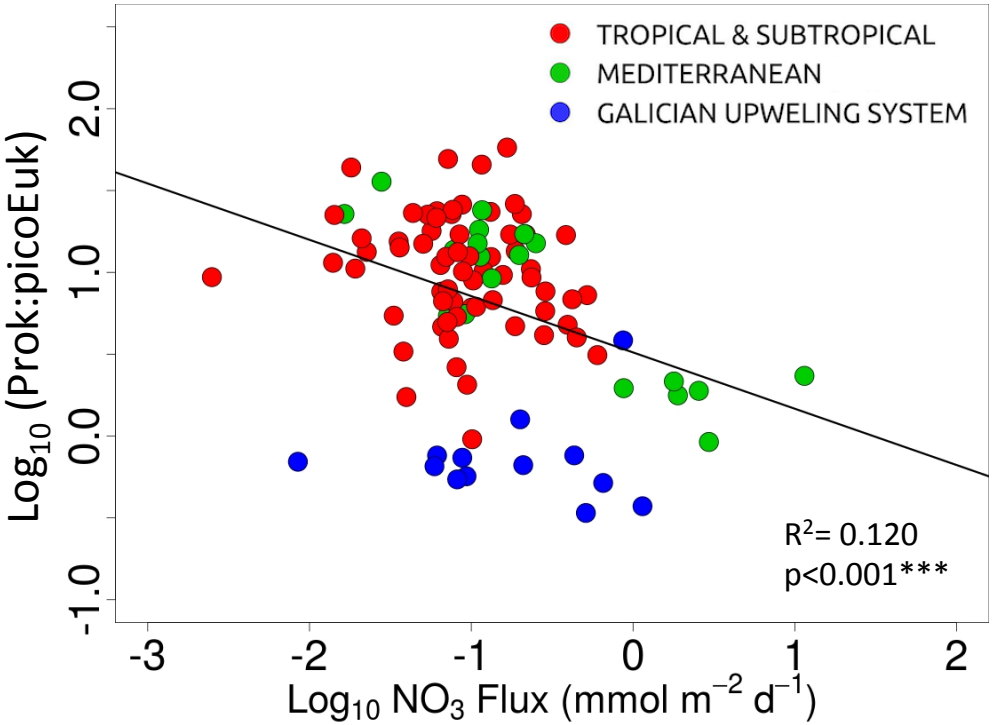
Photic layer depth-integrated picoplankton biomass vs NO_3 diffusive flux



Prochlorococcus was high when NO_3 supply was low, whereas *Synechococcus* and picoeukaryotes increased at high supply

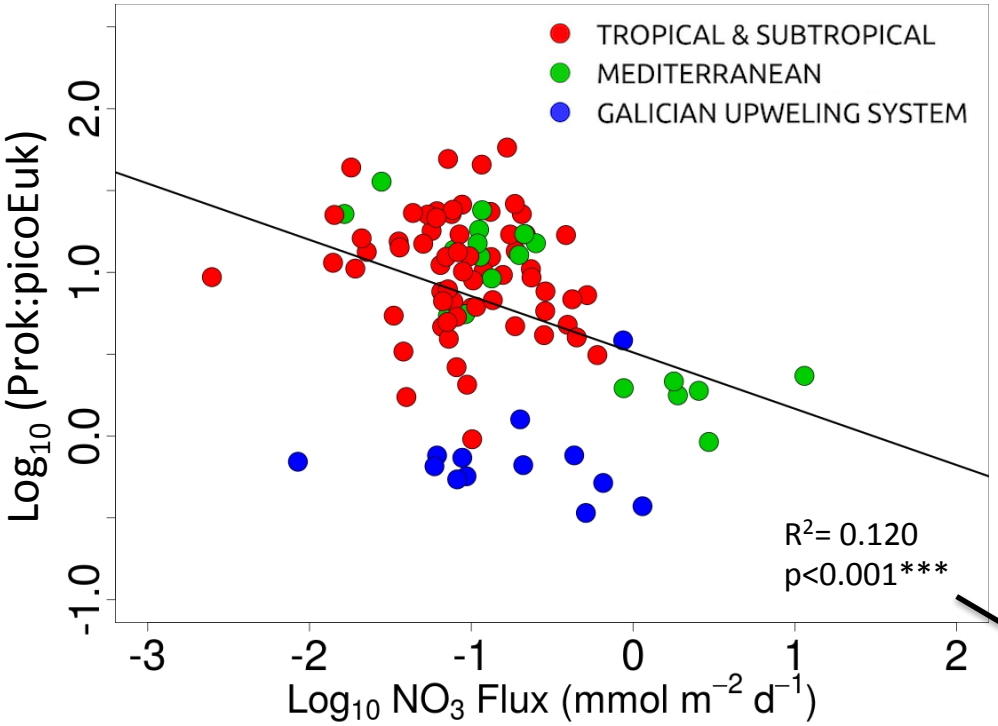
The fate of the carbon fixed in the upper layer depends on the composition of the picoplankton groups (ratio prokaryotespicoeukaryotes) (Corno et al., 2007)

