

Phytoplankton trait-based modelling

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Outline

Introduction

Phytoplankton size-structure in the Atlantic Ocean

Phytoplankton size-based model

Phytoplankton and Zooplankton size-based model

Phytoplankton size evolution

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Traits in ecology

"Traits are a well-defined, quantitative properties of organisms, usually measured at the individual level and used comparatively across species"

McGill et al., 2006

Trade-offs

Traits are subject to trade-offs!

"A trade-off is a negative relationship between two traits where an increase in one is associated with a decrease in the other"

Tilman, 2000

Trade-offs

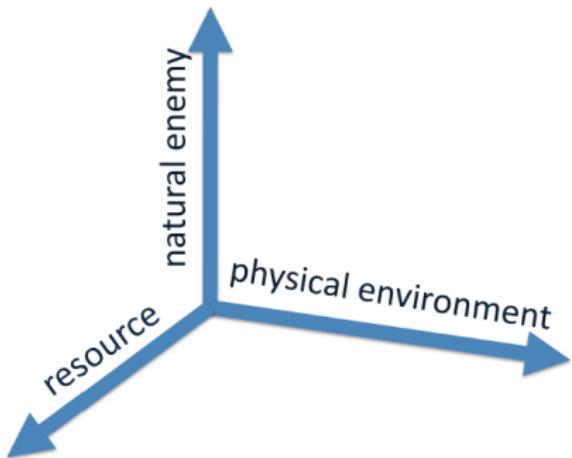


vs.

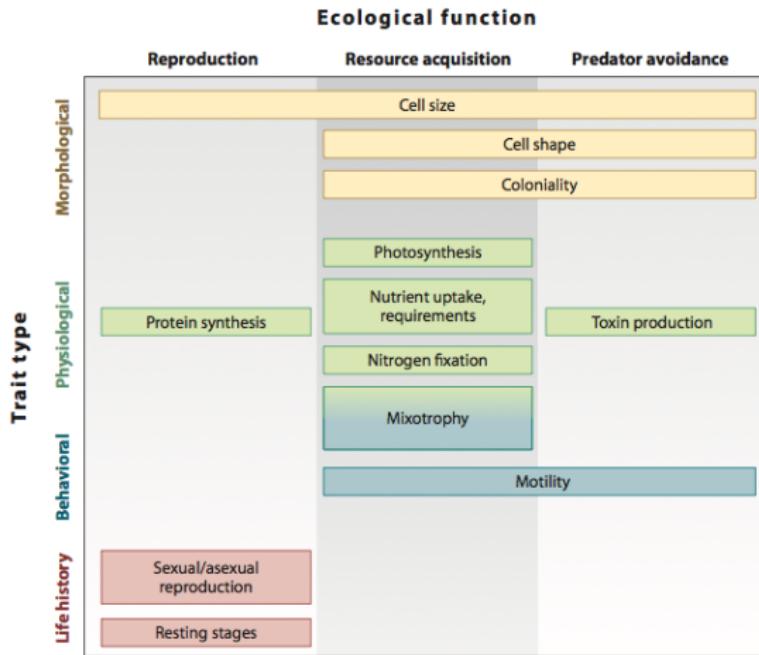


Phytoplankton traits

for each of these axes a whole hierarchy of traits exists that allow phytoplankton to survive and reproduce in the environment

