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Combined effects of light and inorganic carbon on Southern Ocean phytoplankton

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Marine autotrophic organisms convert inorganic nutrients into organic matter during primary production. Light is the essential energy source for this process. One of the major inorganic nutrients in the oceans used in primary production is dissolved inorganic carbon (DIC). Both light and carbon conditions are highly variable in ocean surface waters. Light conditions can fluctuate from too high (photo-inhibition) to too low (light limitation). Inorganic carbon in the surface ocean can decrease to very low conditions during a large phytoplankton bloom, as has been observed notably in the Southern Ocean. On the other hand, the upwelling of CO_2 enriched deep waters and the predicted high future CO_2 concentrations may also affect marine phytoplankton.

The combined effects of light and inorganic carbon availability were assessed in a novel experimental set-up which was designed jointly with the workshops of the Royal Netherlands Institute for Sea Research. In addition, a new experimental protocol was developed. This set-up and protocol provide stable, well maintained, culture conditions. Two different light conditions were used during the experiments, which were high light (240 μmol photons$\cdot$m$^{-2}\cdot$s^{-1}) and low light (80 μmol photons$\cdot$m$^{-2}\cdot$s^{-1}). The phytoplankton was exposed to three different aqueous CO_2 ($CO_{2(aq)}$) concentrations, similar in both light conditions. Those concentrations were Low $CO_{2(aq)}$ ($\sim$ 4-8 μmol$\cdot$kg^{-1}), Intermediate $CO_{2(aq)}$ ($\sim$ 10-14 μmol$\cdot$kg^{-1}) and High $CO_{2(aq)}$ ($\sim$20-30 μmol$\cdot$kg^{-1}).

Two different Southern Ocean phytoplankton species were tested: a diatom, *Proboscia alata*, and a haptophyte, *Phaeocystis antarctica*, During the experiments the $CO_{2(aq)}$ concentrations were continuously monitored by measuring total alkalinity and dissolved inorganic carbon. A variety of parameters was sampled on a daily basis in order to monitor growth, physiology and morphology of the phytoplankton, and the chemistry of the cultures.

From the results of these experiments it becomes clear that the different phytoplankton species do not respond similarly to the different experimental treatments. The effects of the different light intensity treatments on growth, physiology and morphology of the different species were far more significant than the effects of the different $CO_{2(aq)}$ conditions.