Do nutrients drive metabolic density-dependence?

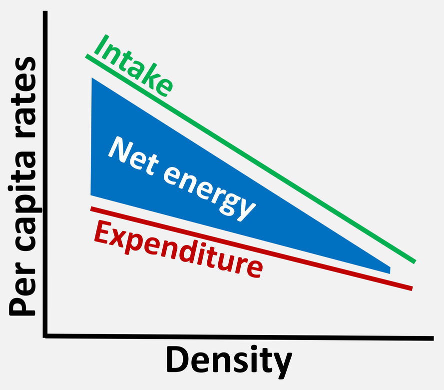
Functional Ecology group
Moritz Klaassen, Giulia Ghedini

Background

1. Negative density-dependence is widespread in nature and often observed as declines in body size and population growth rate in denser populations.

2. Declines in body size have been traditionally explained as a consequence of reduced resource intake but we now know that this is not the full picture.

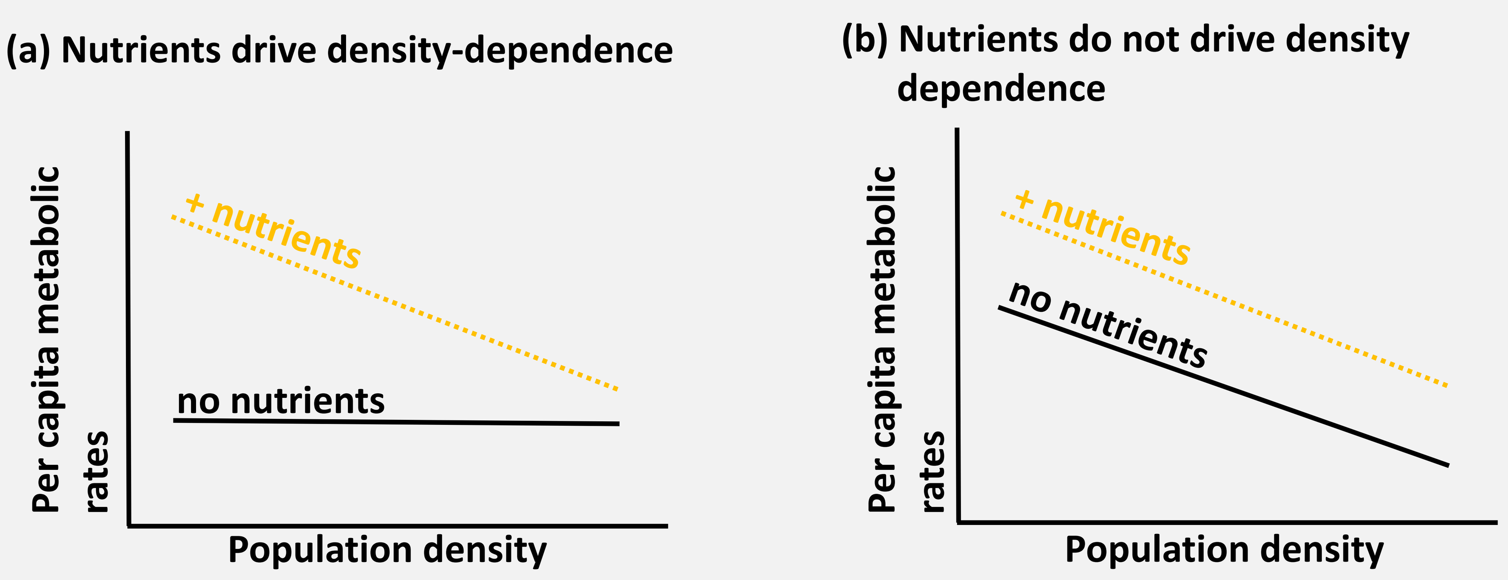
3. Both energy **intake** (feeding/photosynthesis) and **expenditure** (respiration rate) decline with density but intake typically declines faster, reducing **net energy** for growth and reproduction [1,2]



4. But what drives reductions in energy expenditure? Since intake and expenditure are affected by density in different ways, resource availability might not be the only driver. Recent work indeed suggests that organisms might actively downregulate energy expenditure in response to crowding (e.g. when perceiving conspecific cues) [3].

