Phytoplankton community responses to changes in the environment and ecosystem health

Summary

The PhD project aims to assess the health of marine ecosystems by measuring phytoplankton diversity and following changes in their community over various timescales and sea areas. Phytoplankton communities play a vital role in ecosystem health, and changes in species diversity and succession often signal environmental stressors such as eutrophication and increased sea surface temperatures. Furthermore, there are around 300 phytoplankton species associated with harmful algal blooms that, depending on the causative species, may have different harmful effects, such as mortality of cultured fish and invertebrates or toxin accumulation in the food chain. During recent decades, HAB species distribution, blooms, areas affected by HABs and toxicity events related with HAB species have expanded worldwide and among other factors it has also been linked to eutrophication and global change. During the proposed project, interactions and shifts in phytoplankton communities will be monitored in parallel with various environmental parameters. Phytoplankton community composition will be identified by using both traditional morphology-based identification and environmental DNA-based detection. The data used in this project has been collected over several years from the same locations and the sampling will also continue during the duration of the project to capture changes over longer timescales. The results of this work will provide an insight into variability in the phytoplankton community composition, potential interactions between the species and how physical-chemical parameters drive or contribute to the detected changes. This information will be invaluable for understanding the responses of the phytoplankton community to future changes in the marine environment and the overall functioning of marine ecosystems.

Research field:	Earth sciences
Supervisors:	Dr. Maria Cecilia Sarmiento Guerin Sirje Sildever
Availability:	This position is available.
Offered by:	School of Science Department of Marine Systems
Application deadline:	Applications are accepted between June 01, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

The research

Marine ecosystems provide numerous invaluable services, such as food resources, carbon fixation, and thus information on their ecological status is needed. One approach to estimate this is through biodiversity: by analyzing changes in specific (indicator) species abundance or in the species composition of a particular group. Phytoplankton, an important group of primary producers in aquatic ecosystems, abundance, species composition and biomass, form one such indicator under the EU`s Marine Strategy Framework Directive. Phytoplankton species identification based on their morphological features under a light microscope is a standardized method used by many EU countries, including all countries surrounding the Baltic Sea.

However, this approach is time-consuming, requires good taxonomic expertise, and may not allow exact identification due to small size (< 20 µm), similar or variable morphology. Also, identification of some genera based on morphology may be further hampered by changes in morphology or rupture of cells due to the use of fixatives added to preserve the samples until analysis. Molecular tools, such as metabarcoding and environmental DNA (eDNA) based detection, may help to overcome those challenges. Metabarcoding facilitates simultaneous detection of a broad range of taxa based on eDNA. This has proven useful for capturing detailed information on the biodiversity present across the tree of life and led to the exponential growth of the knowledge available, both in terms of previously undescribed biodiversity as well as on the spatial and temporal distribution of the described species.

Time series monitoring is especially useful for determining the natural variability, fluctuations, and changes in community composition. Biological and environmental data collected over longer timescales form a basis for a realistic understanding of human-induced changes in marine communities. Time series monitoring using a combination of metabarcoding data has already proven successful for detecting patterns in communities or specific organisms in

relation to changes in biodiversity, environmental parameters, seasons and anomalous climate effects. High-resolution data in combination with machine learning has been successfully employed to identify the environmental parameters associated with harmful algal blooms. While machine learning can be utilized to predict community dynamics, data mining can be used to unveil previously unknown patterns in species co-occurrence. The application of both approaches based on high-resolution long-term data may further unravel the processes related to the shifts between and within dominant phytoplankton groups. Changes between the dominating groups directly influence the nutrient pool available after the spring bloom, which can promote or suppress cyanobacterial blooms in summer. The different groups also vary in the input of organic matter and thus have a direct impact on the oxygen conditions on the sea floor.

The goal of this Ph.D. project is to provide detailed knowledge on the changes in phytoplankton communities over various timescales. This generates an understanding of how the communities respond to the changes in their environment.

The thesis should address the following questions: 1) Which timescales are more suitable to detect ecologically meaningful changes in phytoplankton communities? 2) Are there differences between sea areas in the trends displayed by the phytoplankton community? 3) What are the future perspectives of the microalgal community to handle changes in environmental parameters?

Supervisors

Main supervisor: Assistant Prof. Sirje Sildever (TalTech)

Co-supervisors: Senior Researcher Cecilia Sarmiento (TalTech) and Researcher Conny Sjöqvist (Åbo Akademi University, Finland).

Responsibilities and (foreseen) tasks

- Participation in collecting seawater samples;
- Analyzing phytoplankton samples by light microscopy;
- Molecular work: DNA extraction from seawater samples, PCR, preparation of samples for sequencing;
- Bioinformatics: analysis of sequencing results;
- Downloading environmental data from public databases and analyzing the data;
- Analysis and synthesis of the results, preparation of manuscripts;
- Support teaching activities of Assistant Prof. Sirje Sildever and Senior Researcher Cecilia Sarmiento

Applicants should fulfill the following requirements:

- A master's degree in one of the following subjects: Science, Natural Sciences, Applied Chemistry and Biotechnology;
- A clear interest in the topic of the position;
- Experience in morphology-based analysis of phytoplankton samples;
- Experience with molecular work (DNA extraction, PCR, preparation for sequencing);
- Experience with working with the results of metabarcoding;
- Excellent command of English;
- Strong and demonstrable writing and analytical skills;
- Capacity to work both as an independent researcher and as part of an international team;
- Capacity and willingness to assist in organizational tasks relevant to the project.

The following experience is beneficial:

- Experience with bioinformatics;
- Working knowledge of statistics and usage of R/R Studio or other software for statistical analysis;
- Experience with machine learning and data mining.

The candidate should submit a research plan for the topic, including the overall research and data collection strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

We offer:

- 4-year full-time (fully funded) PhD position in an outstanding Baltic Sea research institution with a large portfolio of ongoing pan-European and national public sector applied research projects;
- The chance to participate in research and applied science projects;

- Opportunities for conference visits, research stays, and networking with globally leading universities and research centers in the fields of marine and molecular ecology.

About the department

Tallinn University of Technology (TalTech), the only technological university in Estonia, is the flagship of Estonian engineering and natural sciences. Here the synergy between different fields (technological, natural, exact, economic, and health sciences) is created and new ideas are born.

The Department of Marine Systems at TalTech is a leading oceanographic and meteorological R&D unit in the Baltic Sea region. We focus (1) on marine ecology research, (2) on oceanographic process research based on scientific analysis to find cause-and-effect relationships, and (3) on developing marine monitoring and forecasting services. We have long-term experience in phytoplankton monitoring utilizing the traditional morphology-based approaches and are also employing molecular detection to improve the detection of microalgae and gain further information on their responses to the changes in the marine environment. We also represent Estonia in the ICES-IOC Working Group on Harmful Algal Bloom Dynamics. We collaborate closely with researchers from the Department of Geology and the Department of Chemistry and Biotechnology at TalTech. The Marine Ecology Laboratory has also a wide array of accredited workflows to provide services to public and private institutions and companies in the field of marine ecology.

(Additional information)

For further information, please contact Assistant Prof. Sirje Sildever (sirje.sildever@taltech.ee) and Senior Researcher Cecilia Sarmiento (cecilia.sarmiento@taltech.ee).

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