Phytoplankton drivers in a marine system influenced by allochthonous organic matter – the Baltic Sea

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt förvar i Lilla Hörsalen (KB3A9), KBC fredagen den 28 oktober, kl. 9:30.
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Climate change scenarios predict that seawater temperature and precipitation will increase in the Baltic Sea region during the next century. In the northern part of the Baltic Sea, increasing inflows of the terrestrial allochthonous dissolved organic matter (ADOM) are expected to be a major consequence of elevated rainfall, which can alter light and nutrient availability for phytoplankton. The aim of my thesis was to elucidate effects of ADOM on phytoplankton production, community, size-structure and nutritional strategy along offshore south-north gradients in the Baltic Sea, as well as in estuarine systems exposed to seasonal variation in river discharge. Field studies, a mesocosm experiment and a modeling study were used to explore these issues.

Results from the field studies and mesocosm experiment illustrated that the nutritional strategy, size-structure and cellular pigment content of the phytoplankton were governed by changes in ADOM, and thus in light and nutrient availability. A summer study along an offshore south-north gradient showed that the proportion of mixotrophic phytoplankton increased towards the north. In this area the concentrations humic substances (proxy for ADOM) were high, while the light availability and phosphorus concentrations were relatively low. The phytoplankton cells responded to reduced light availability by increasing their chlorophyll a: carbon ratio. Additionally, the levels of photoprotective pigments decreased from south to north, as a result of acclimation to a low-light environment and reduced exposure to ultraviolet radiation. According to ecological assumptions picophytoplankton should be favored in light- and nutrient-limited environments. However, the results did not follow that pattern, the proportion of picophytoplankton being highest in the relatively nutrient rich Baltic Proper. The study was performed during the decline of an extensive bloom of filamentous cyanobacteria, a successional phase in which picophytoplankton often dominate the phytoplankton community.

The estuarine studies performed in the Bothnian Bay (Råne estuary) and in the Bothnian Sea (Öre estuary) showed different successions. In the Råne estuary no spring phytoplankton bloom occurred and highest primary production was observed during the summer. This absence of a spring bloom was explained by low phosphorus and high ADOM concentrations, while the summer maximum could be explained by higher temperature and nutrient concentrations. In the Öre estuary a marked phytoplankton spring bloom was observed as well as an ADOM sustained bacterial production phase. The later secondary peak of bacterial production observed in summer, concomitant with an extended secondary primary production peak, suggests that autochthonous dissolved organic matter supported the bacterial growth. Furthermore, the photosynthetic efficiency (i.e. phytoplankton growth rates) was lower during spring, indicating that high ADOM, and thus lower light and phosphorus availability, disfavored phytoplankton growth.

Our modeling study showed that climate change can impact the food web; however effects will be different between basins. In the southern Baltic Sea elevated temperature and nutrient discharge may promote nutrient recycling and oxygen consumption, potentially extending anoxic areas, sediment nutrient release and cyanobacteria blooms. In the north, increased inflow of ADOM may promote heterotrophic bacterial production and decrease primary production due to light attenuation and lower phosphorus availability. This will favor the heterotrophic microbial food web and consequently lead to lower food web efficiency of the ecosystem.

Keywords
phytoplankton, nutrients, allochthonous organic matter, humic substances, structuring factors