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DISSERTATION TITLE: *Light, temperature, and nutrients as drivers for primary productivity in phytoplankton*

Phytoplankton are unicellular, photosynthetic organisms that float freely in the water masses of lakes and oceans. Utilizing sunlight they convert CO_2 to organic carbon and are thereby the foundation of pelagic food webs, and an important component in the carbon cycle. In addition to light, phytoplankton are influenced by factors like temperature and nutrients – most importantly nitrogen (N) and phosphorus (P). The overall aim of my PhD thesis has been to improve our understanding of how such factors interact and affect various aspects of phytoplankton productivity. This is important to predict how production in aquatic systems may respond to environmental changes.

One environmental factor that is changing in boreal lakes is the concentration of dissolved organic carbon (DOC), which has increased in many lakes over the last decades. More DOC makes the water browner, with potentially less light available for phytoplankton. One may therefore imagine DOC having a negative effect on the pelagic primary production due to shading. I tested this hypothesis for 75 Scandinavian lakes, and found that in lakes with comparable nutrient concentrations, the lakes with high concentrations of DOC had lower primary productivity. My findings suggest that if DOC is to continue increasing in the future, primary productivity may be reduced due to increasing light limitation.

Light conditions may also affect how much phytoplankton require of different nutrients like N and P – nutrients can be limiting for the development of phytoplankton biomass. On the basis of an experiment and a meta-analysis of published data, I found that growth under low light is associated with higher requirement for N relative to P, and higher likelihood of N-limitation. But why is it so? The likely explanation is that low light causes the cells to produce more pigment (e.g. chlorophyll) so that they can harvest the scarce light more efficiently. Pigments are bound to proteins within the chloroplasts, and these “pigment-protein complexes” are in N, but not in P.

Requirement for N relative to P, and thereby the tipping point between N and P limitation, has also been suggested to vary with temperature. In a carefully controlled experiment, I found that phytoplankton growing in warmer water had a higher requirement for N relative to P compared to those growing under colder conditions. The warm-acclimated cells thus became shifted towards N-limitation. If this is a trend for phytoplankton in general, climate warming may alter the balance between N and P limitation of phytoplankton, possibly causing more prominent N-limitation.