In situ imaging highlight the important role of giant mesopelagic protists in the biogeochemical cycles of carbon and silicon

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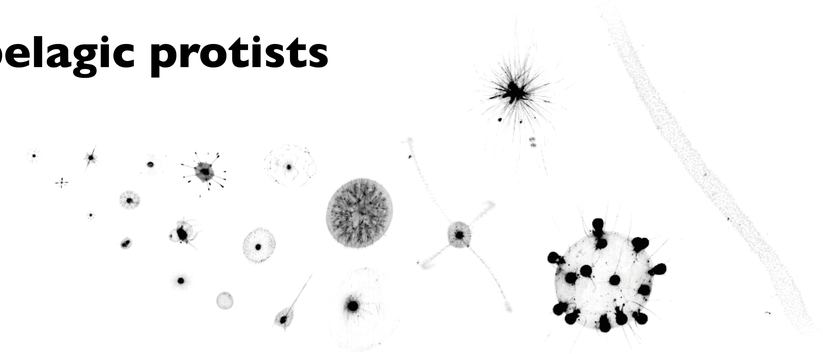


Introduction

Rhizaria are an ancient lineage of protists among which **planktonic taxa** have evolved to populate modern oceans from the surface to the abyss[1]. They cover a wide size range (a few µm to several cm), the largest specimens being referred to as **giant protists**. In the current classification, planktonic Rhizaria include **Phaeodaria**, **Radiolaria** and Foraminifera. The first two mostly biomineralize siliceous skeletons. They possess various trophic modes while inhabiting different ecological niches. Many Radiolaria dwelling in the sunlit layers of the ocean (Collodaria & Acantharia) are **mixotrophic** (symbiosis with microalgae). Phaeodaria, dwelling deeper in the oceans, are detrivorous, feeding upon sinking aggregates.

Because **traditional sampling techniques damage** their most fragile representatives, especially larger ones, **Rhizaria have often been neglected in biogeochemical studies**. Still, during the last decade, considerable progress in quantifying the abundance of these fragile zooplanktonic organisms could be achieved thanks to the fast development of **in situ imaging** tools. This revealed their s**ubstantial contribution to elemental stocks**[2] and **fluxes**[3] as well as their role as **gatekeepers of the Biological Carbon Pump**[4].

Nevertheless, an assessment of both their carbon and silica biomasses using accurate size to-volume allometric relationships, as well as their carbon demand and biogenic silica (bSi) production, has never been conducted globally. This leaves the full extent of their contribution and importance in biogeochemical cycles unclear and unquantified.

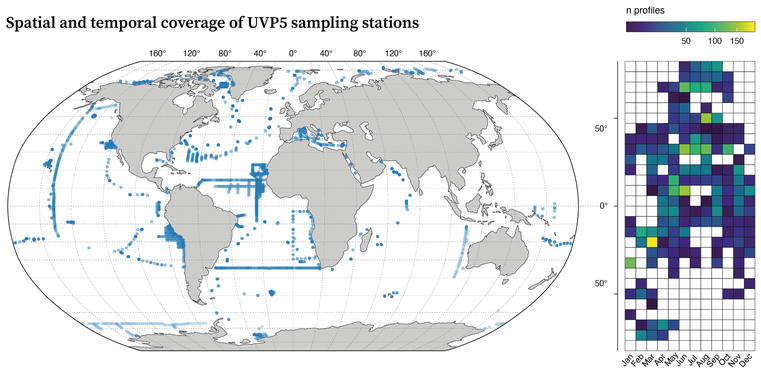
Methods

Data

We compiled a dataset composed of:

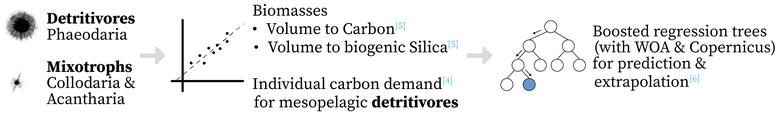
- 4 252 UVP5 (sd & hd) vertical profiles (0-1 000 m) collected between 2008-2021
- 167 551 manually validated & annotated Rhizaria images (size >600 µm)

Spatial and temporal coverage of UVP5 sampling stations



(Left) Geographical locations of the stations, (Right) seasonal distribution of sampling points according to latitude (squares colored proportionally to the sampling effort)

