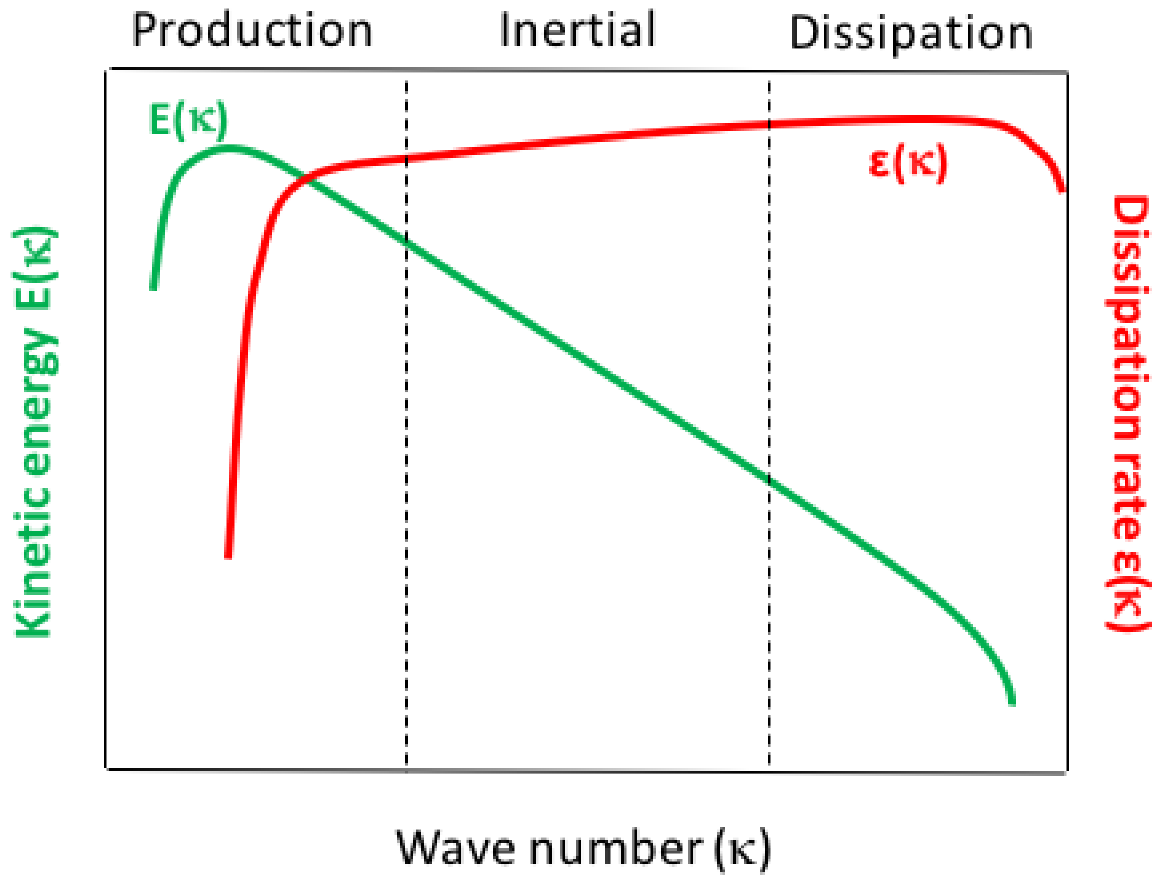
Role of mixing on microphytoplankton community structure

M. Villamaña[1], B. Mouriño-Carballido[1], E. Marañón[1], P. Cermeño[2], P. Chouciño[1], M. Estrada[2], B. Fernández-Castro[1], F.G. Figueiras[3], J.L. Otero-Ferrer[1], B. Reguera[4]

1. Universidade de Vigo
2. Institut de Ciències del Mar, CSIC-Barcelona
3. Instituto de Investigacións Mariñas, CSIC-Vigo
4. Instituto Español de Oceanografía-Vigo

mvillamana@uvigo.es

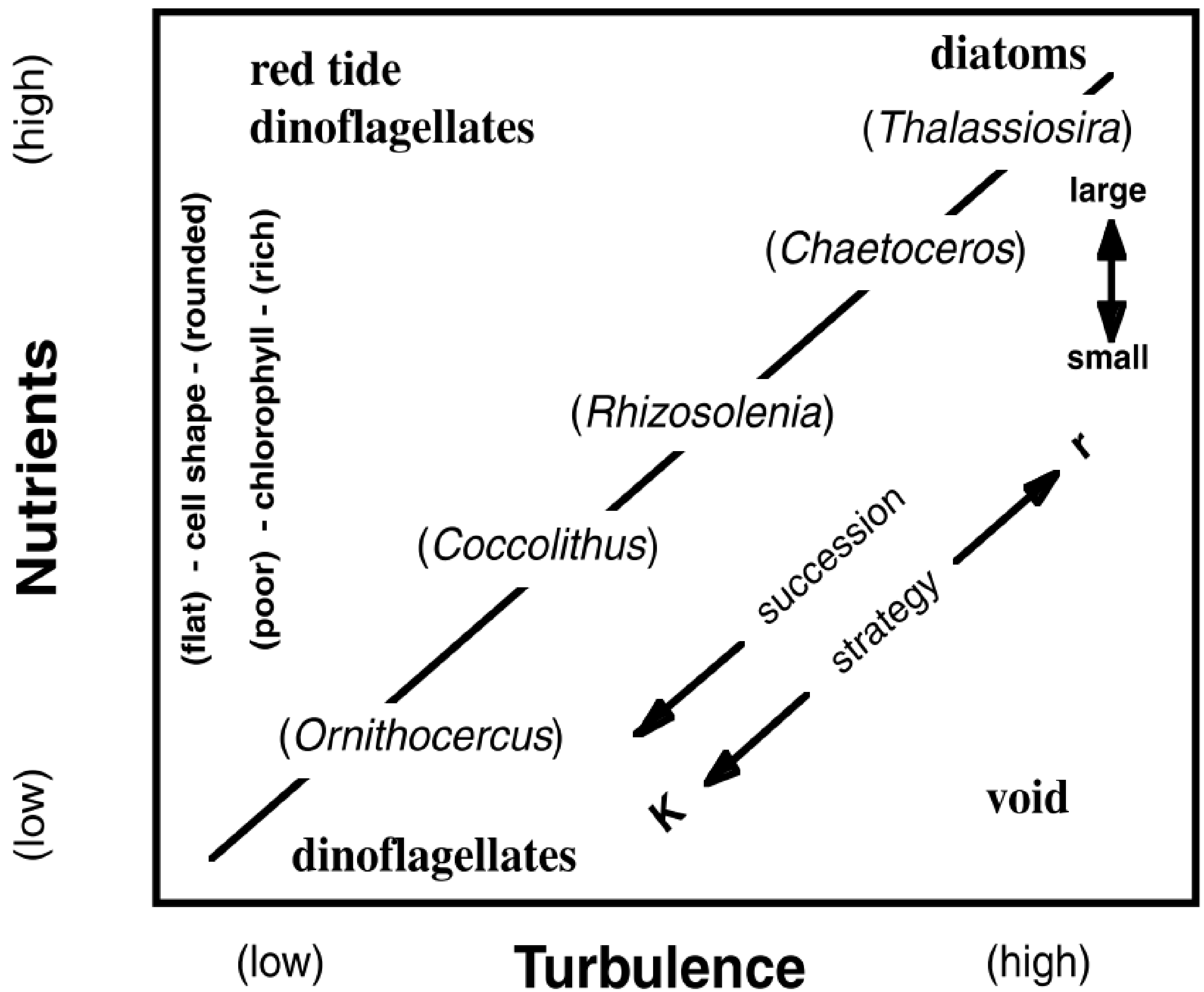
What is turbulence?