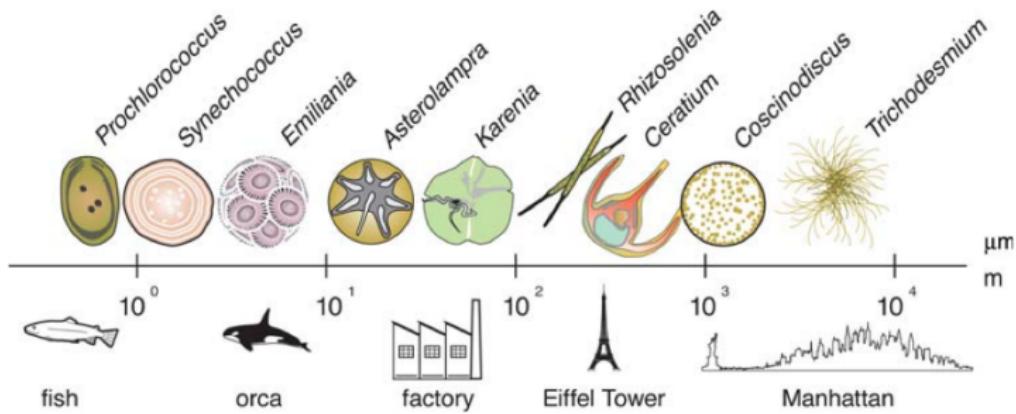


Phytoplankton traits



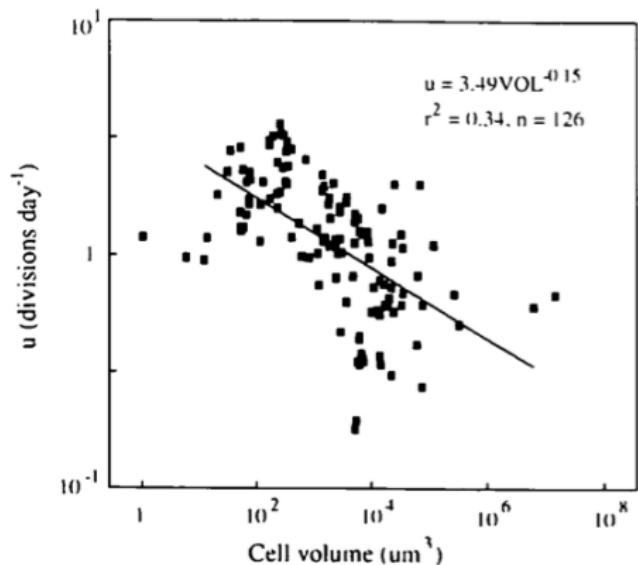
Litchman et. al., 2008

Cell size



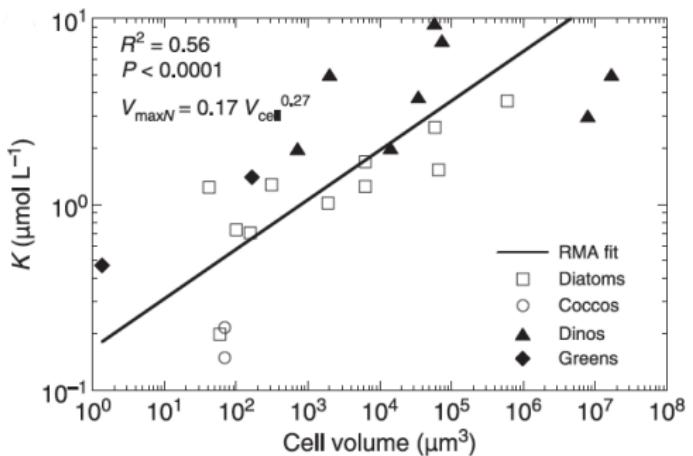
Finkel et. al., 2009

Cell size vs. growth



smaller phytoplankton grows faster

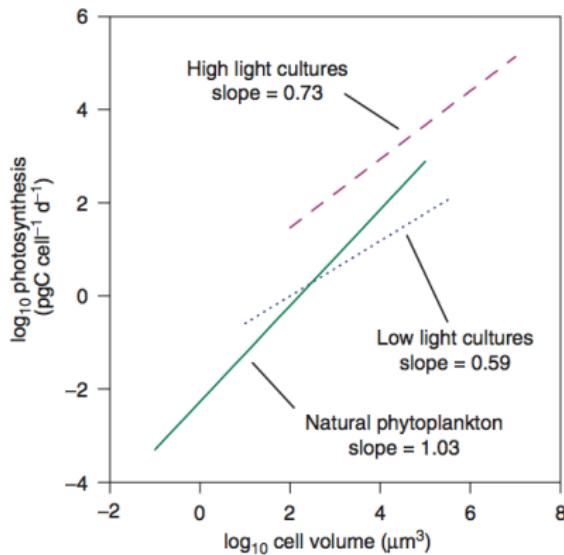
Cell size vs. nutrients



smaller phytoplankton requires less nutrients

Litchman et al., 2007

Cell size vs. photosynthesis

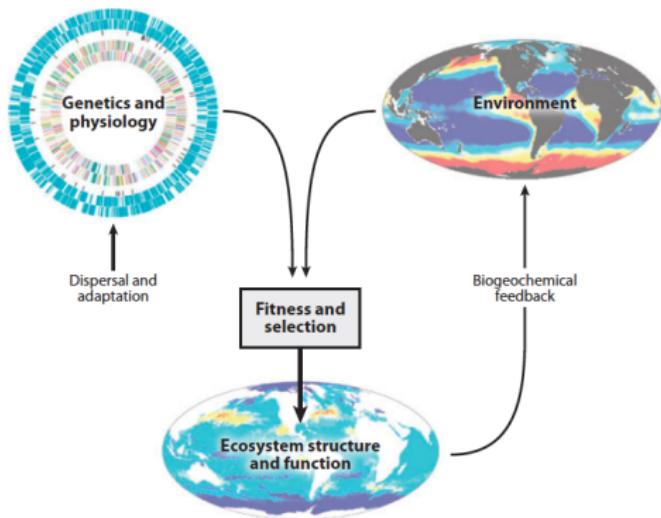


smaller phytoplankton photosynthesizes more efficiently

Importance of the environmental conditions

"Everything is everywhere, but the environment selects"

Baas Becking, 1934



Follols and Dutkiewicz, 2011

Research questions

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2. Which are the major drivers that shape phytoplankton communities in the Atlantic Ocean?
3. What is the relative contribution of bottom-up and top-down controls?
4. What is the relative contribution of these controls at long term environmental regimes?

Tasks

1. Select an appropriate dataset and develop a trait-based characterization of phytoplankton communities in contrasting regions of the Atlantic Ocean.

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2. Implement a size-based model to understand the factors shaping the phytoplankton community structure in contrasting regions of the Atlantic.
3. Extend the proposed size-based model to incorporate a trait-based mechanistic description also for the zooplankton community.
4. If time allows, set up the model for long-term evolutionary studies in order to understand the factors that shapes phytoplankton size evolution through geological times.

