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Integrative approach applied to the study of phytoplankton

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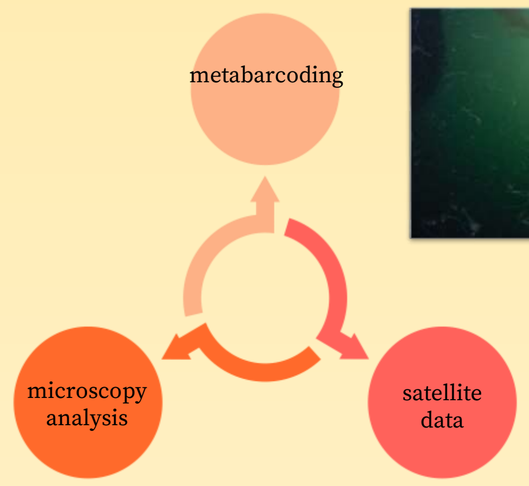
Introduction

Phytoplankton is essential for ecosystem services but are also responsible for harmful algal blooms (HABs) including mucilage phenomena that can exert significant consequences for human health and the environment. Traditionally, phytoplankton are analyzed using light and electron microscopy, which are time-consuming and require specialized taxonomic expertise. Molecular techniques, such as metabarcoding, provide deeper insights but lack quantitative data and are limited by incomplete reference databases. Additionally, satellite monitoring enables large-scale observations but requires ground-truth validation. By integrating microscopy, molecular methods, and remote sensing, a more comprehensive understanding of phytoplankton dynamics and their role in marine ecosystems can be achieved.

Oxygen production — **Carbon cycling & climate regulation** — **Indicator of environmental change** — **Harmful algal blooms & mucilage**

Aims of the PhD project

- **Study 1** Study the abundance and biodiversity of microalgae in mucilage aggregates in the Northern Adriatic Sea using metabarcoding & microscopy analysis
- **Study 2** Analyze phytoplankton communities by combining metabarcoding and microscopy, focusing on cryptic, small, and potentially toxic species that may escape microscopic detection in the LTER Senigallia coastal station
- **Study 3** Validate data obtained from satellite sensors, e.g., functional types, through the LTER Senigallia Susak Transect dataset
- **Study 4** Expand and validate molecular sequences present in the database, with focus on the potentially toxic microalgal species



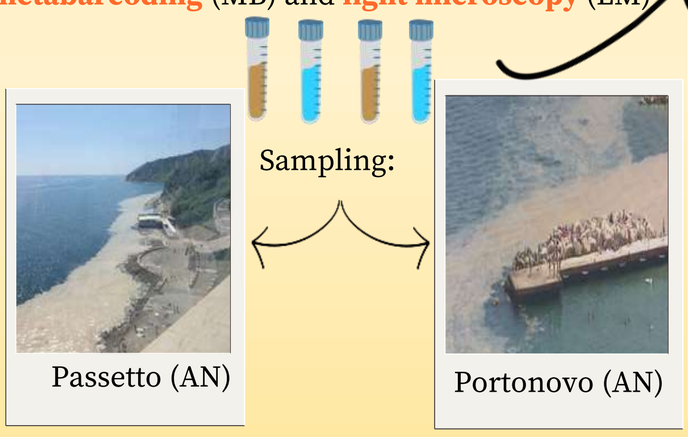
Study 1

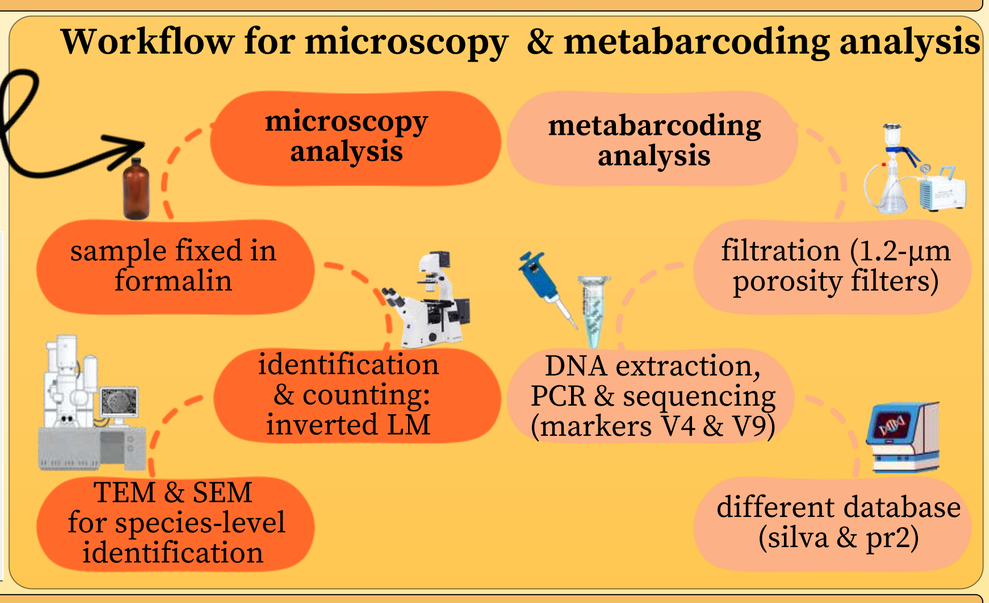
Introduction

- Large **mucilage aggregates** appearance is a phenomenon known **since 1729**. More recently they appeared in 1988-1990 and 1999-2002.
- In 2024 the phenomenon initiated in **early June near Rovinj**, spread counterclockwise along the Adriatic coast until Apulia.
- Mucilage event was highly dynamic. Aggregates shifted in shape, consistency, and location throughout the day due to wind and currents, moving up and down the water column depending on its turbulence and stability.
- The phenomenon persisted for approximately 3 months, classified as a non-toxic HAB, the mucilage had significant impacts (tourism, fishery, aquaculture).