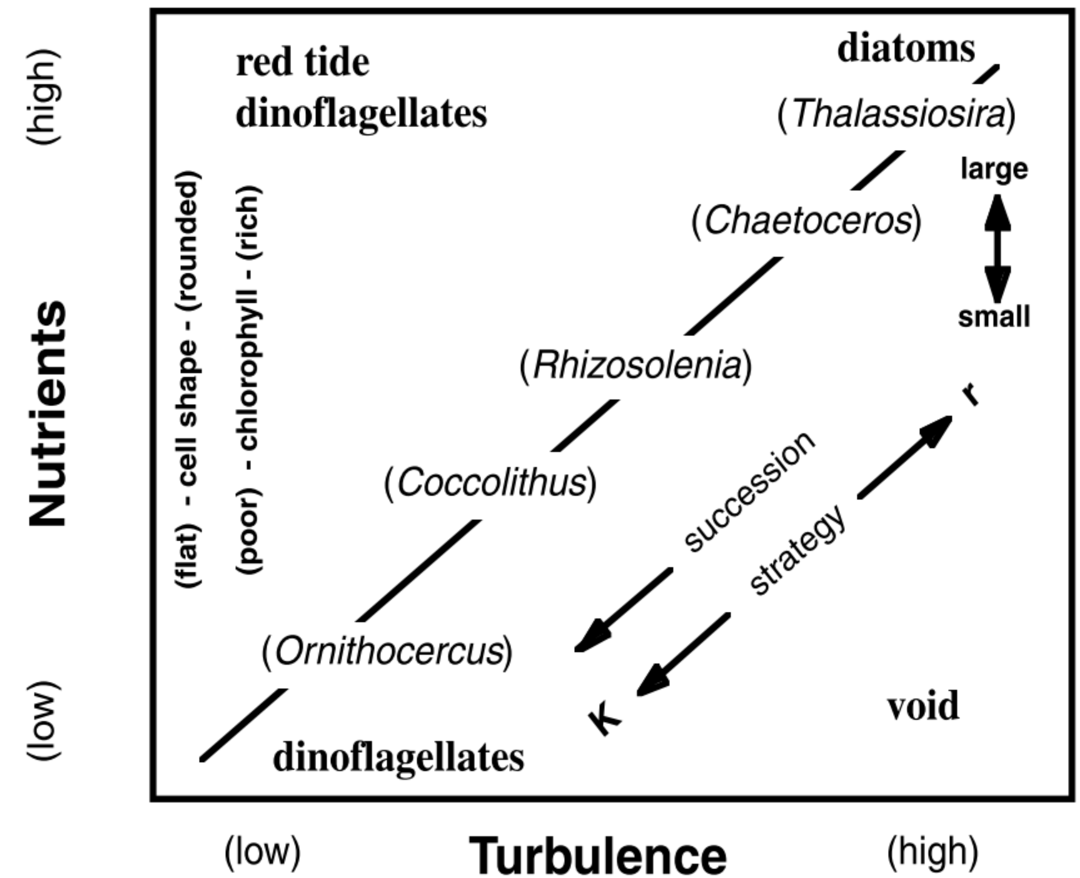
ε = dissipation rate of turbulent kinetic energy (turbulence)

Kz = vertical diffusivity coefficient (mixing)

Margalef´s Mandala (1978)