Ratio Prokaryote to picoEukaryote biomass vs NO_3 fluxes



The ratio Prok to picoEuk biomass decreases with nutrient supply

Generalized Additive Models (GAM): NO_3 Flux, Light availability (LA), Temperature (T)



× 3,2

Log_{10} (Prok:picoEuk)=-0.220*Log10 (**NO_3 Flux**)-s(**LA**)+0.028**T**

R^2(adj)=0.389
p<0.05*

Light availability and temperature do also play a role

Chemostats competion experiments

Picoplankton groups:

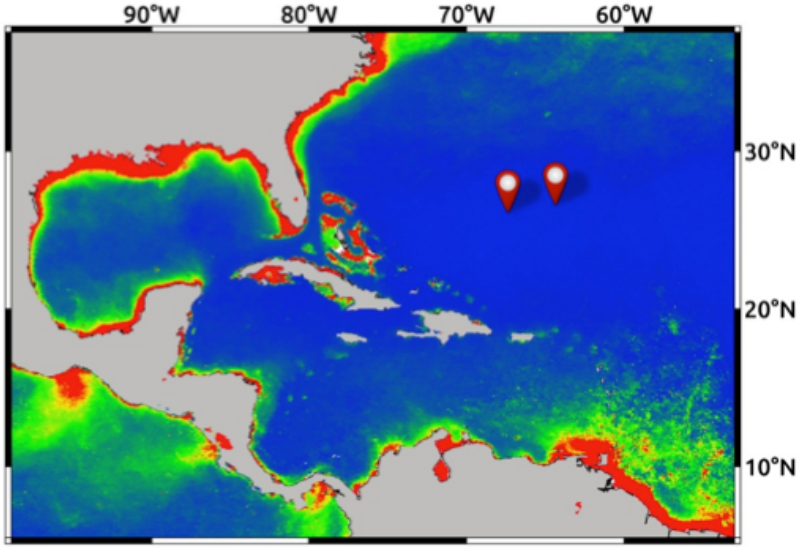
- *Synechococcus sp.* (RCC-2366)
- *Micromonas pusilla* (RCC-450)