Material & Methods

Throughout the duration of the phenomenon, weekly samples of **mucilage** and **surrounding water** were collected and analyzed using both **metabarcoding** (MB) and **light microscopy** (LM)

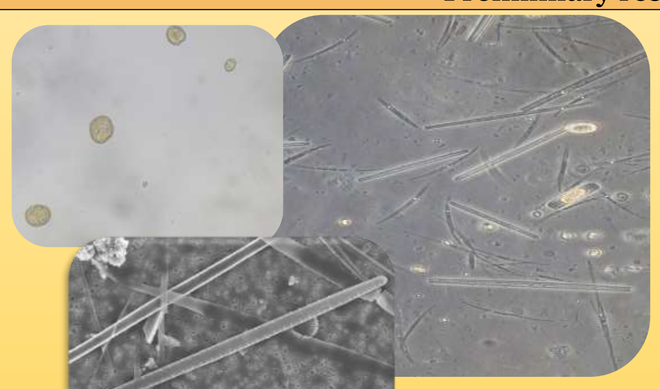


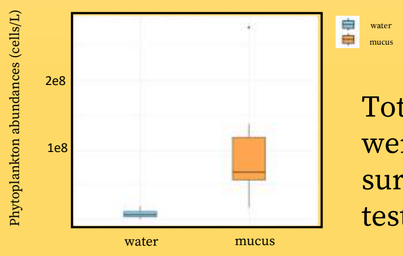


Preliminary results

Microscopy analysis showed:

- Starting phase: a high abundance of *Gonyaulax fragilis*
- Later, dominant species within the mucilage were: *Nitzschia* sp., *Nitzschia gobbii* and *Thalassionema nitzschoides*, while only empty thecae of *G. fragilis* were observed.

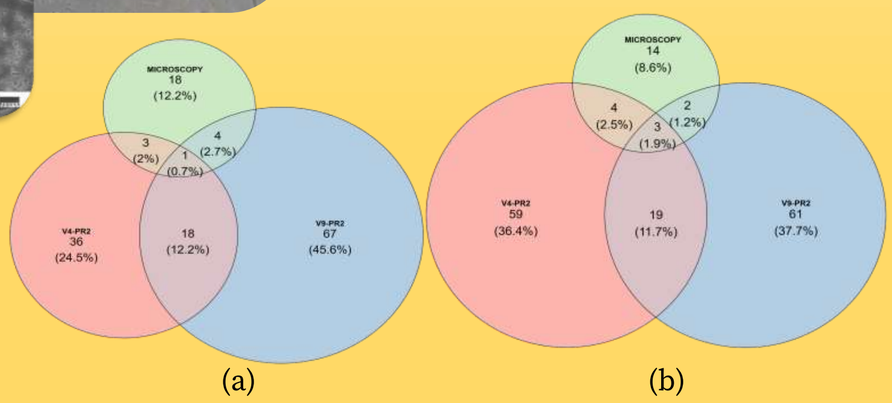




Total abundances in mucilage were significantly higher than in surrounding water (Wilcoxon test, p value < 0.05)

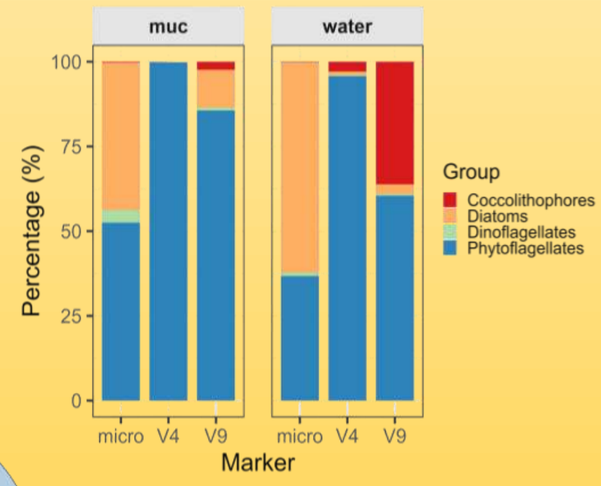
Metabarcoding analysis

Venn diagrams representing the number of shared and unique species of mucus (a) and water (b) considering LM and MB, using V4 and V9 18S rRNA regions and PR2 as reference databases for the taxonomic assignment.



(a) (b)

MB revealed a higher biodiversity than LM.



Percent composition of phytoplankton community by LM, MB V4 (PR2) and MB V9 (PR2).

Preliminary conclusions

As already observed in other areas worldwide, this phenomenon began with a bloom of the dinoflagellate *Gonyaulax fragilis*.

When the bloom declined, the rupture of the thecae released a high amount of sticky polysaccharide rich cytoplasmic content. This likely acted as a trigger for the formation of larger aggregates.

Later aggregates hosted a rich and diversified diatom community that contributed to the mucilage enlargement and evolution.