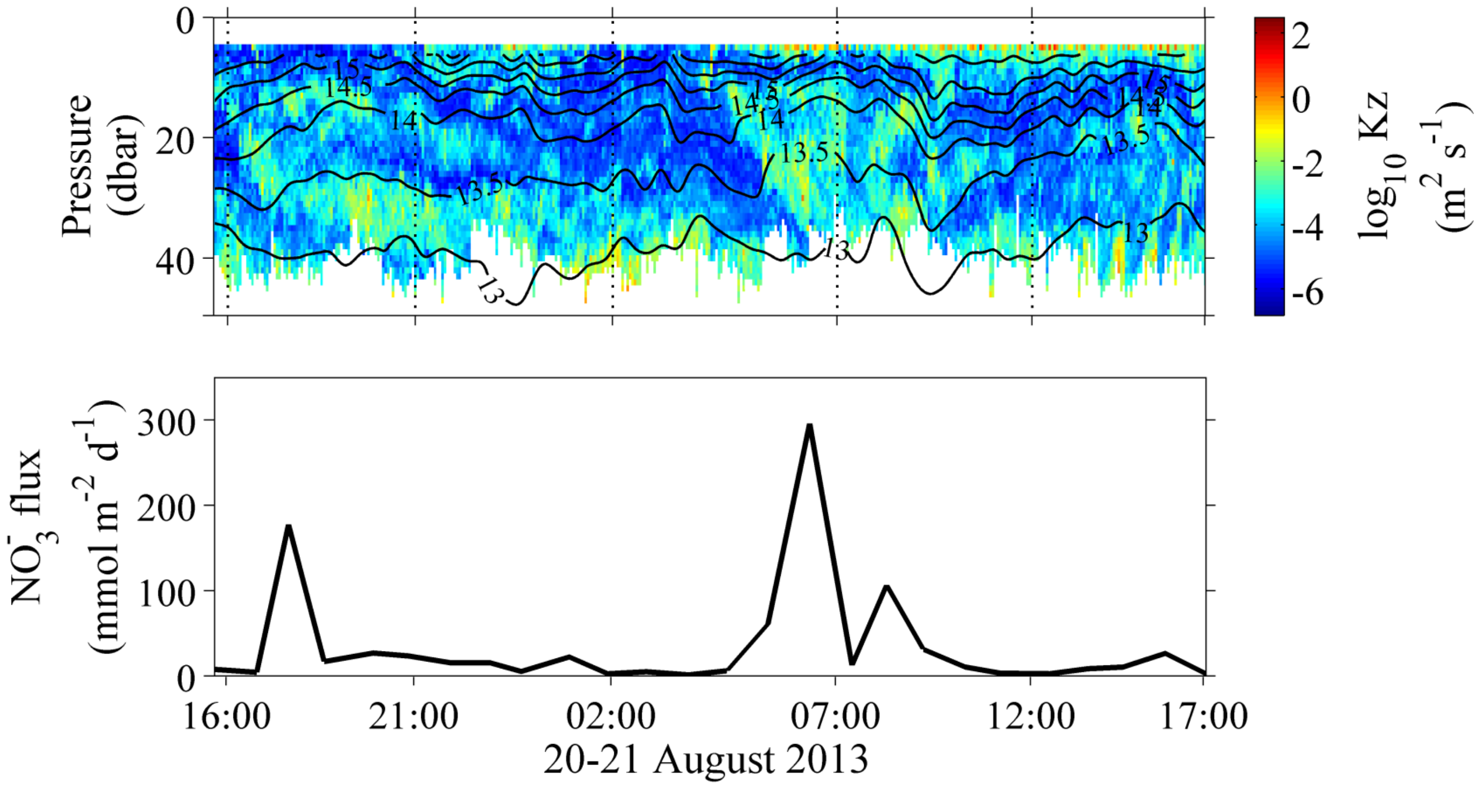


Margalef´s Mandala (1978)



Diatoms are predominant in the mixing range of 2 - 100 $cm^2 s^{-1}$ and dinoflagellates in 0.02 - 1 $cm^2 s^{-1}$

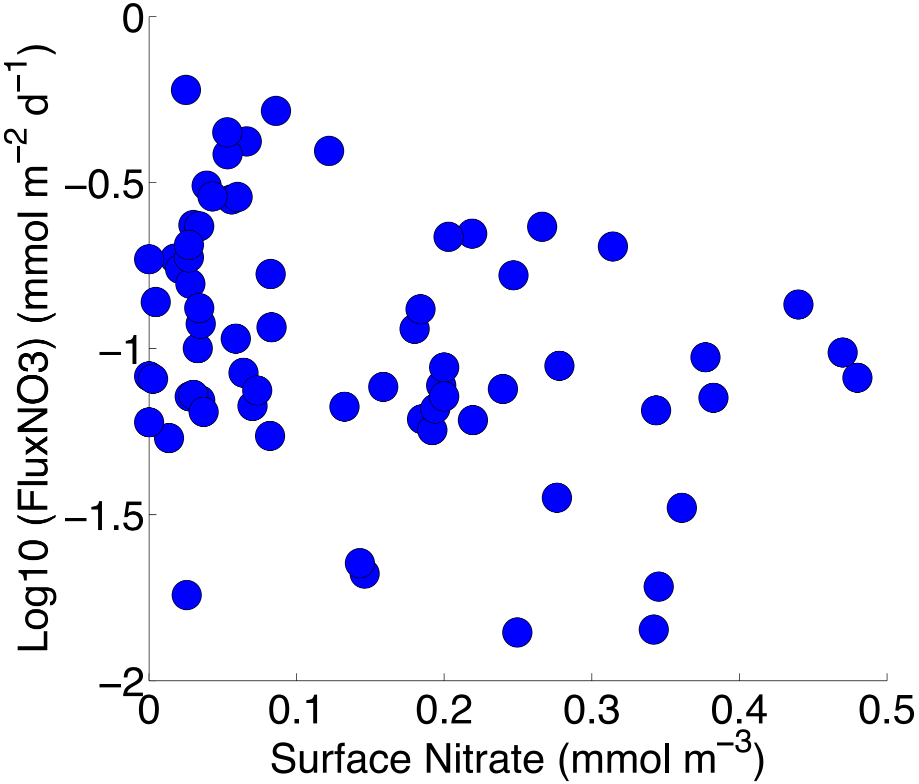
Internal wave mixing and nutrient supply on the Ría de Vigo (NW Spain)



Villamaña et al. (L&O, in press)