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Phytoplankton size-structure in the Atlantic Ocean

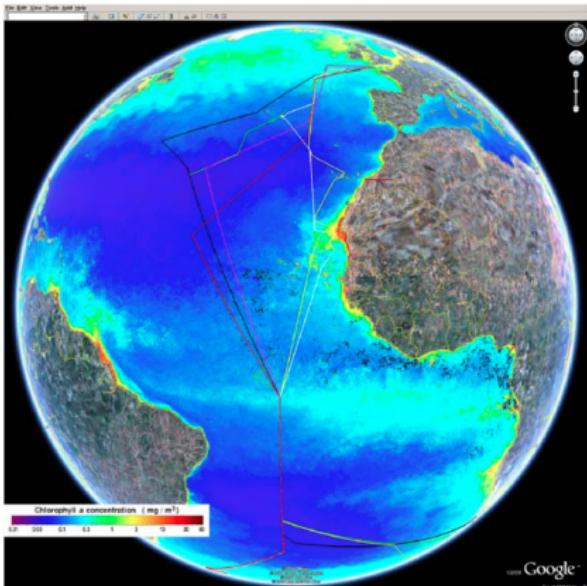
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Background

The Atlantic Meridional Transect Programme

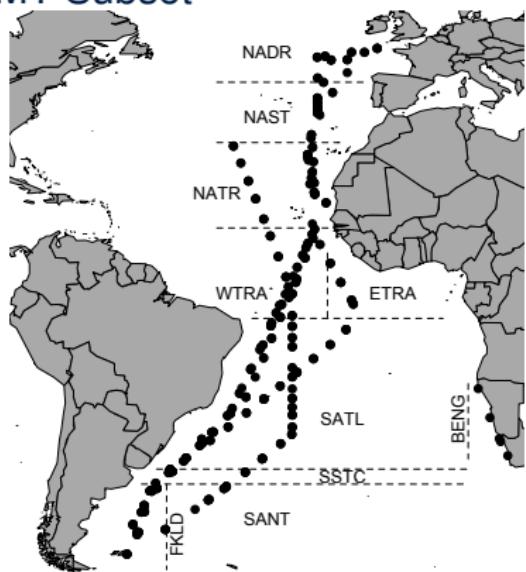


- From 1995- until now
- Twice a year
- Total 21 cruises
- Phytoplankton size-fractions, Nutrients...

Robinson et al., 2009

Methods

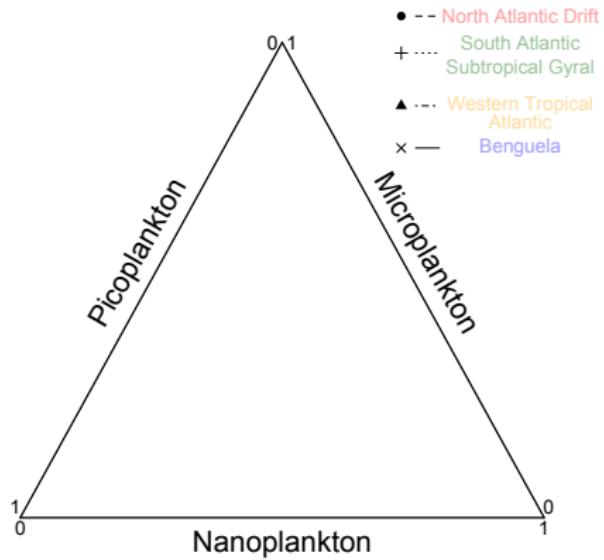
AMT Subset



- 9 AMT cruises
- 410 samples
- Pico-, nano-, and microplankton
- Longhurst (2006) classification
- K-means classification based on nutrients and temperature
- Environmental selection on the size-structured phytoplankton community

