

# Climatology and trends in Chl-a and nutrients from FerryBox timeseries in the Baltic Sea

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## And some additional recent developments

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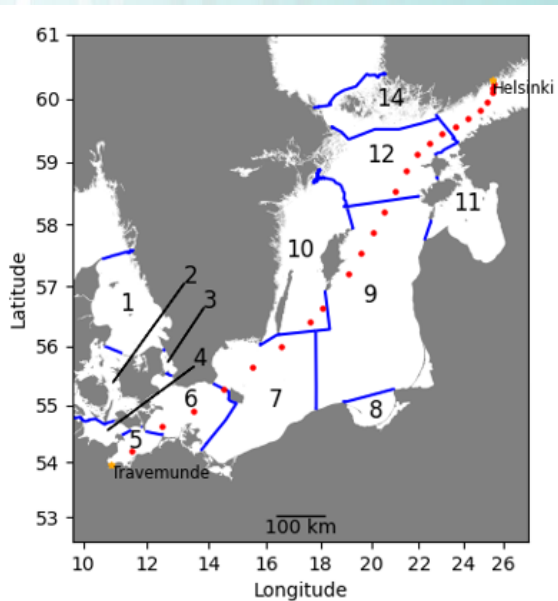
## Background

- **Eutrophication** remains one of the main environmental problems in Baltic Sea
- Detailed understanding of the **regional differences, seasonality and long-term changes** in the eutrophication process is needed
- Trad. monitoring enables the generation of **long time series** at those locations, but often with **low temporal resolution**. For example: the Finnish national monitoring cruises visit open sea stations four times per year at most
- Monitoring the seas would benefit from a **multi-platform sampling strategy**, as not all scales can be adequately covered by a single platform. **FerryBox** measurements provide information on **fine scale trends in surface waters**
- We analysed **climatologies of nutrient and Chl *a* concentrations and their trends** in different regions of the Baltic Sea using data collected by FerryBox on the Finnmaid ferry during the period 2007-2020
- Data product under Copernicus INSITU\_GLO\_BGC\_REP\_OBSERVATIONS\_013\_046



## Methods

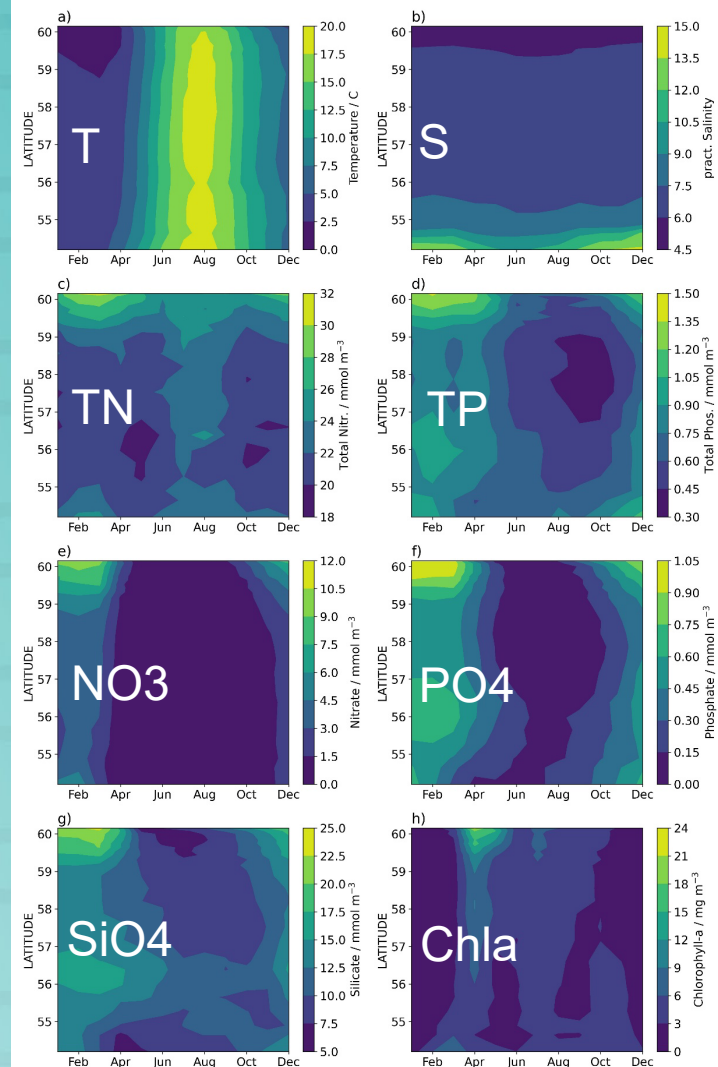
- **Discrete water samples** (24 samples from pre-selected transects) are collected in Ferry FINNMAID with ISCO water sampler at predetermined locations (as the route is not always the same, water sampling is triggered at fixed longitudinal positions) approximately twice per month, refrigerated during the cruise and analyzed at the SYKE laboratory.
- Nutrient concentrations (**Total N, Total P, NO<sub>3</sub>, PO<sub>4</sub> and SiO<sub>4</sub>**) were measured approximately once per month. **Chl a** was measured from each sample