Mixing and stratification: related but not the same

Nitrate flux versus surface nitrate concentration in oligotrophic regions



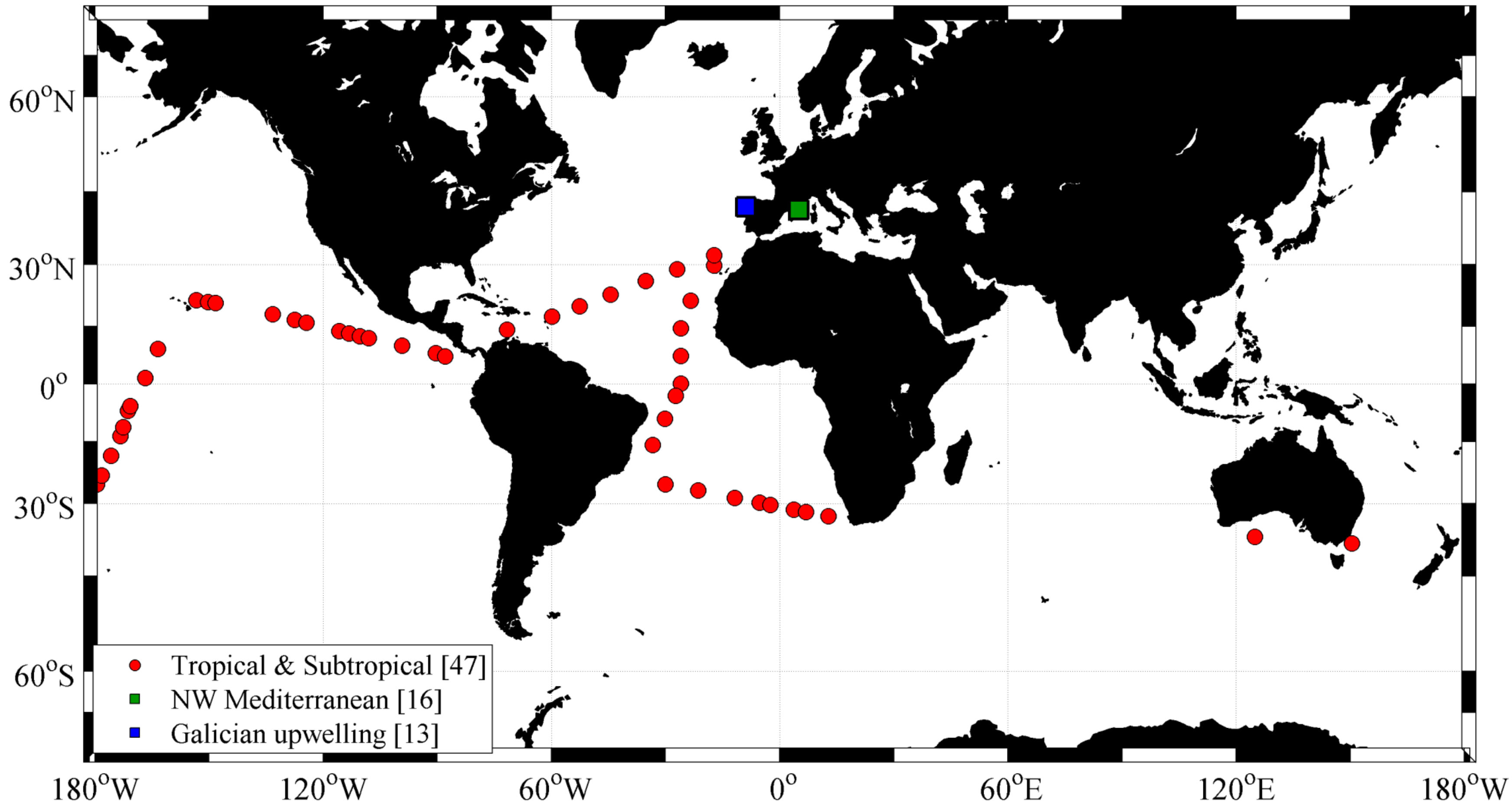
Mouriño-Carballido et al. (2011, L&O)

Changes in nutrient concentration can be disconnected from changes in nutrient supply

Our goal

To investigate the role of light and nutrient availability (derived from mixing) on the biomass of diatoms and dinoflagellates

Data set of microturbulence and microphytoplankton



76 Stations:

- Microstructure turbulence
- Nitrate concentration
- Microphytoplankton community composition

Light and nutrient availability derived from mixing

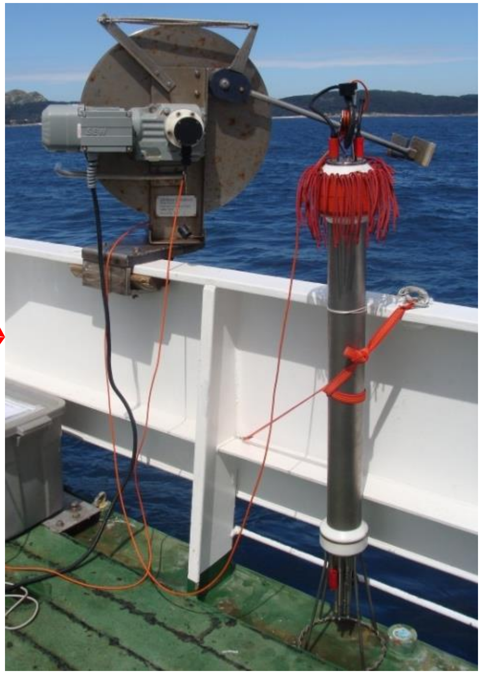
Light availability

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

Nitrate supply

$$NO_3^- \ diffusive \ flux = -\boldsymbol{Kz} \cdot \left(\frac{d[NO_3^-]}{dz} \right)$$

$$NO_3^- \ advective \ flux \ = \frac{I_W \ x \ D}{A} \cdot \ [NO_3^-]_{bottom}$$



