

All about the marine /sea ice diatom *Nitzschia lecointei*

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N. lecointei van Heurck 1909 can be found in high densities in sea ice and is also abundant in shallow benthic ecosystems. Due to its ecological relevance and importance to the sea ice ecosystem, this species was chosen as model organism for studying sea ice algal ecophysiology under climate change.

N. lecointei was isolated from sea ice in the Amundsen sea January 2011 and was kept in f/2 medium at -1.5°C at the University of Gothenburg. In a series of experiments, we tested short-term and long-term acclimation to elevated $p\text{CO}_2$, synergism between elevated $p\text{CO}_2$ and temperature, and effects of increased temperature in 9 weeks darkness. Variables tested included e.g. growth, photosynthetic activity, concentration and composition of photosynthetic pigments, oxygen productivity, concentration and composition of fatty acids, bacterial biomass, external carbonic anhydrase activity and oxidative stress. Not all variables were measured in all experiments.

Generally, in terms of growth *N. lecointei* seems quite tolerant to changes in pH and $p\text{CO}_2$, probably due to the fact that this species grows in an environment with large seasonal variations in the carbonate system. However, increased $p\text{CO}_2$ resulted in physiological changes that may have important ecological consequences, such as cellular stoichiometry. For instance, we observed changes in carbon metabolism, and fatty acid content and composition, that did not affect the growth rate. When the experimental period was increased (194 days, ca. 60 asexual generations), we observed a small reduction in growth at 960 $\mu\text{atm } p\text{CO}_2$ after 147 days. Carbon metabolism was significantly affected, resulting in higher cellular release of dissolved organic carbon. When studying the synergism between temperature (-1.8 and 2.5°C) and $p\text{CO}_2$ (390 and 960 μatm), synergism was detected in growth rate and acyl lipid fatty acid content. Carbon enrichment only promoted (3 %) growth rate closer to the optimal growth, but not at the control temperature (-1.8°C). Optimal growth rate was observed around 5°C in a separate experiment. The total content of fatty acids was reduced at elevated $p\text{CO}_2$, but only at the control temperature. PUFAs were reduced at high $p\text{CO}_2$. When combining increased temperature and different salinity conditions, the growth rate was higher at 3°C than at -1.8°C. Salinity 10 clearly limited growth rate and the highest growth rates were found at salinity 20 and 35. In another experiment, high and low temperature together with treatments simulating ice formation and melting conditions were studied. Here, the highest levels of oxidative stress were found in low temperature and ice melting treatments, respectively. With respect to 9 weeks in the dark, cell numbers were higher at -1.5°C compared to 3°C, but when retrieved to light conditions, after one week higher cell numbers were observed at 3°C versus -1.5°C. Furthermore, cell numbers were lower when acetate was added to the dark treatments but not in glucose and glutamate treatments.

Although *N. lecointei* seem quite tolerant to environmental stress, effects of climate change may be different depending on ocean warming scenario or season, resulting in reduced food quality for higher trophic levels. Synergy between temperature and other stress factors may be particularly important in polar areas since a narrow thermal window generally limits cold-water organisms.