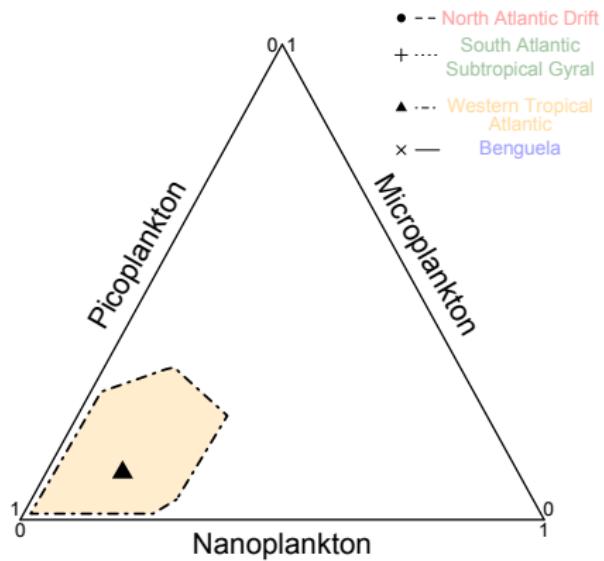
Major findings

Phytoplankton community structure - Longhurst



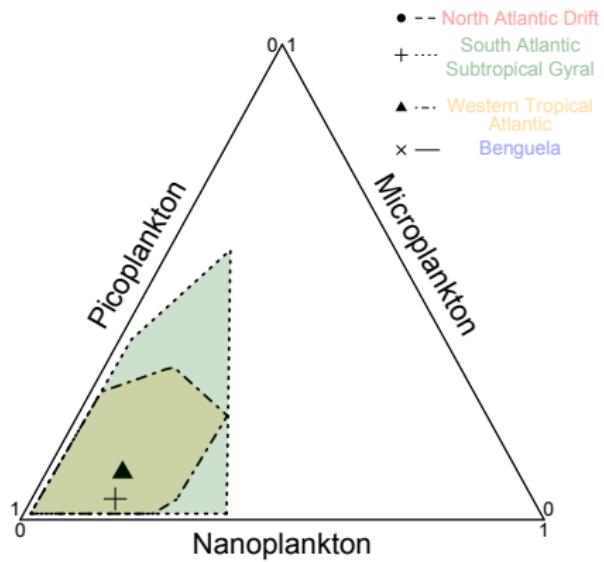
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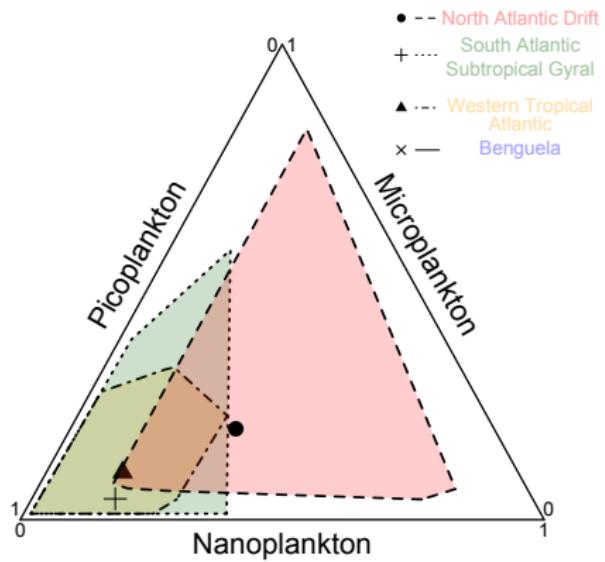
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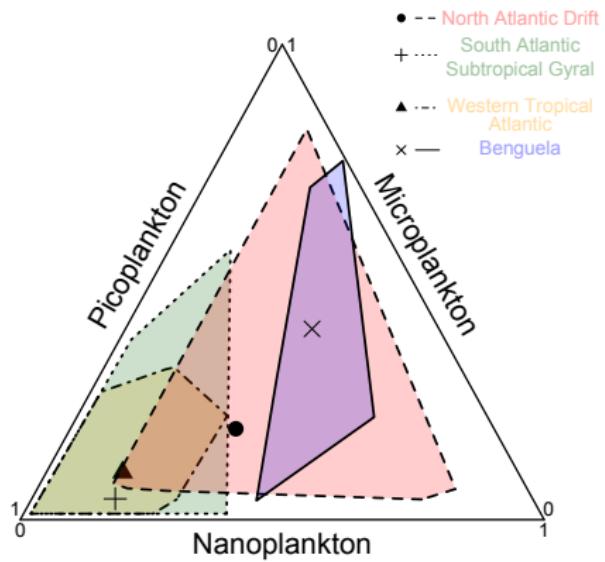
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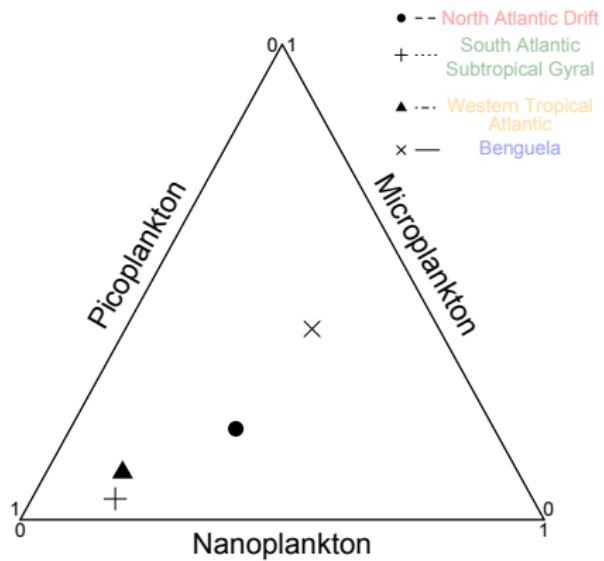