Microstructure profiler

Diatoms and dinoflagellates biomass

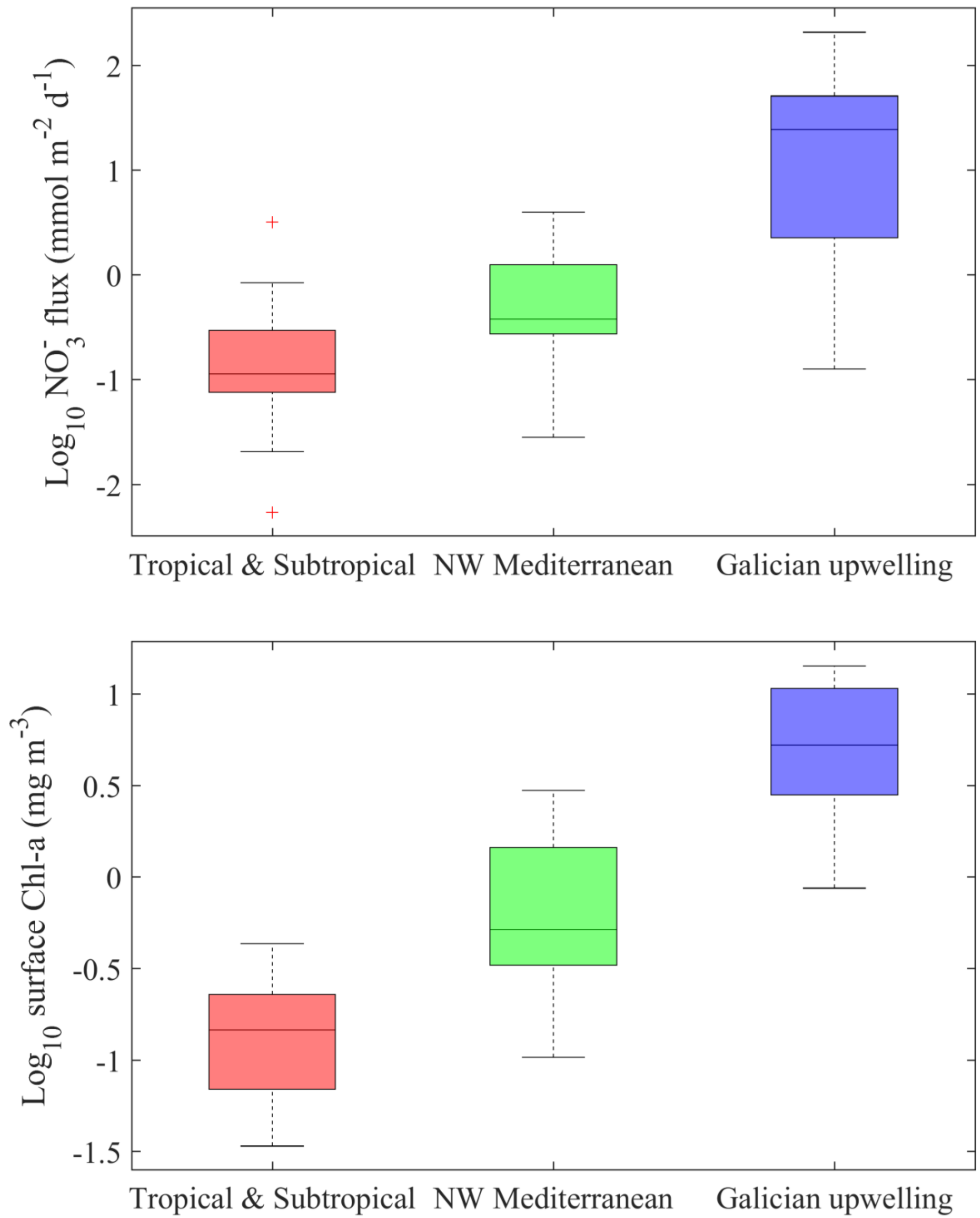
cell abundance → inverted microscope

cell biovolume → dimensions and shapes
Hillebrand et al (1999)

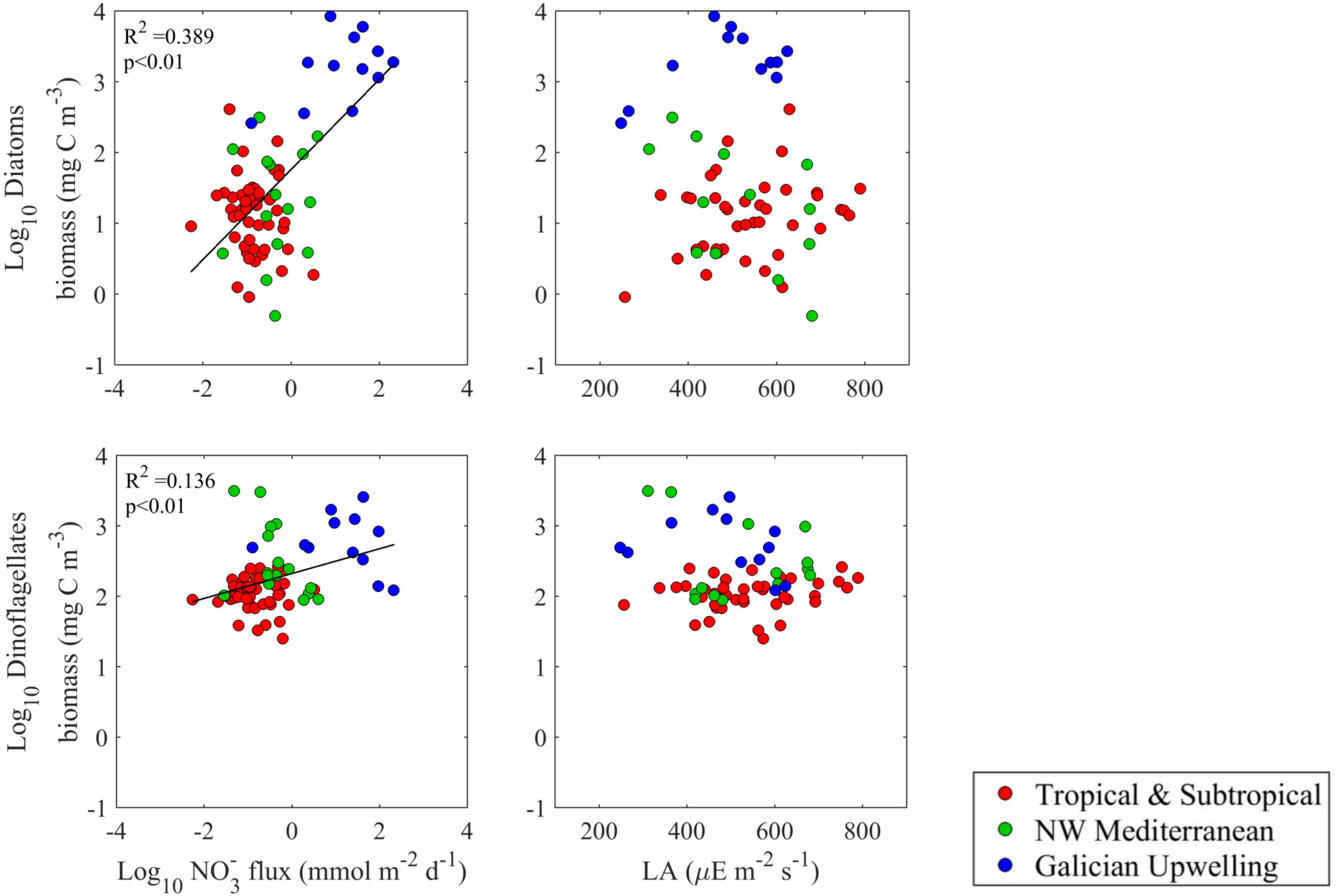
cell carbon → volume-to-carbon conversion factor
Menden-Deuer and Lessard (2000)

