Dynamics of nutrients and phytoplankton Chl *a* influenced by mesoscale and sub-mesoscale physical processes in the Gulf of Finland (Baltic Sea)

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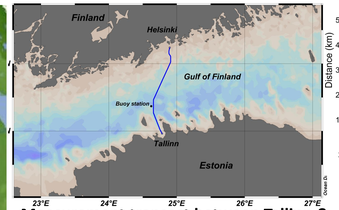
Motivation

Heterogeneity in distribution of nutrients and phytoplankton is in a great extent influenced by hydrophysical processes in mesoscale and sub-mesoscale. In order to understand these links and to estimate the role of physical processes versus vertical migrations and growth of phytoplankton, high-resolution measurements and sampling have to be conducted. The measurement program in spring-summer 2010 was designed to map both, the horizontal and vertical distribution of ecological state variables in the Gulf of Finland (Baltic Sea) with sufficient resolution, duration and extent.

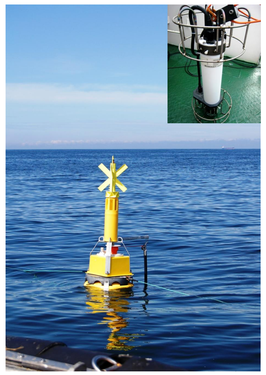
The Baltic Sea

Ship of Opportunity

Autonomous measurement system on board ship

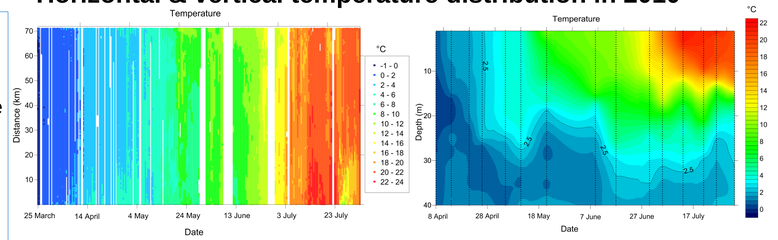


Measurement transect between Tallinn & Helsinki and buoy station in the Gulf of Finland

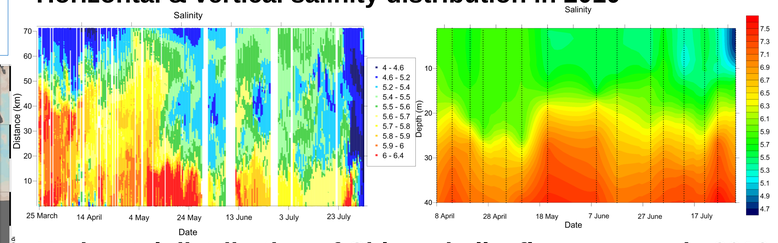


Buoy & vertical CTD profiler

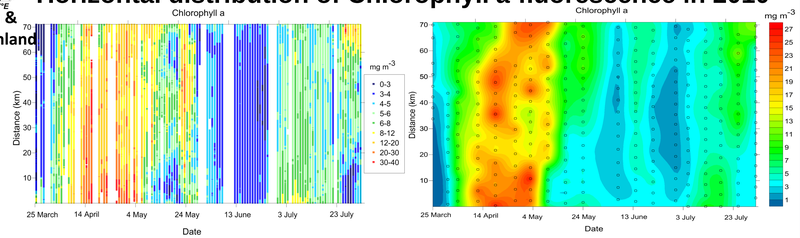
Horizontal & vertical temperature distribution in 2010



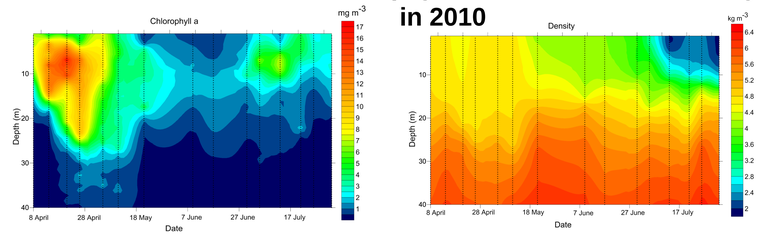
Horizontal & vertical salinity distribution in 2010