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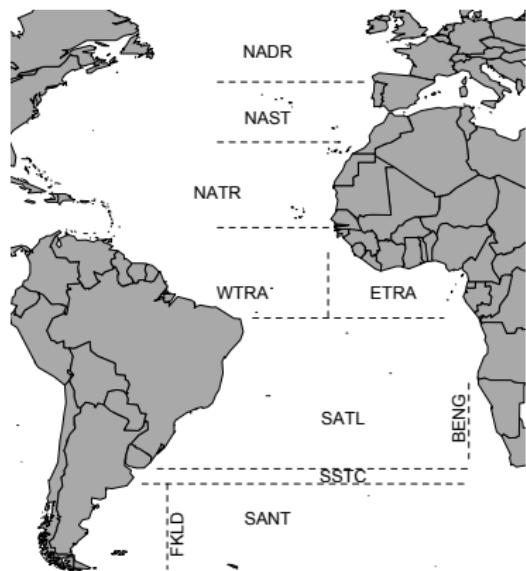
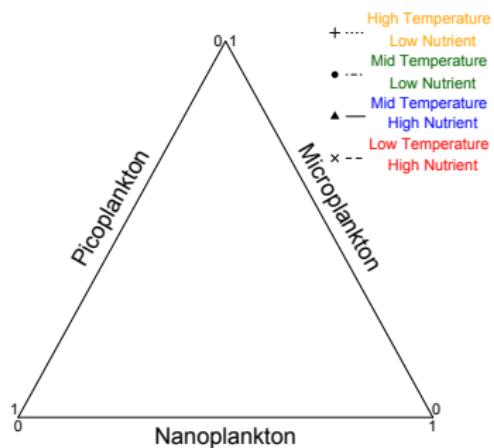
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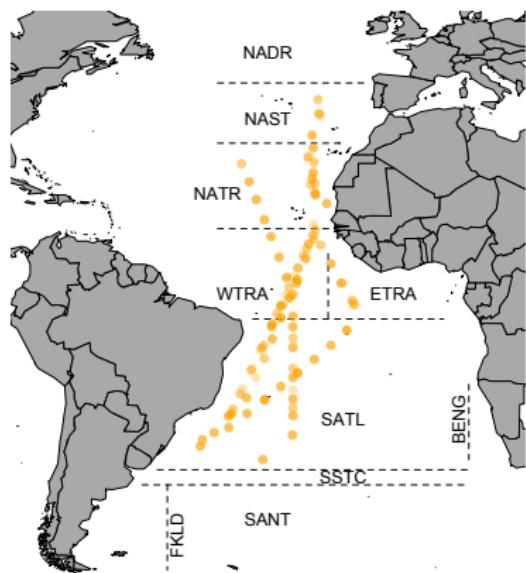
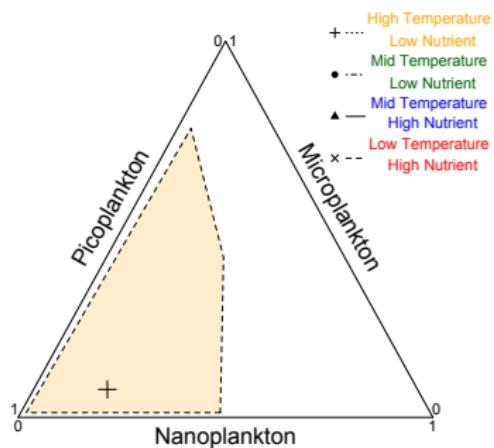
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Phytoplankton community structure - k-means clusters