$$\boxed{\text{C biomass} = \text{cell abundance} \times \text{cell carbon}}$$

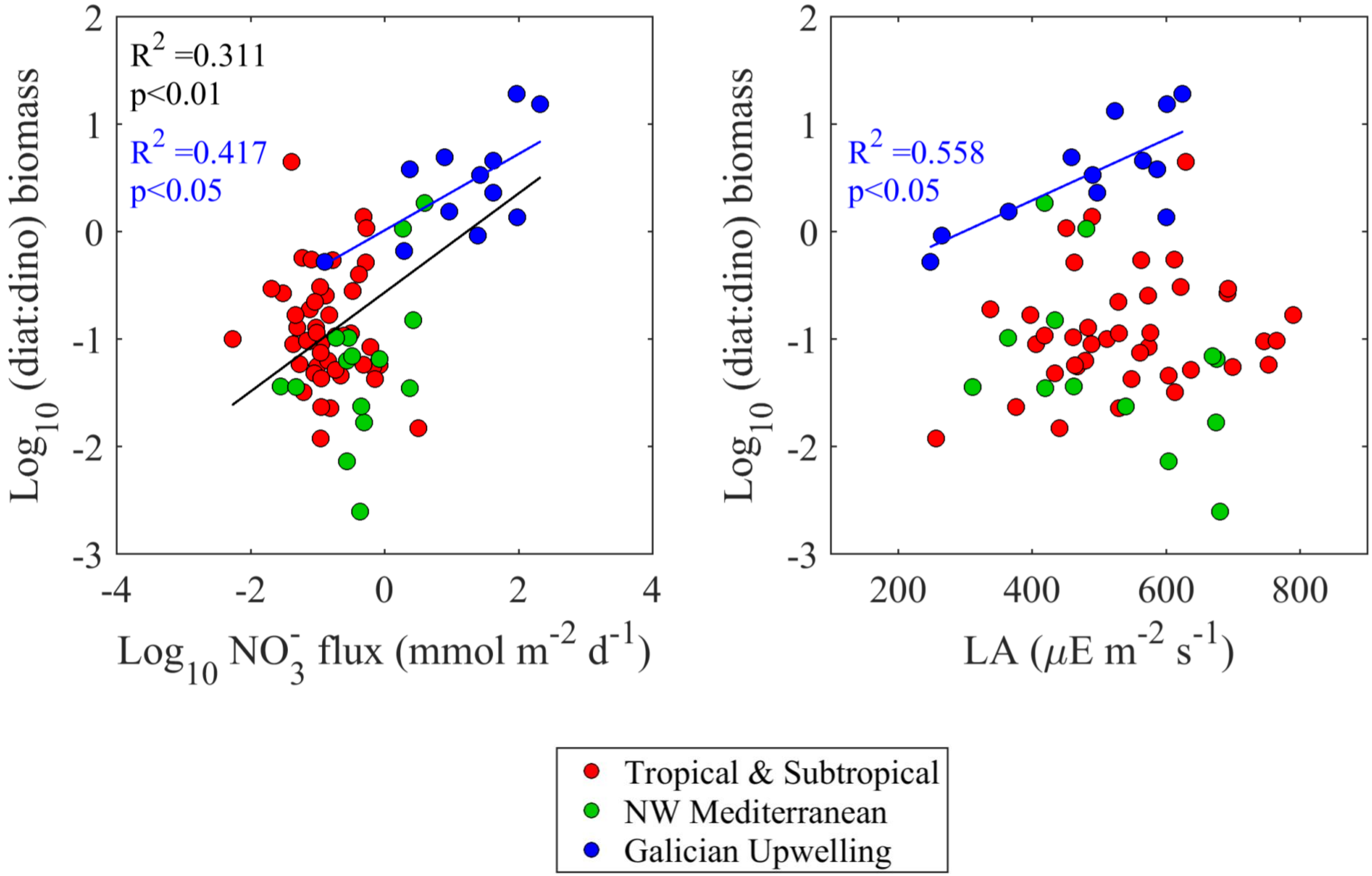
Variability in nitrate fluxes and surface Chl-a