Aim

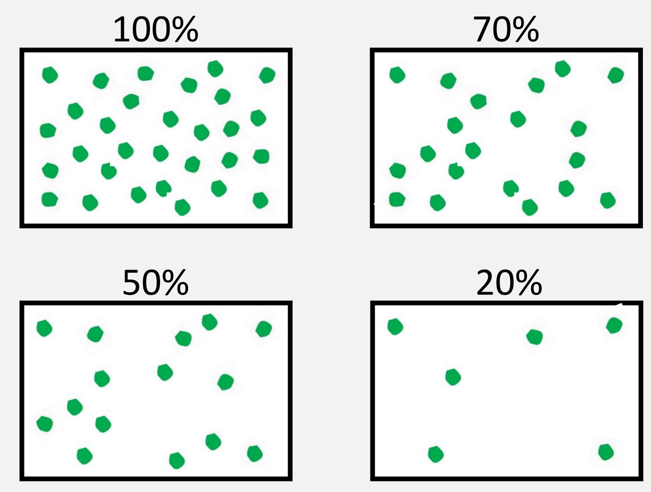
We aim to disentangle the importance of nutrients and crowding on metabolic density-dependence in marine phytoplankton and hypothesize:



Methods

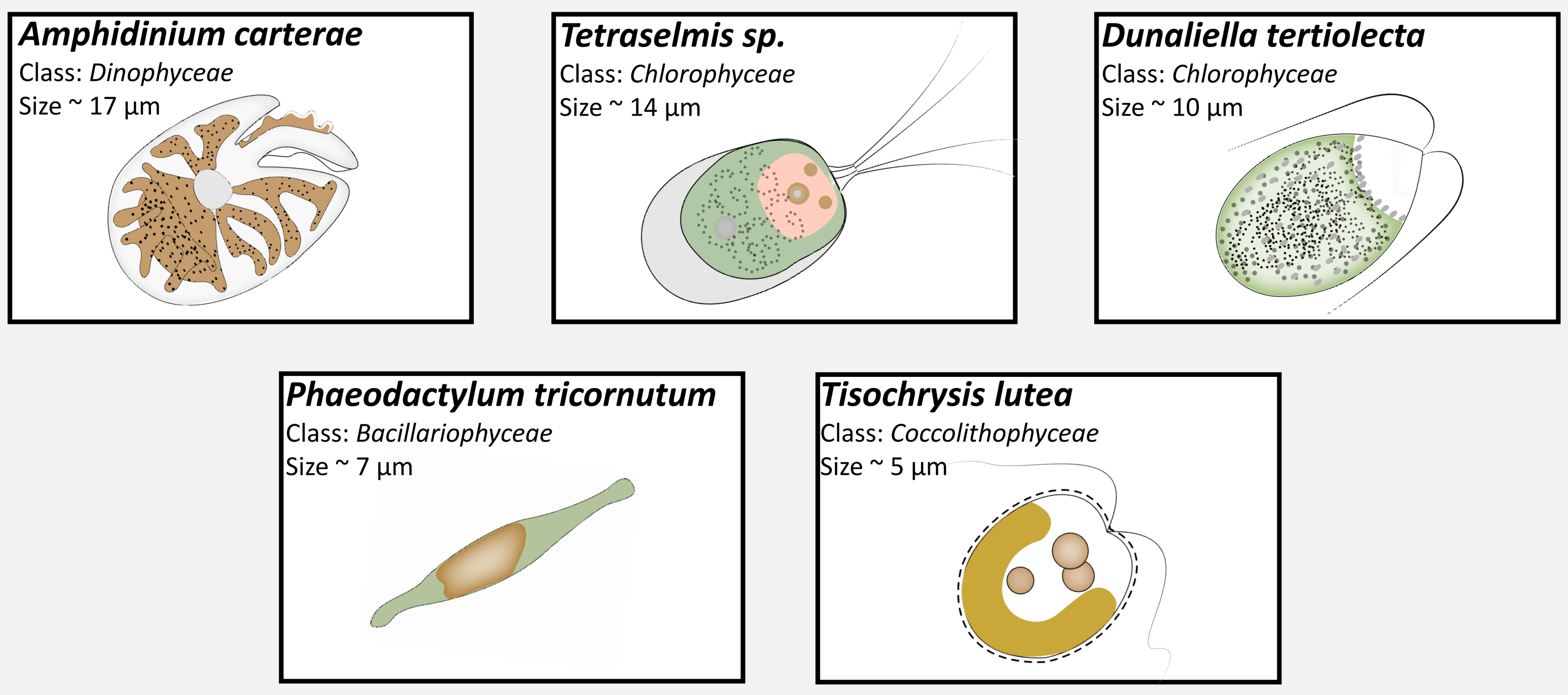
1. Nutrient Removal:
- Repeated centrifugation of individual phytoplankton species.
- Resuspension of algal pellets in two artificial seawater (ASW) media: nutrient-free (ASW) and nutrient-rich (ASW F)[4].

2. Density Manipulation:
- Diluted species to a standardized biovolume of 600,000 µm³/µl and created 70%, 50%, and 20% dilutions for both nutrient conditions.