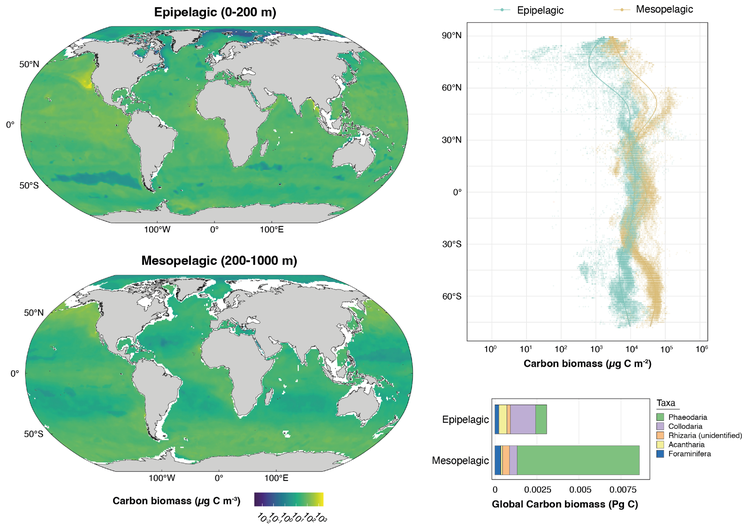
Model



Carbon cycle

Biomasses

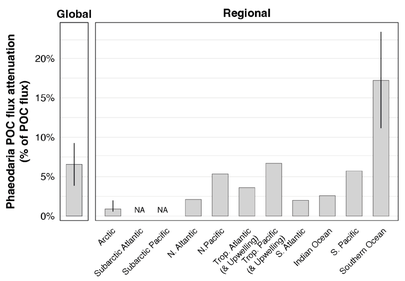
Predicted global organic carbon biomass in planktonic Rhizaria



- Pelagic Rhizaria are ubiquitous, with marked differences between trophic types
- Epipelagic Rhizaria biomass is dominated by **mixotrophs** (Collodaria & Acantharia). These can thrive in **oligotrophic gyres**
- Mesopelagic Rhizaria biomass **2x larger** than in the epipelagocand dominated by **detritivores** (= Phaeodaria)
- Overall biomasses 1-2 order(s) of magnitude lower than previously estimated (without dedicated V-to-C allometry)
- Prevalence of Rhizaria at **high latitudes** (in particular in the Austral Ocean) where they were previously though to be absent

Contribution to global carbon-flux attenuation

Global & regional contribution of mesopelagic Phaeodaria to gravitational carbon flux attenuation



Annual C demand = 0.46 Pg C y^{-1}

Detritivorous Rhizaria could attenuate ~3.8-9.2% of the gravitational POC flux exported out of the euphotic zone

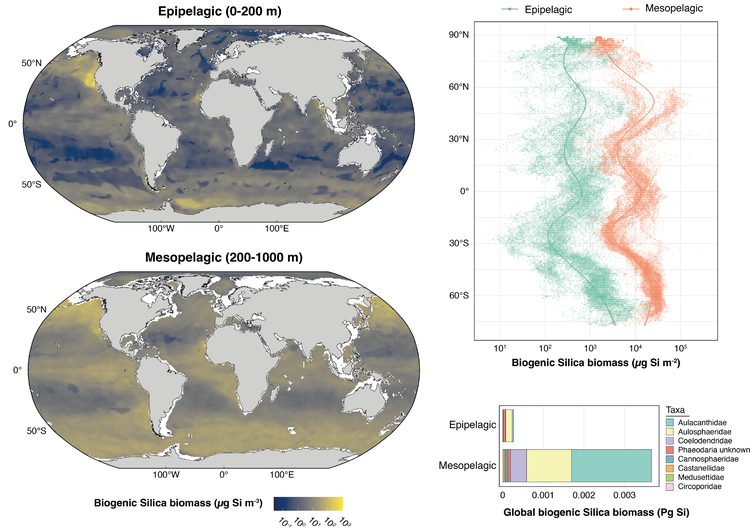
Consistent with local estimates [4]

- Important regional variability
- Since they can produce fecal pellets ('mini-pellets') do they contribute + or - to the carbon cycle?

Silica cycle

Biomasses

Predicted global biogenic silica biomass in silicifying planktonic Rhizaria



Epipelagic

Biomass = 0.34 Tg bSi (>600 µm)

→ 7-18% of integrated bSi pool (if <600 µm Rhizaria added)

Production = 0.70 Tg Si y^{-1} (>600 µm)

→ **Orders of magnitude lower than diatoms** (or even <600 µm Rhizaria)

Mesopelagic

Biomass = 3.91 Tg bSi (>600 µm)

→ 0-15% of integrated bSi pool (mostly represented by sinking bSi ?)

Production = 3.95 Tg Si y^{-1} (>600 µm)

→ **100% of production? No other taxa contribute to bSi production in the mesopelagic ocean !?**

Take home-messages

1. Despite their newly found low C biomass compared to metazoan zooplankton biomass, Rhizaria have **substantial biomasses throughout the water-column**
2. Trophic types explain vertical & horizontal distributions of planktonic Rhizaria
3. Detrivorous Rhizaria play an important role, never quantified at global scale, in **attenuating carbon fluxes worldwide**.
4. As Rhizaria **abundance increase with decreasing cell size**, the contribution of <600 µm Rhizaria to C and Si cycle is yet to be quantified

References

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Acknowledgments

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