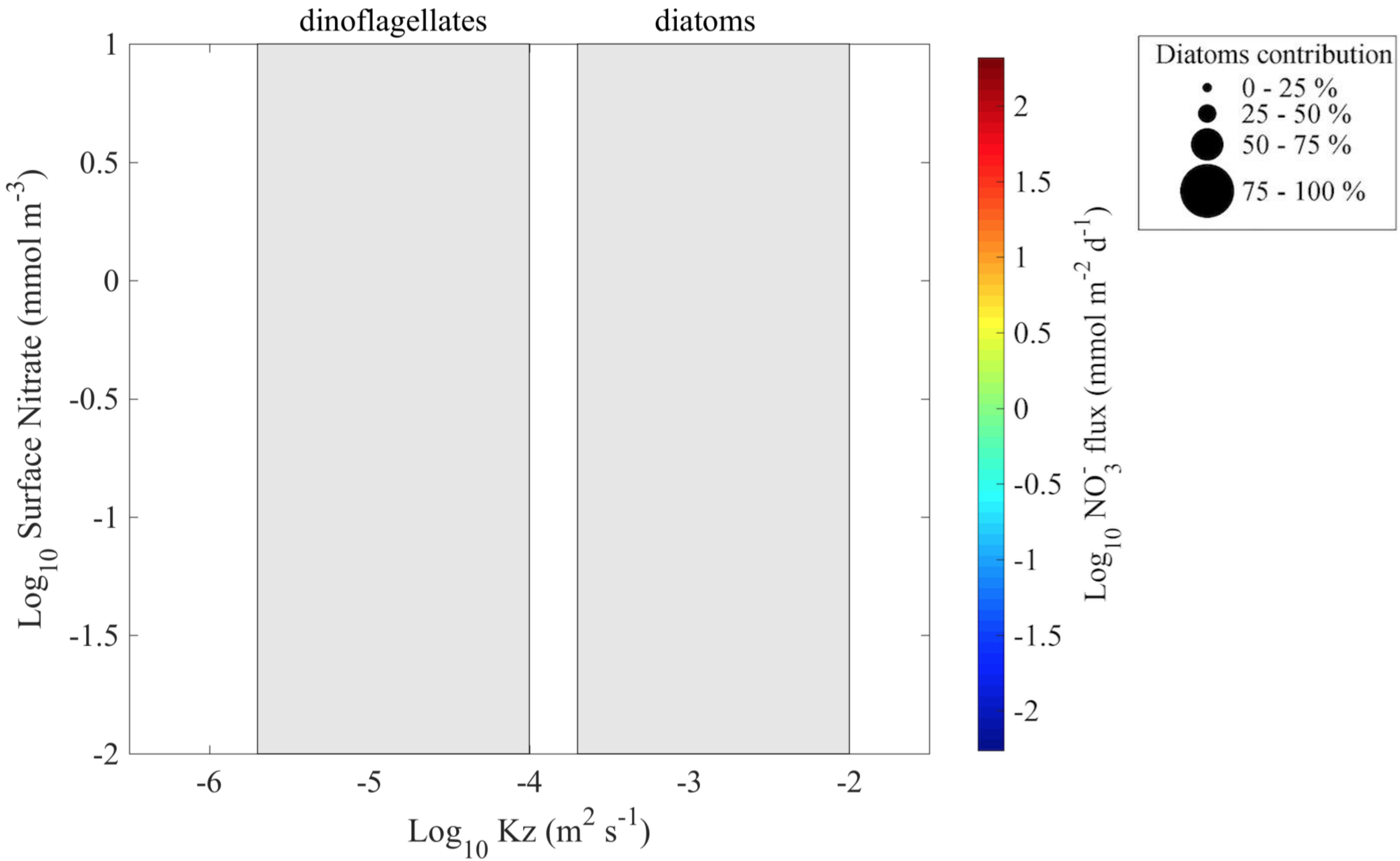
Diatoms and dinoflagellates biomass vs. nitrate flux and LA



Ratio diatoms to dinoflagellates biomass vs. NO_3^- flux and LA



Dominance of diatoms vs. Kz, NO_3^- concentration and NO_3^- flux



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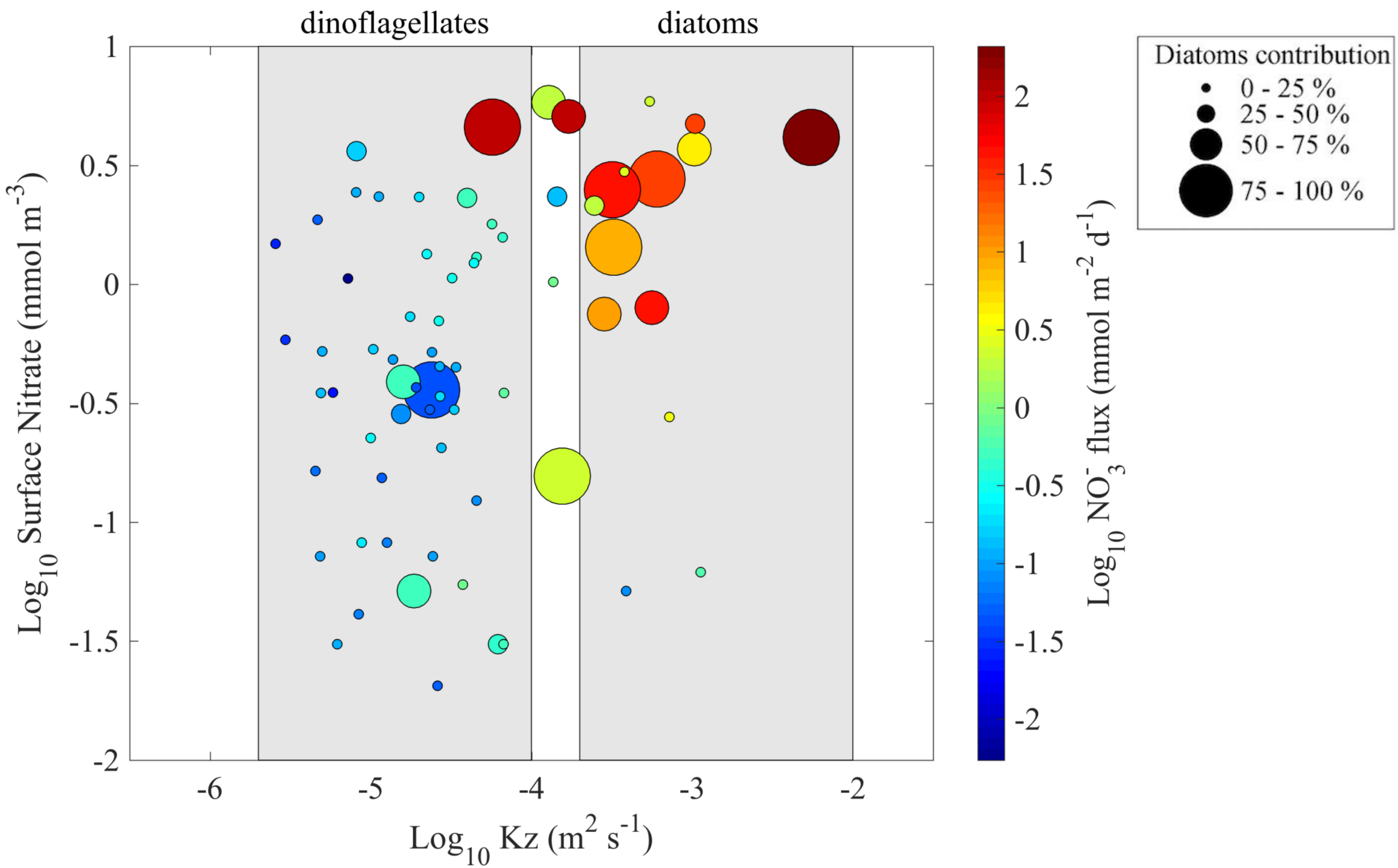