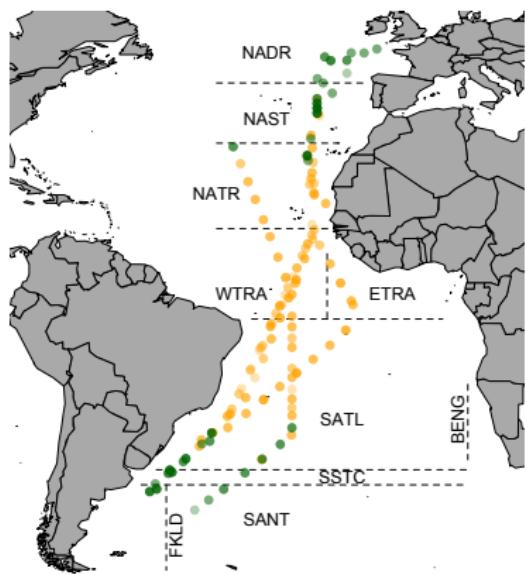
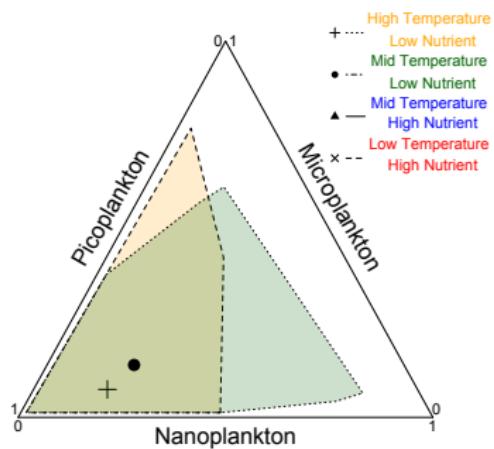
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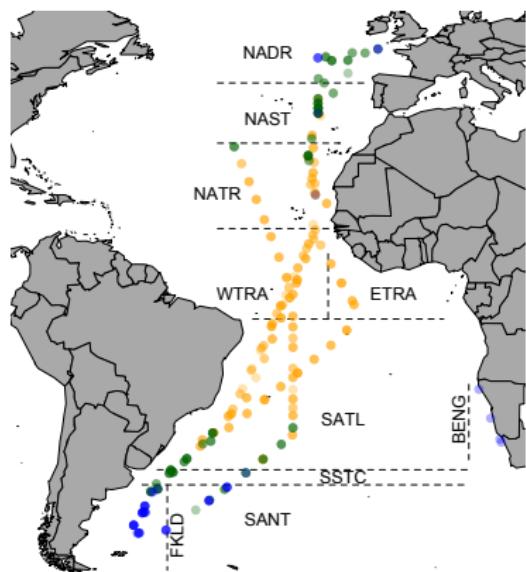
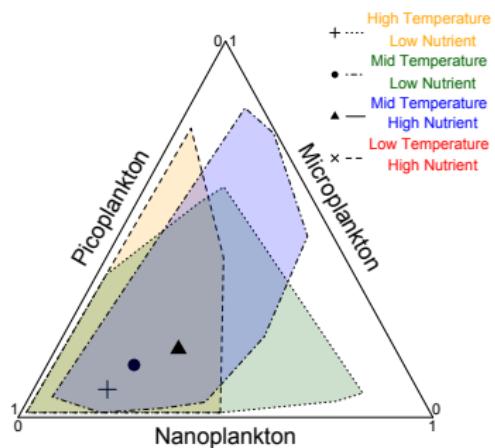
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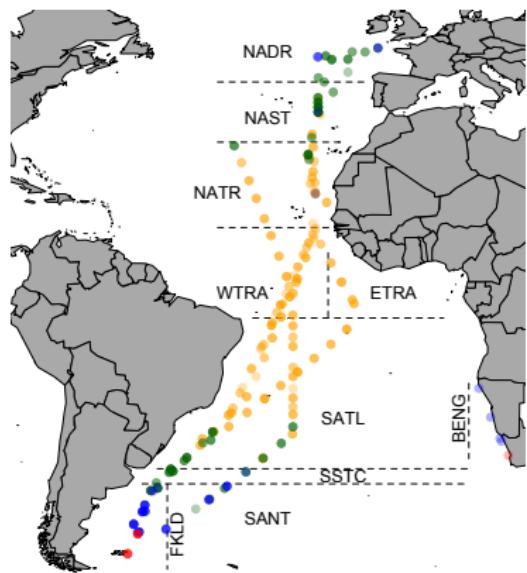
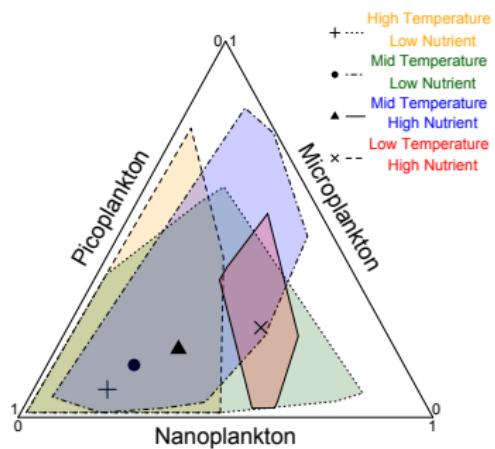
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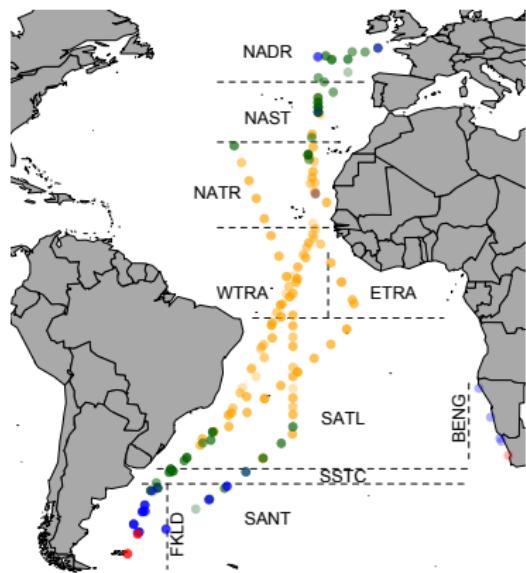
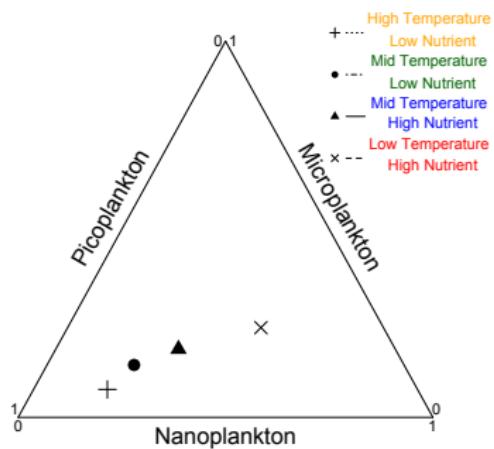
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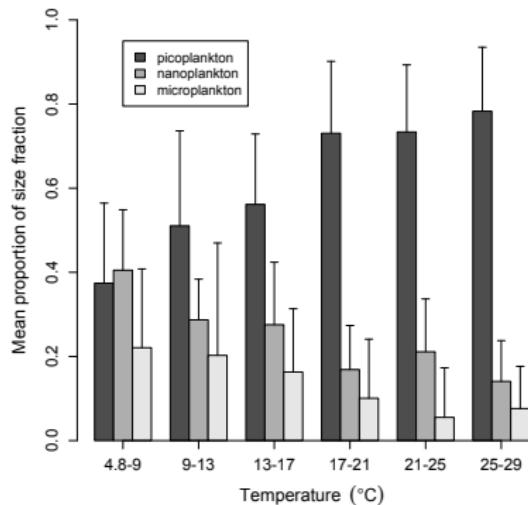
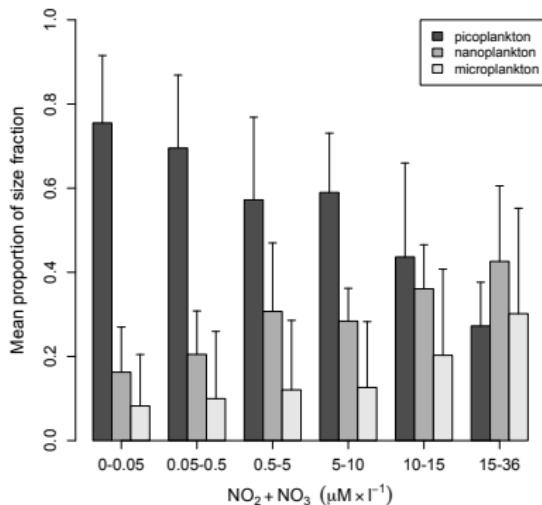
Major findings