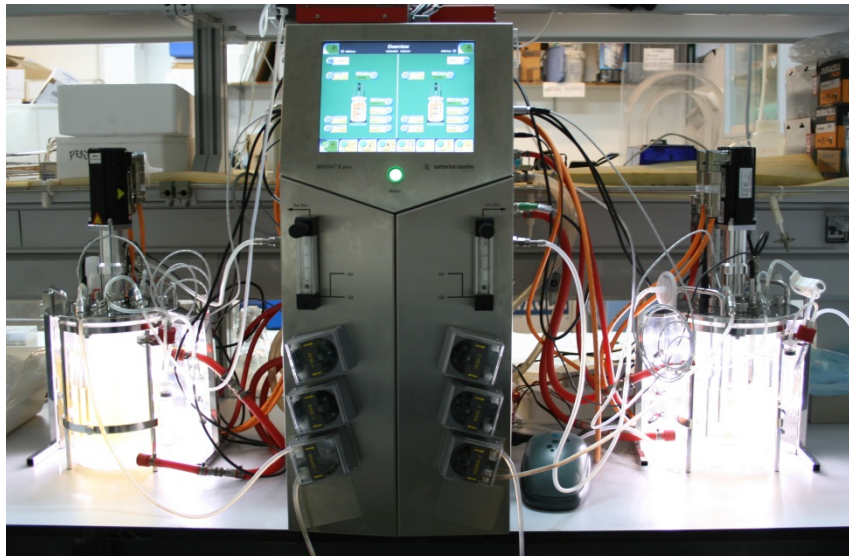
Fully-aclimated populations:

- Media: modificated PCR-S11 (N:P=5:1)
- Light: 100 µE
- Temperature: 21ºC
- Steady-state (Dilution rate: 0.225 d^{-1})

Nutrient perturbations (5 µM NO_3):

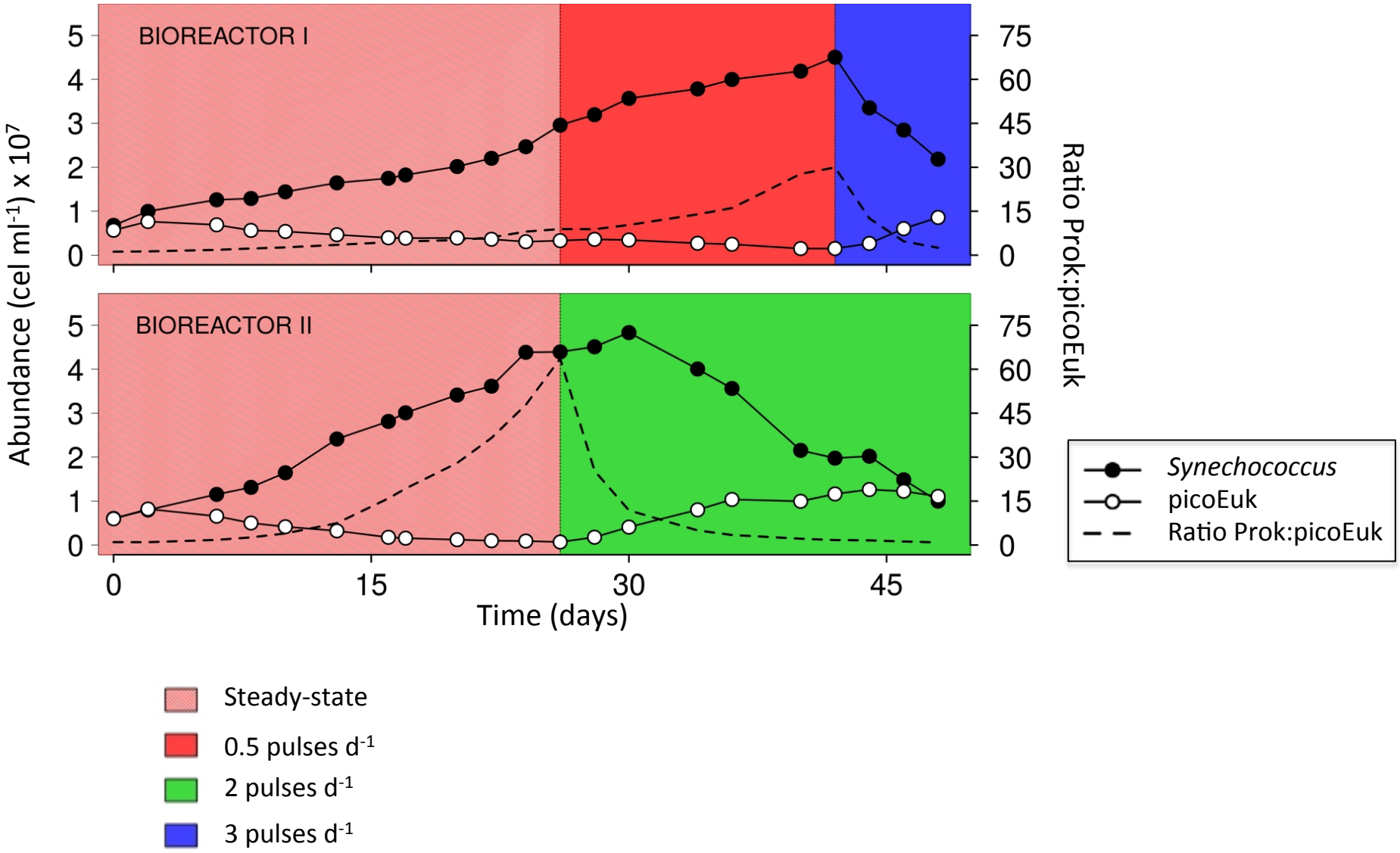
- 0.5 pulses d^{-1}
- 2 pulses d^{-1}
- 3 pulses d^{-1}