- Finnmaid took different routes over the years. The route with the most measurement data, passing east of the island of Gotland, was selected.
- As the sampling positions were not exactly the same for all cruises, they were grouped into zones with a radius of roughly 5 km resulting in **24 zones**.
- **19-25 samples per year** for each zone.
- The seasonality within each zone was approximated by binning the values by month of the year and calculating the mean of each bin.
- **Average annual cycle, anomalies and trends estimated**

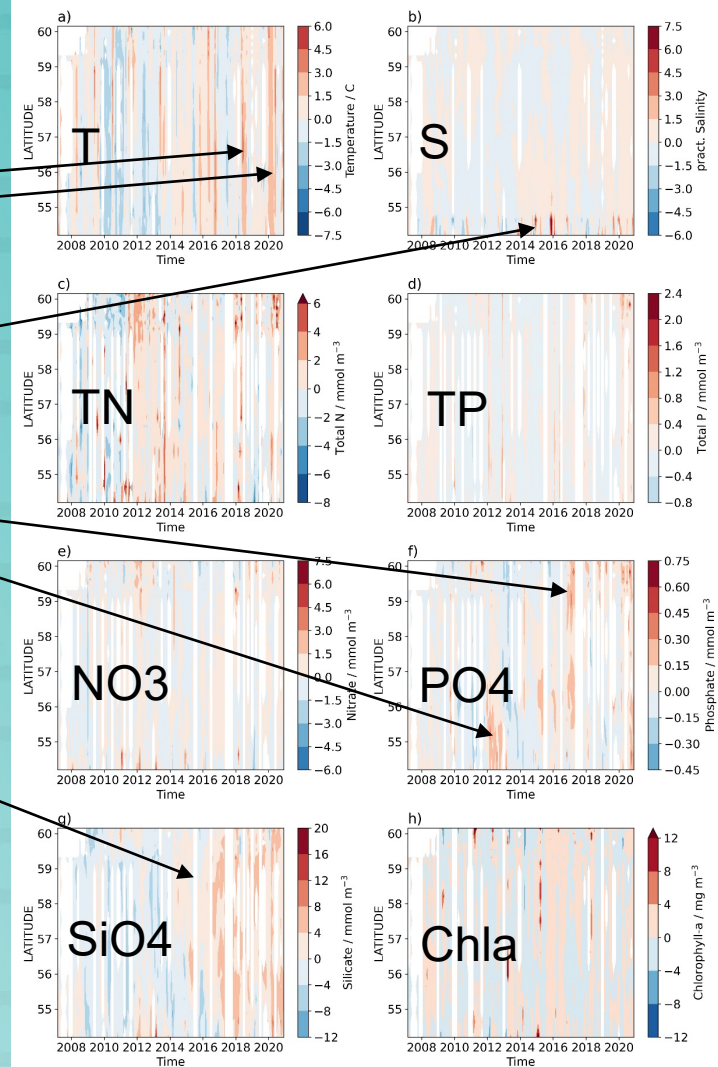
## Results 1/3, climatologies (for 2007-20)

- Summer increase of TN (Cyanobacteria)
- Early spring full depletion of  $\text{NO}_3$
- Spring consumption of  $\text{PO}_4$  and  $\text{SiO}_4$ , but not full depletion, or later than for  $\text{NO}_3$
- Nutrient depletion and Chl<sub>a</sub> development indicate ~2 months longer growth season in south than in north
- Gulf of Finland much more eutrophied
- Spring bloom dominates the phytoplankton Chl signal