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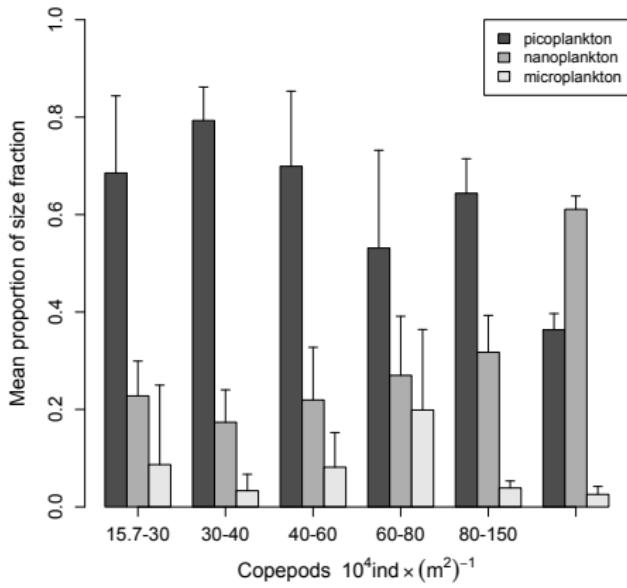
Major findings

Environmental selection- Nutrients and Temperature



Major findings

Environmental selection - Grazing pressure



Summary

- Environmental conditions strongly influence the trait distribution over large scales

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- Environmental conditions strongly influence the trait distribution over large scales
- Increased trend of mean size fractions in contrasting regions of the Atlantic
- Strong bottom-up controls on the phytoplankton community composition
- Our analysis captures remarkable features of the cell size variation at an ocean basin scale and irrespective of temporal changes

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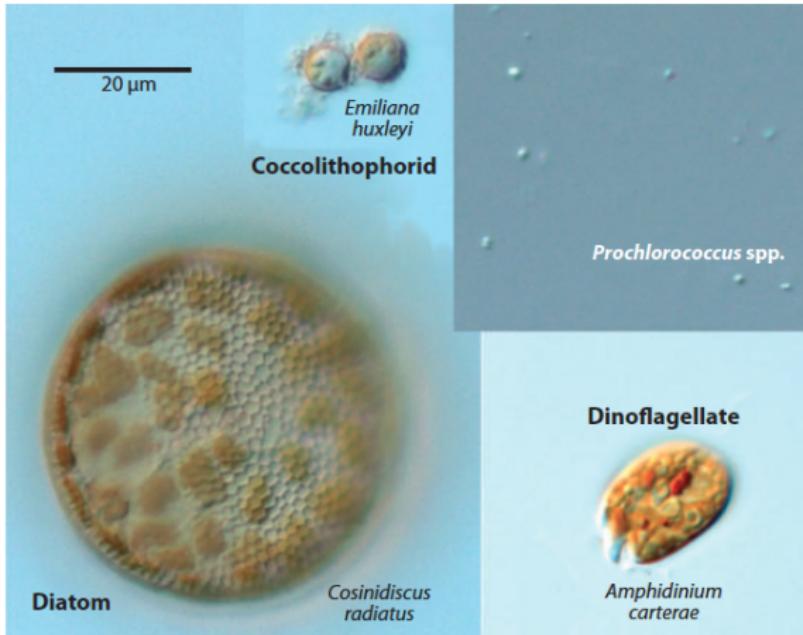
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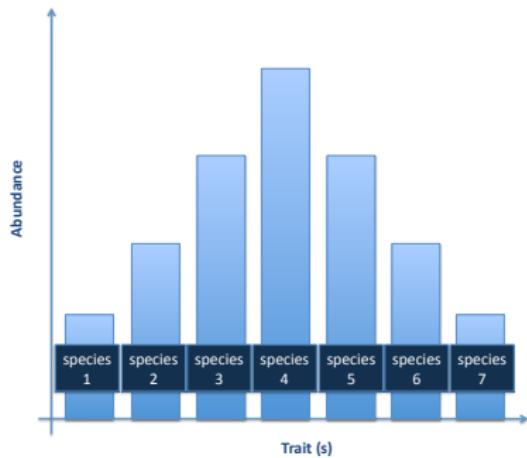
Phytoplankton size-based model



Follows and Dutkiewicz, 2011

Phytoplankton size-based model

Full model



$$\frac{dP_1}{dt} = r(s_1) P_1$$

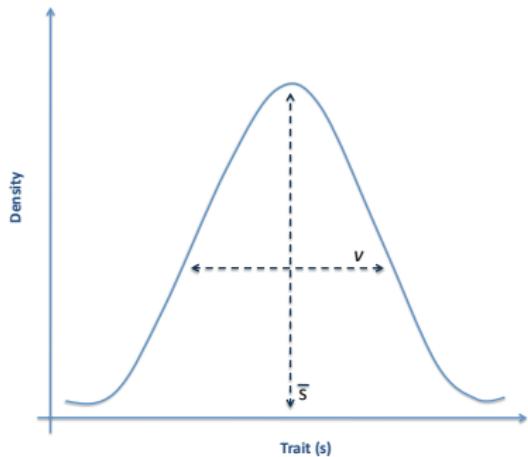
⋮

$$\frac{dP_n}{dt} = r(s_n) P_n$$

Merico, 2009

Phytoplankton size-based model

Aggregate model



$$\frac{dP_T}{dt} = \left[r(\bar{s}) + \frac{1}{2} v \frac{\partial^2 r(\bar{s})}{\partial s^2} \right] P_T$$

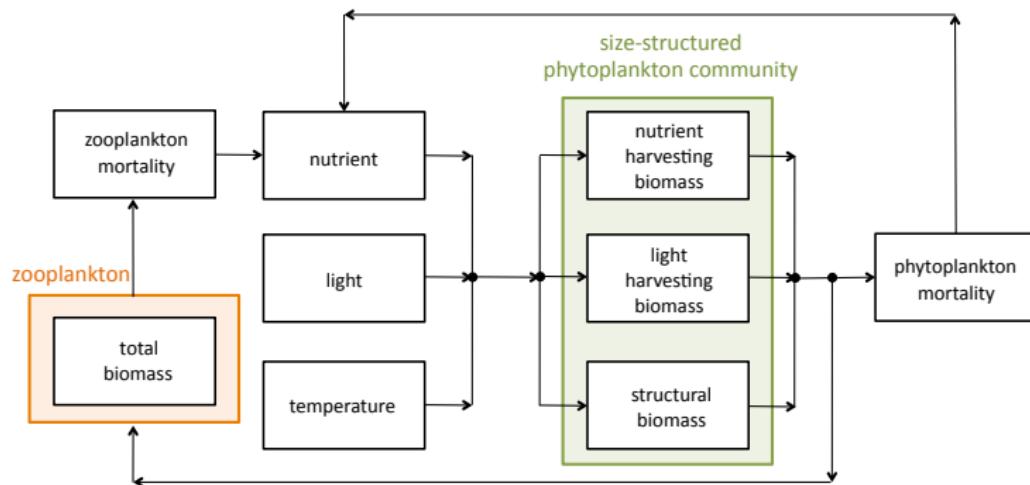
$$\frac{d\bar{s}}{dt} = v \frac{\partial r(\bar{s})}{\partial s}$$