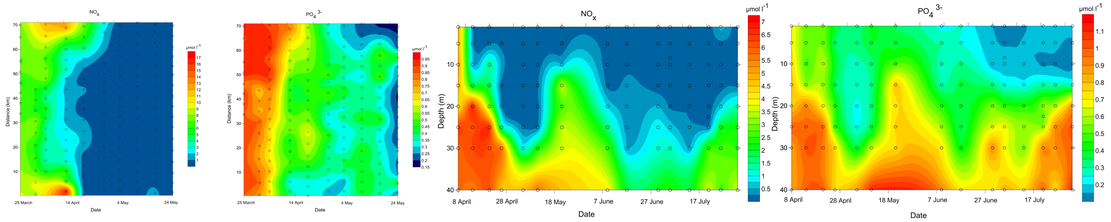
Horizontal distribution of Chlorophyll *a* fluorescence in 2010



Vertical distribution of Chlorophyll *a* fluorescence & density in 2010



Horizontal & vertical distribution of nutrients (NO_2^-+NO_3^- , PO_4^{3-}) in 2010



Measurements in the surface layer

Autonomous measurement system installed on board a ferry travelling between Helsinki and Tallinn (distance – 80 km) was used for measurements and sampling in the surface layer (water intake at 4 m depth). Temperature, salinity and Chl *a* fluorescence were recorder along the ferry route twice a day with a time step of 20 s (corresponding approximately to a spatial resolution of 150 m) and weekly water sampling at 17 locations was conducted. Water samples were analyzed for nutrient concentration (samples collected in March-May), Chl *a* content and phytoplankton species composition and biomass.

Vertical profiling and water sampling

The vertical distributions of temperature, salinity and Chl *a* fluorescence were measured by a moored water column profiler deployed close to the ferry line. Vertical profiles acquired at the buoy station were transmitted after every profiling conducted with a time step of 3 hours in the layer from 2 to 45 metres. CTD measurements and water sampling on board the research vessel SALME were performed from early April until mid August. Water samples were analyzed for nutrient concentration, Chl *a* content and phytoplankton species composition and biomass.

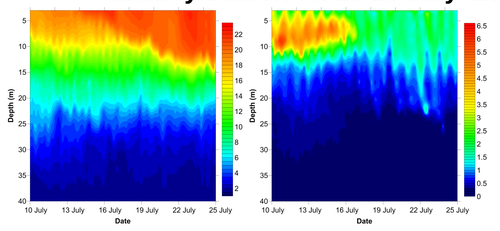
Results

The results show high variability of Chl *a* distribution both in time and space. In general, the vertical Chl *a* dynamics was characterized by an intense spring bloom in April-May in a relatively deep layer (also sedimentation of biomass is seen), low Chl a values in the sub-surface layer (below 10 m depth) during the summer minimum in June and occurrence of higher Chl *a* concentrations in the surface layer in July when the water temperature increased considerably.

Spring bloom dynamics and heterogeneity was closely linked to the physical forcing – prevailing circulation in the surface layer, development of stratification (including upward and downward movement of seasonal thermocline) and mesoscale features/processes. Spring bloom started before the water temperature has reached the temperature of highest density – vertical stratification was maintained by the salinity distribution. Surface layer in the regions of more intensive spring bloom became depleted of nitrogen faster than in the rest of the study area. Unusual secondary peak in spring bloom observed in late May was caused by an advection of less saline water mass into the study area and upward movement of the seasonal thermocline and nutriclines.

Based on high-resolution profiling at buoy station in June-July, the vertical Chl *a* dynamics was characterized by a diurnal signal (especially since 16 to 25 July) with downward migration of phytoplankton reaching greater depths when the nutriclines went deeper. After 25 July a coastal upwelling occurred near the southern coast (and a coupled downwelling near the northern coast) and the phytoplankton communities were drifted to the north. We have observational evidences that similar vertical distribution of phytoplankton that was observed on16-25 July at the buoy station occurred during a longer period in the central part of the Gulf. It shows that the horizontal distribution as well as vertical distribution and migration pattern of phytoplankton in summer is very closely linked to the mesoscale processes in the stratified Gulf of Finland.

High-resolution dynamics of temperature and fluorescence (in a.u.) at buoy station on 10-25 July 2010



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