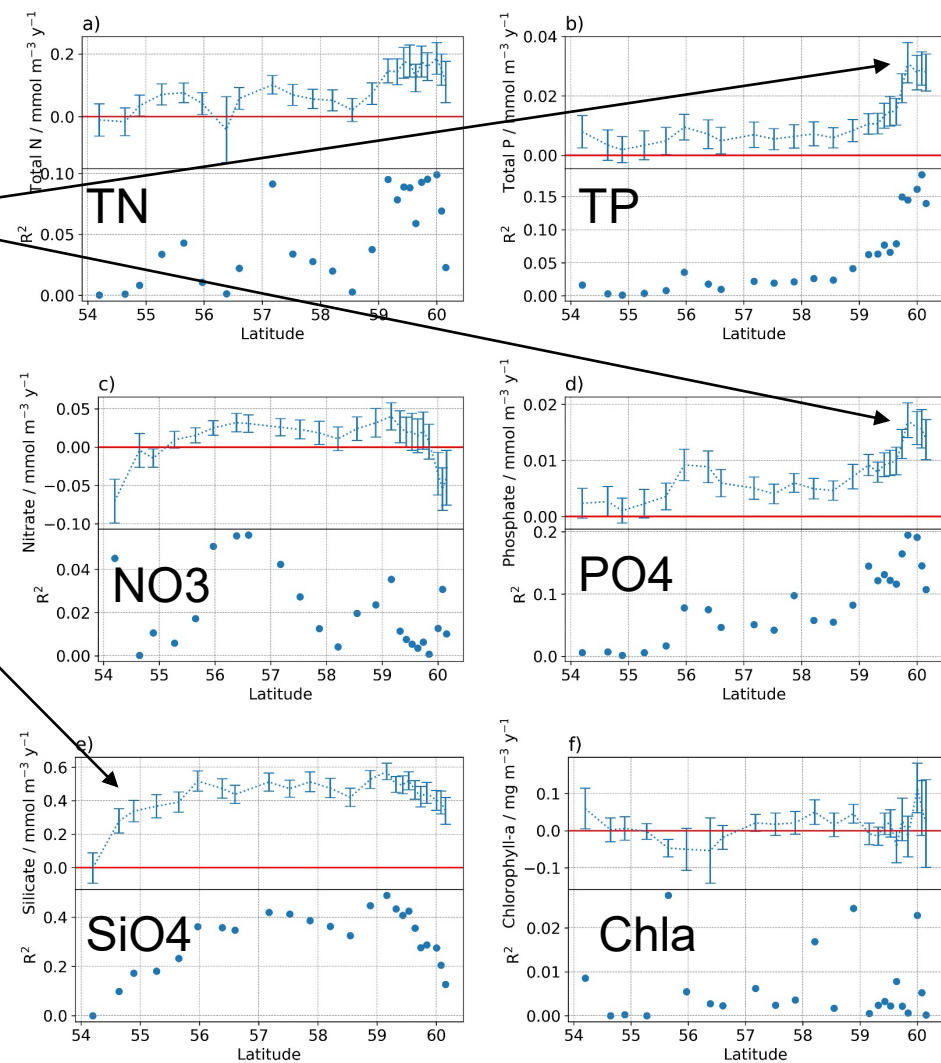
## Results 2/3, anomalies

- The record warm summer of 2018 and beginning of 2020
- Intrusions of high saline water are seen as spikes in the southernmost study area
- $\text{PO}_4$  concentrations showed high variation and extended periods (several months) of high and low anomalies were detected
- Exceptionally high DSi concentrations were measured throughout the transect since 2017



# Results 3/3, trends

- Total P and PO<sub>4</sub> concentrations increased during the period 2007-2020, especially in the northern zones.
- DSi concentrations increased at an average yearly rate of 0.3-0.5  $\mu\text{mol L}^{-1} \text{y}^{-1}$  at each zone except zone 1
- Total N, nitrate and Chl a concentrations have not changed significantly during the period 2007-2020



## Conclusions 1/2

- Nutrient concentrations in the surface water have changed very little during the past 14 years, with two exceptions. 1) **an increase of total P and PO<sub>4</sub> in the Gulf of Finland** & 2) **an overall increase in the often overlooked DSi concentration**. Despite the recent mitigation measures taken these trends in nutrient concentrations are not abating, an observation also supported by HELCOM
- The observed increase in DSi concentrations contradicts, in the short term, the prediction of decreasing DSi concentration in the Baltic Sea. **DSi concentration has increased relative to NO<sub>3</sub>**, suggesting that the already N-limited Gulf of Finland has become relatively **less silica limited**. Changing Si:N ratios might affect relative nutrient limitation dynamics among diatom species thus **affecting the composition of the phytoplankton community** (...or changes in phytoplankton community, from diatoms to dinoflagellates, affect the availability of free silicate).
- **Increase of PO<sub>4</sub>** concentrations noted mainly in the northern part of our study area, suggesting that **cyanobacterial blooms will be an issue** for a long time to come, as cyanobacteria gain a competitive advantage in low inorganic N:P ratios