$$\frac{dv}{dt} = v^2 \frac{\partial^2 r(\bar{s})}{\partial s^2}$$

Merico, 2009

Phytoplankton size-based model

Model Scheme



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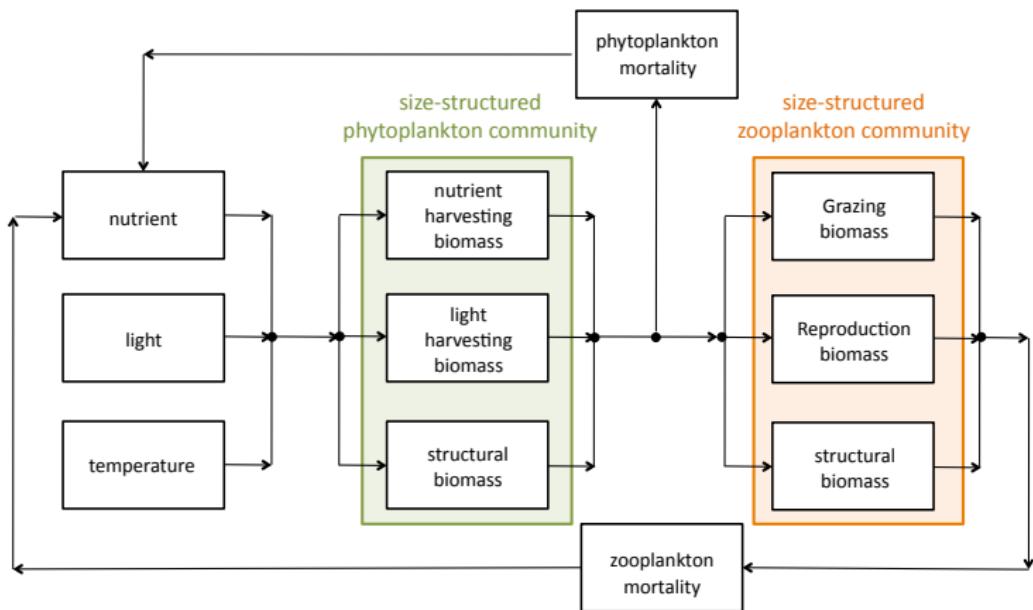
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Phyto- and Zooplankton size-based model

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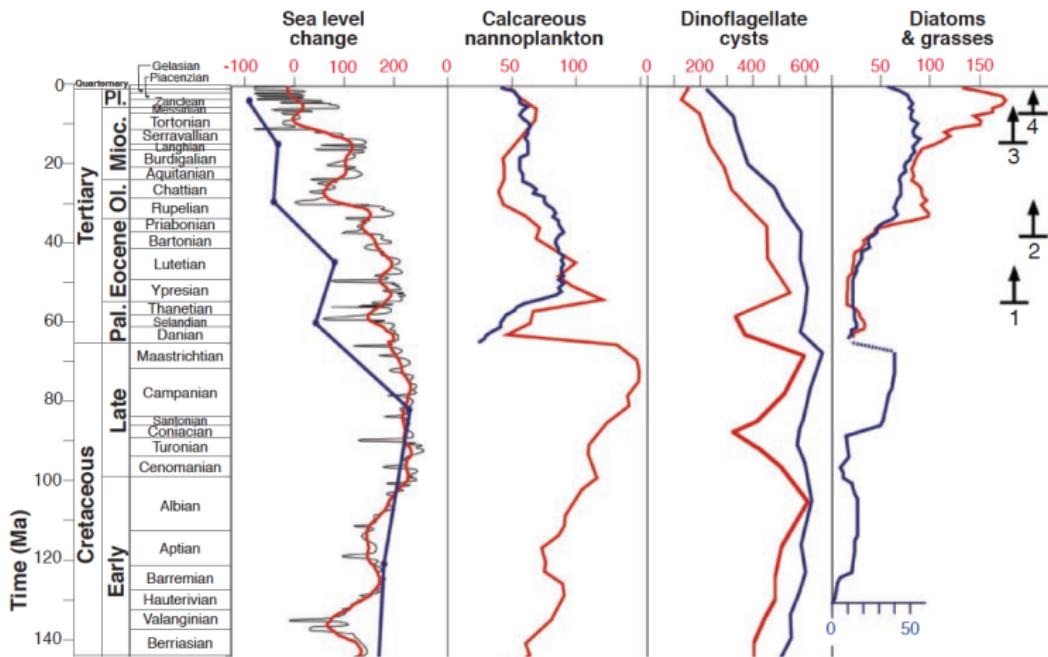
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Falkowski, 2004

Thank you for your attention...

Does size really matters?



In the case of Phytoplankton...Yes it does!!