Sartorius Biostat Plus

Population dynamics under nitrate-limiting and nitrate-pulsing conditions



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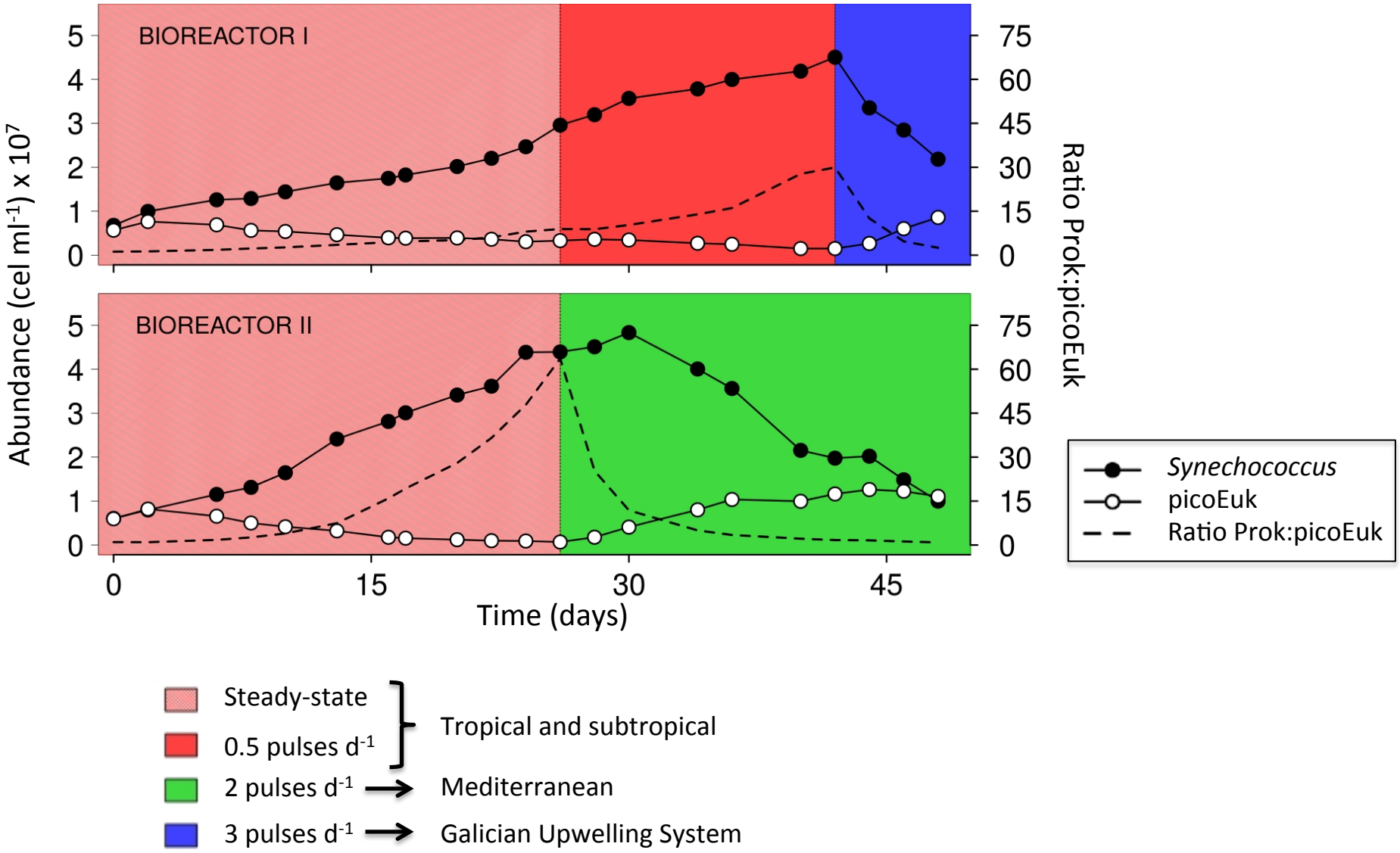