Conclusions

1. Mixing regimes for diatoms and dinoflagellates coincide with the values proposed by Margalef

2. Nutrient supply was more important than light availability in controlling the biomass of diatoms and dinoflagellates

Thank you!

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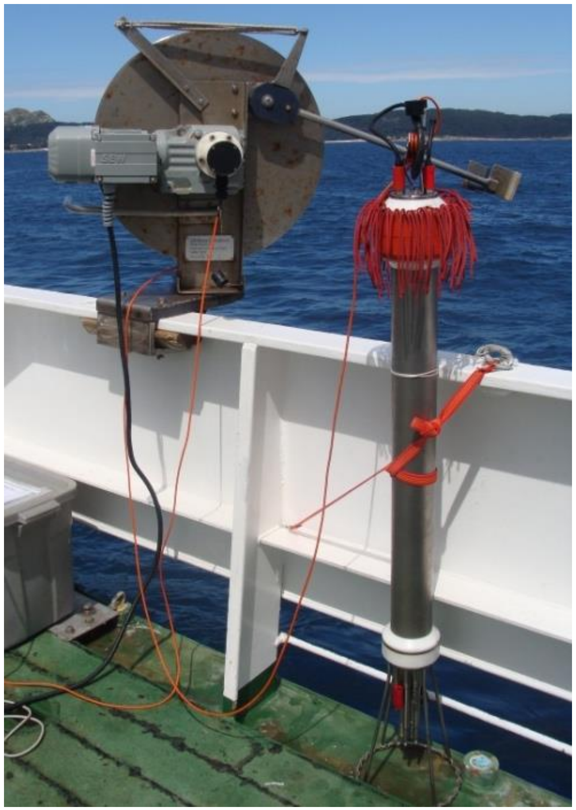
MINISTERIO DE EDUCACIÓN, CULTURA Y DEPORTE

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

mvillamana@uvigo.es

How do we quantify turbulence and mixing? Microstructure profiler



Shear $\left({}^{du}/_{dz}\right)$:

$$\frac{du}{dz} = \frac{dU}{dt} \mathrm{x} \frac{1}{2\sqrt{2}SG\rho V^2}$$

Dissipation rate of turbulent kinetic energy (ε):

$$\varepsilon = 7{,}5\,\nu \left(\frac{\partial u}{\partial z}\right)^2$$

Vertical diffusivity coefficient (Kz):

$$Kz = e\frac{\varepsilon}{N^2}$$

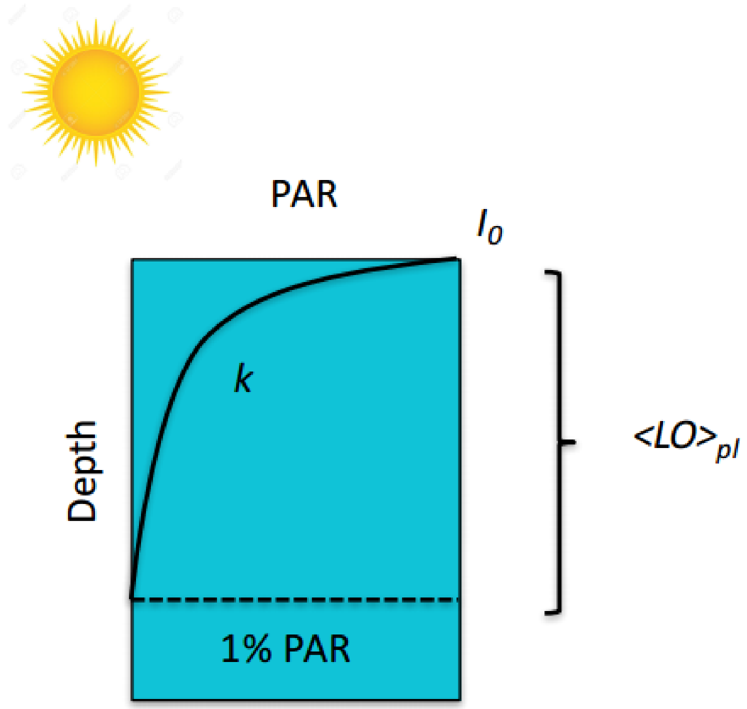
Nutrient supply

$$NO_3^-\ diffusive\ flux = -Kz \cdot \left(\frac{d[NO_3^-]}{dz}\right)$$

$$NO_3^-\ advective\ flux\ = \frac{I_W\ x\ D}{A} \cdot\ [NO_3^-]_{bottom}$$

Light availability (LA)

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



I_0: Surface PAR (Photosynthetic Active radiation)

k: Light Attenuation Coefficient

LO_{pl}: Averaged photic layer Osmidov Scale $LO = (\varepsilon N^{-3})^{1/2}$