## Conclusions 2/2

- The **increase of both DSi and PO<sub>4</sub>** in the Gulf of Finland might be **related to sediment processes and introduction of deep water to the surface layer**, as variation in benthic DSi and PO<sub>4</sub> fluxes show similar patterns. Connection between sediment hypoxia and DSi release from the sediments?
- There has been no reduction in eutrophication, as shown by high Chl a concentrations and the **lack of a trend in Chl a concentration**
- Alg@line water sample data has been used in **HELCOM products**. **DSi concentration might be considered another potential indicator** of the ecological status of the planktonic community, and its possibility to strengthen the diatom/dinoflagellate index might be worth exploring
- Other potential uses for the data: seasonal trends, nutrient ratios and nutrient limitation analysis, post-spring bloom excess PO<sub>4</sub> and its capacity to fuel summer cyanobacterial blooms, nutrient depletion ratios during phytoplankton blooms. **However, studying these optimally may require adjustments in current sampling frequencies and automated nutrient analysis would be an optimal next step for increasing the frequency of FerryBox nutrient sampling.**





Work in press

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### Section 3.2. Trends in nutrient and chlorophyll *a* concentrations from FerryBox transect time series in the Baltic Sea

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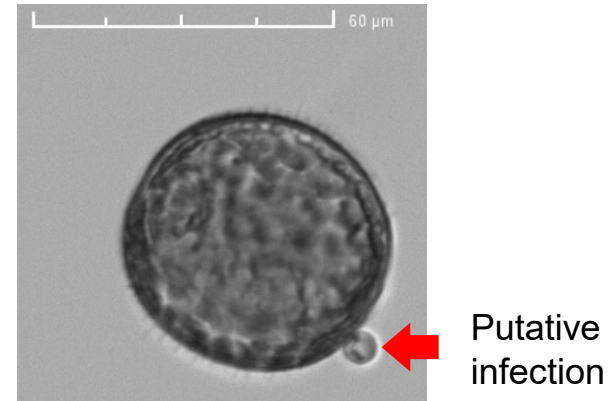
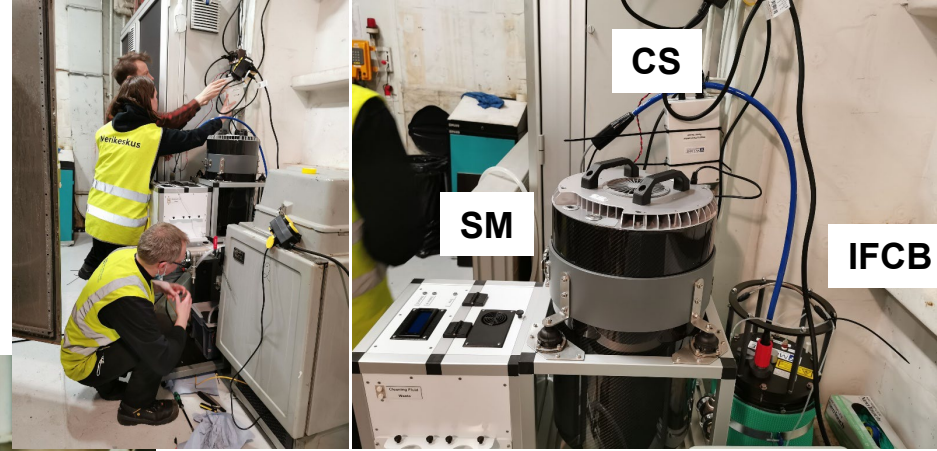


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# Additional recent developments - Imaging devices test run – Spring 2022

- IFCB + CytoSense – 1st time connected to Finnmaid
- Phytoplankton parasites survey (collaboration UTU, ÅA) – included deployment of CS automated staining module (SM).