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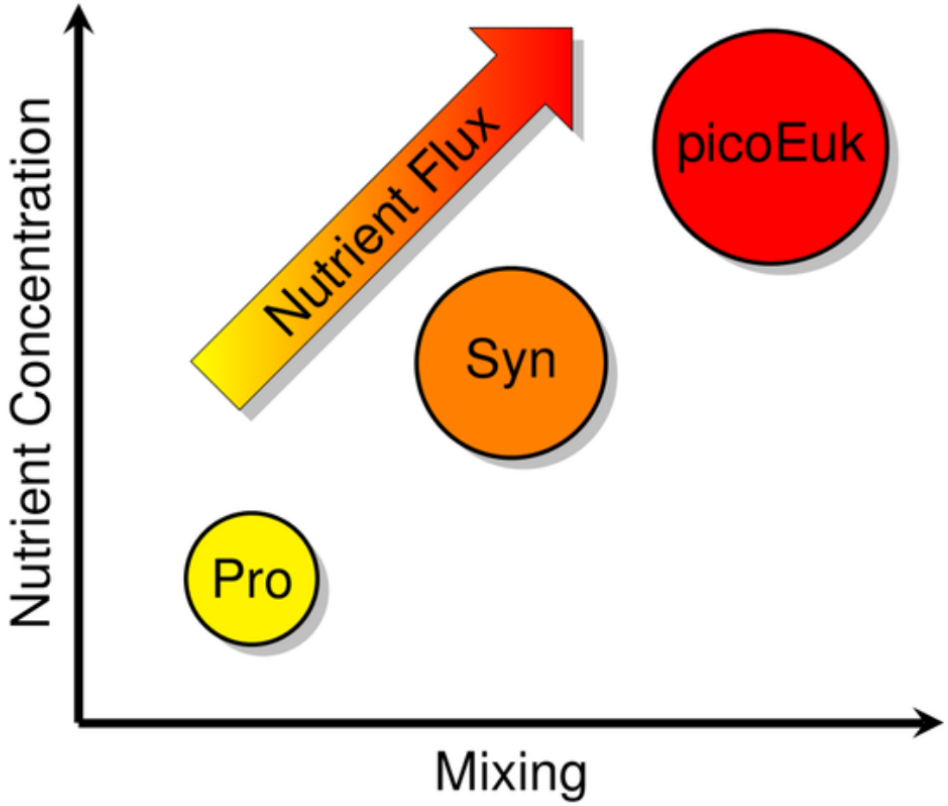
Dominance of picophytoplankton groups to biomass