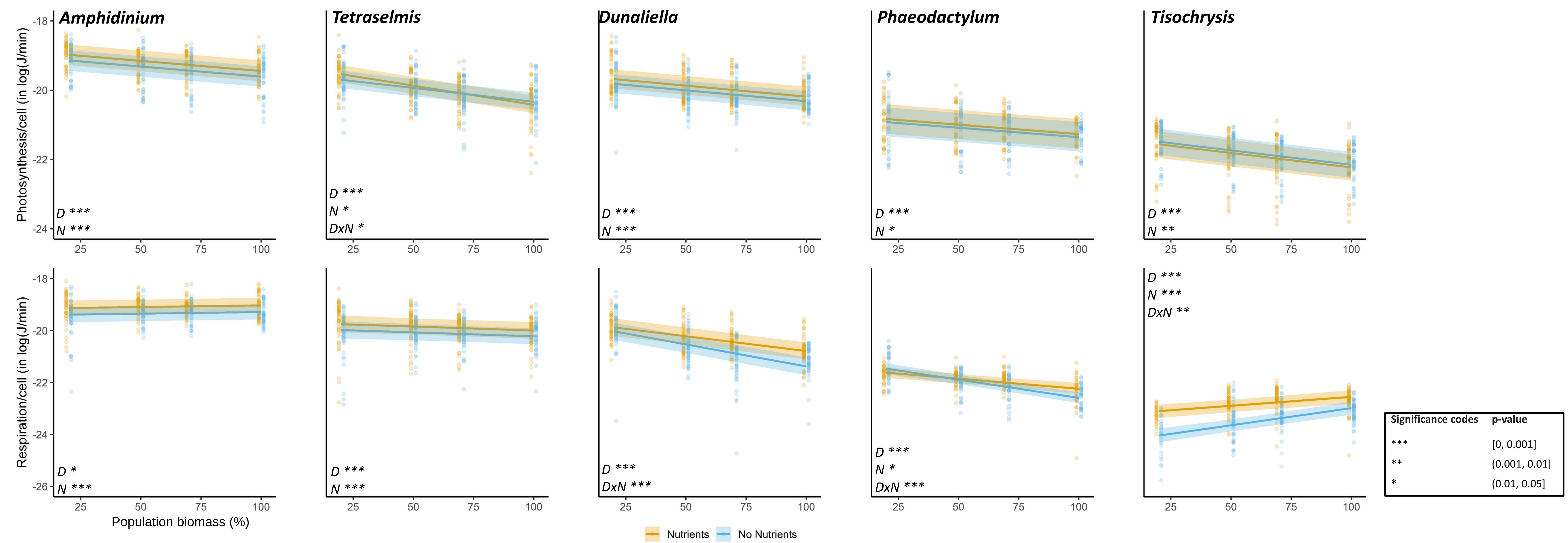


3. Respirometry:
- Measured oxygen evolution rates (photosynthesis, respiration) using sensor dish readers (PreSens, Germany)
- Calculated metabolic rates (VO_2; µmol O_2/min) and converted rates to energy production and consumption (J/min/cell) for analysis.

Study species



Results



Discussion

- Overall, as expected, phytoplankton cells have **higher metabolic rates with nutrients** relative to treatments without nutrients. Photosynthesis responds more consistently than respiration to nutrients across species.

- However, our results suggest that **nutrients are not the main driver of metabolic density-dependence** because in most cases cells alter their metabolic activity in a similar way with and without nutrients.

- These (preliminary) results suggest that these phytoplankton species might respond to crowding by altering their metabolic activity, potentially to anticipate future changes in resource abundance. We are now considering more explicitly the role of conspecific cues on metabolism and their interactions with other factors that might influence energy use in phytoplankton, such as **light availability** (more shading in denser populations).

- Understanding the mechanisms that govern **organismal energy use** is crucial for predicting population dynamics, particularly in the context of **shifting resource availability and changes in population abundances** resulting from human-driven environmental change.

GULBENKIAN SCIENCE
"la Caixa" Foundation

1. Ghedini et al. 2017. *Ecology.* doi: 10.1002/ecy.2033.
2. Noergaard et al. 2021. *Functional Ecology*. https://doi.org/10.1111/1365-2435.13721.
3. Lovass, et al. 2020. *Journal of Experimental Biology.* doi: 10.1242/jeb.224824.
4. Guillard RRL. 1975. *Cultures of Marine Invertebrate Animals.* doi.org/10.1007/978-1-4615-8714-9_3.

mklaassen@igc.gulbenkian.pt
gghedini@igc.gulbenkian.pt