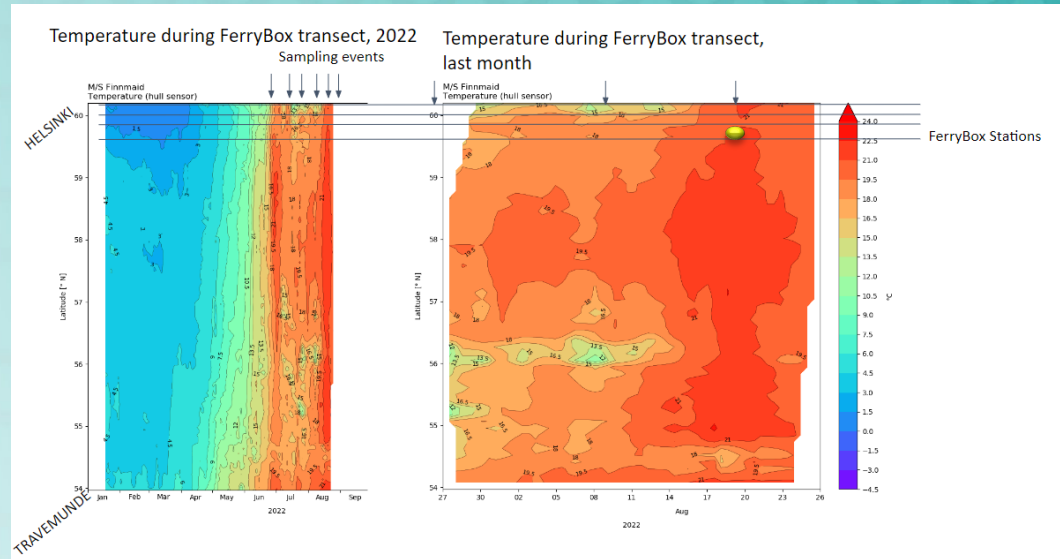
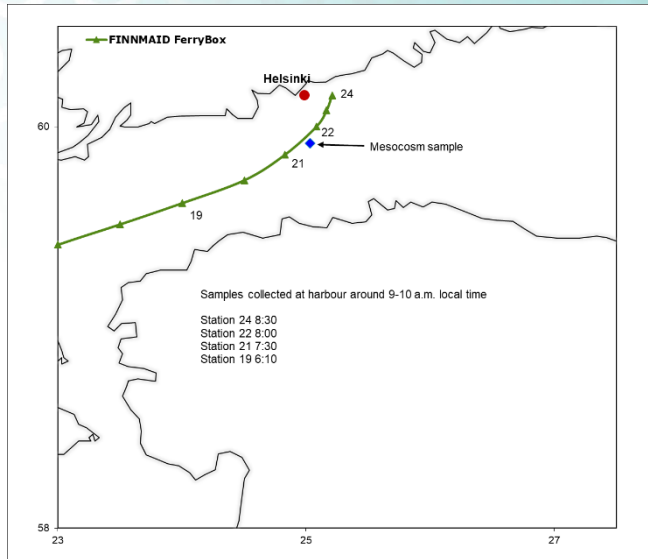




# Additional recent developments – Baltic Microbial Food Web under the Heat Wave - Aug 22

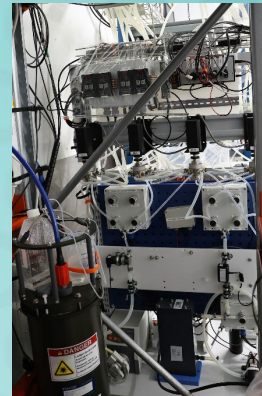
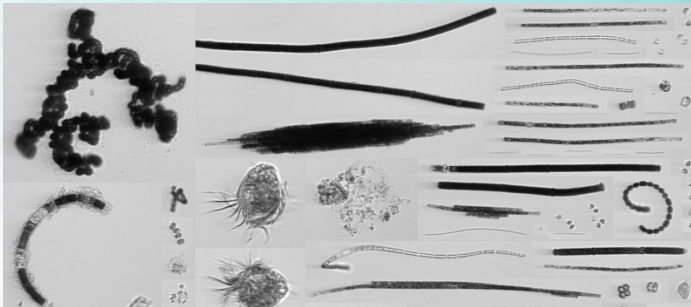
The Power to combine **Experimentation (mesocosms)** with in-situ **Observations (FerryBox)**

- Same area with the mesocosm experimental water
- Same methods with the experiment for Viruses, Bacteria, Flagellates and Microplankton



# Additional recent developments – Baltic Microbial Food Web under the Heat Wave - Aug 22

- Joint JERICO-S3 and AQUACOSM-plus study on Baltic Sea heatwaves at GoF Pilot Supersite.
- With the support of the Transnational Access of JERICO-S3, international groups from IGB (Germany), HCMR (Greece) and CNRS (France), participated in the experiment.
- High-frequency measurements of plankton ecosystem structure and functioning using the autonomous sampling and analysis instrument [AquaBox](#), sensors and imaging systems, as well as the kinetics of planktonic organisms from viruses to zooplankton



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**MINKE** project is organizing a three-day hybrid training-workshop:

**"INTRODUCTION TO METROLOGY FOR YOUNG AND EARLY CAREER MARINE SCIENTISTS"**

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# Thank You !



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