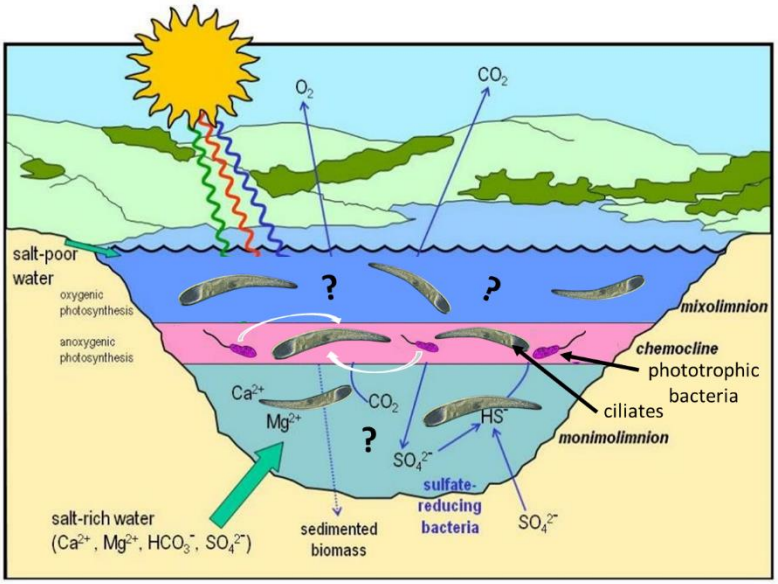
Master project for the year 2021

A microbial whale – the giant ciliate *Spirostomum teres* feeding on phototrophic bacteria in Lake Cadagno (Ticino)

Background

Lake Cadagno is a permanently stratified (meromictic) lake located at 1921 m asl. in the beautiful Piora valley, in the southern part of the Swiss Alps (46°33' N, 8°43' E). The permanent water stratification allows in a depth of 12-14 m (the chemocline) for the development of a dense community of anaerobic phototrophic sulfur bacteria (Danza et al. 2018), which use reduced sulfur compounds as electron donors for CO_2 fixation (Storelli et al. 2013; Luedin et al. 2019).



The **motile purple sulfur bacterium (PSB)** ***Chromatium okenii*** can mix small portions of water by a mechanism called **bioconvection** (Sommer et al. 2017). Indeed, when such microbes accumulate locally in a layer, the density of the water increases. This layer of heavier on top of lighter water sinks and mixes with the surrounding water. Continuous upward swimming of *C. okenii* provides the energy to maintain the water motion. However, details on the environmental drivers and ecological consequences of this bioconvection are still unknown. It could be **an important evolutionary mechanism** that makes ***C. okenii*** **an efficient competitor** for other microbial taxa present in the chemocline. This is of interest as these less abundant taxa, such as green sulfur bacteria (GSB), would even have higher affinity to light and H_2S (SNF BIOCAD project). However, **bacteria live not alone in this layer**, but are confronted with **potential predators**. Only recently, we discovered **high numbers of a giant ciliate, *Spirostomum teres*** (up to 0.6 mm long), which seems to efficiently graze on *C. okenii*. It is **still unclear which impact the feeding of the ciliate has** on *C. okenii* and on **the total bacterial community**. Additionally, it is still not known if the occurrence of ciliates is restricted to the chemocline or if they (periodically?) migrate into other water layers.

Aim of the Master-thesis

The aim of this thesis is to investigate the occurrence of ciliates, more precisely of the species *Spirostomum teres*, in its natural environment (Lake Cadagno) and in the laboratory, verifying its ecological impact on the bacterial community and thus also on the bioconvection process. The project combines fieldwork related to regular sampling on Lake Cadagno with work in the laboratory, such as the cultivation of *S. teres* and feeding experiments with different bacteria.

Contact

We are looking for a highly motivated environmental science student interested to work in the laboratory, but also in the field to join several samplings at the meromictic Lake Cadagno (http://www.cadagno.ch/). The place of work will be half in Zürich at the Limnological Station (UZH), and half in Bellinzona at the Laboratory of applied microbiology from SUPSI.

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Short description of intended work and work packages (WP)

WP1: Spatial and temporal dynamics of *Spirostomum teres* & other bacterivores in Lake Cadagno

- Learn the identification and quantification procedure for ciliates, based on samples already collected in the year 2020 from Lake Cadagno.
- Describe the seasonal succession and fine scale diurnal dynamics of ciliates in the Lake Cadagno (from June to September 2021).
  Fieldwork with regular samplings on Lake Cadagno. This monitoring will be very useful to answer the following specific questions:
  - How is the movement of these aerobic ciliates in the anoxic bacterial layer regulated?
  - Does bioconvection alter interactions of the microbial community with zooplankton grazers at the upper limit of the chemocline? (*In situ* hybridization of food vacuoles)
  - Are there other zooplankton feeding on sulfur bacteria and thus competing with *S. teres*? Are ciliates the top-predators in the layer?

WP 2: Work with isolated organisms

The main purpose of this WP2 will be to define whether *S. teres* has a specific preference for one or the other anoxygenic phototrophic sulfur bacterium.

- Learn how to grow isolates of *S. teres* (already present) in Zürich (T. Posch Lab).
- Controlled feeding experiments with PSB (*Chromatium okenii*, *Thiodictyon syntrophicum*) and GSB (*Chlorobium pheobacteroides*), alone or in combination.
  This work will be done **in the laboratory** and will be important to answer the following specific questions:
  - Does *S. teres* choose its prey selectively?
  - Does the number of bacteria influence the feeding rates of *S. teres*?
  - Does the active movement of *C. okenii* (unique with scourge) affect the grazing behaviour of *S. teres*?

Indicative timetable and deliverables

Beginning 2021

Timetable will be created together with the Master-student.

References

Danza F., Ravasi D., Storelli N., Roman S., Lüdin S., Bueche M., Tonolla M. (2018) Bacterial diversity in the water column of meromictic Lake Cadagno and evidence for seasonal dynamics. PloS one 13: e0209743-e0209743.

Luedin S.M., Storelli N., Danza F., Roman S., Wittwer M., Pothier J.F., Tonolla M. (2019) Mixotrophic Growth Under Micro-Oxic Conditions in the Purple Sulfur Bacterium "*Thiodictyon syntrophicum*". Frontiers in Microbiology 10.

Sommer T., Danza F., Berg J., Sengupta A., Constantinescu G., Tokyay T., Bürgmann H., Dressler Y. Sepulveda Steiner O.R., Schubert C.J., Tonolla M., Wüest A. (2017). Bacteria-induced mixing in natural waters. Geophysical Research Letters 44:9424–9432.

Storelli N., Peduzzi S., Saad M.M., Frigaard N.U., Perret X., Tonolla M. (2013). CO_2 assimilation in the chemocline of Lake Cadagno is dominated by a few types of phototrophic purple sulfur bacteria. FEMS Microbiology Ecology 84(2):421-432.