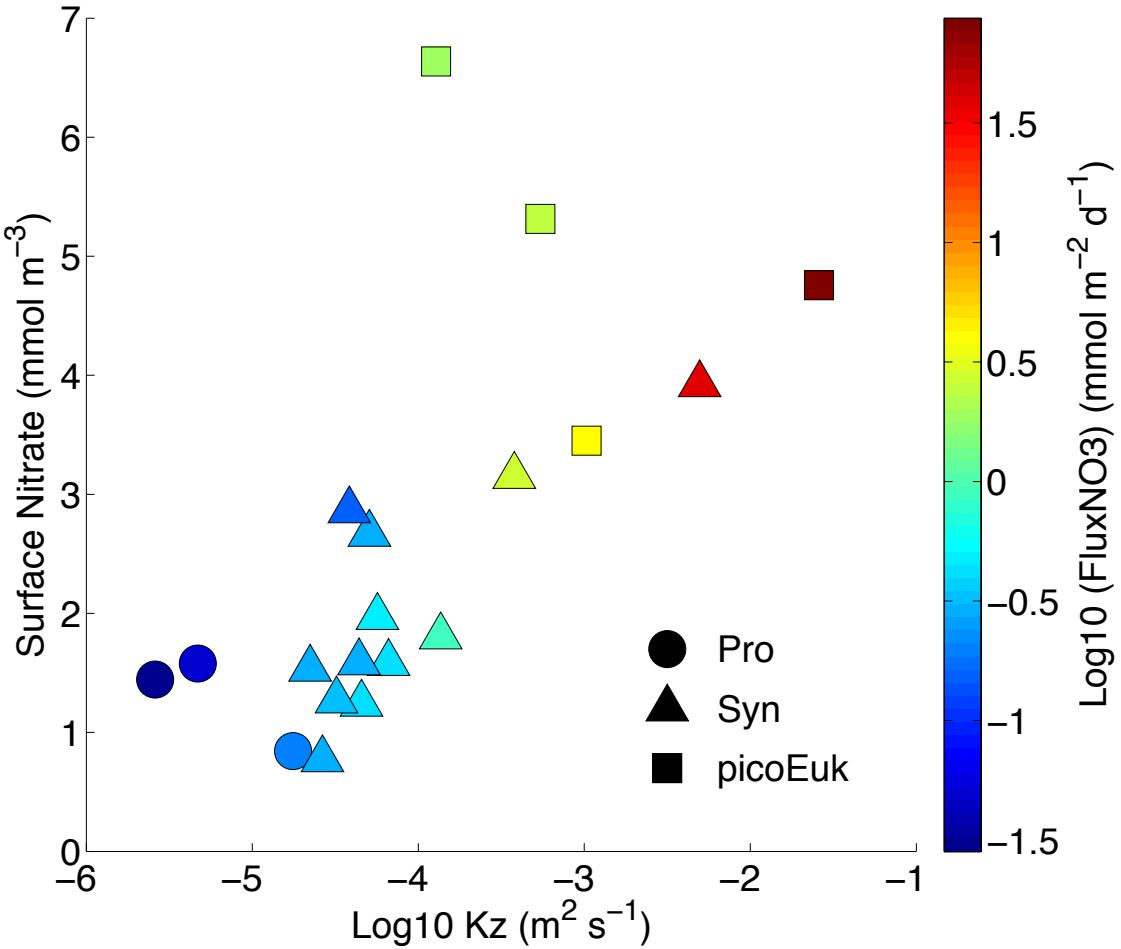
Mouriño-Carballido et al. (2016, MEPS)

Due to differences in nutrient uptake abilities, picophytoplankton groups exhibit different behaviour to nutrient supply

Thanks to…

- Grant CTM2012-30680 to B. Mouriño-Carballido (Spanish goverment)
- Grant CTM2009-06712-E/MAR to B. Mouriño-Carballido (Spanish goverment)
- Grant CSD2008-00077 to C. Duarte (Spanish goverment)
- Grant CTM2008-06261-C03 to M. Latasa (Spanish goverment)
- Grant CTM2004-05174-C02 to E. Marañón (Spanish goverment)

Dominance of picophytoplankton groups to biomass vs nitrate, mixing and NO_3 fluxes



Picophytoplankton groups exhibit different behaviour to nutrient supply, probably reflecting differences in nutrient uptake abilities