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Pelagic Ecosystem CO_2 Enrichment (PeECE III) Study: A glimpse at the future ocean

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If global CO_2 emissions continue to rise on current trends, upper ocean pH will decrease to levels probably lower than have been experienced for tens of millions of years and, critically, at a rate of change 100 times greater than at any time over this period. The magnitude of CO_2-induced ocean acidification can be predicted with reasonable confidence. Its impacts on marine organisms and their ecosystems are largely uncertain. While sensitivities at the organism level are readily addressed in well-constrained laboratory experiments, the results from such experiments can not be easily extrapolated to the ecosystem level. To test the effects of ocean acidification on pelagic ecosystems, we have conducted a series of CO_2 enrichment studies (PeECE I-III) in the Large Scale Mesocosm Facility at the University of Bergen, Norway.

The latest study in this series, PeECE III, involved 47 scientists from 14 partner institutes, with expertise ranging from marine and atmospheric chemistry to molecular and cell biology, marine ecology, and biogeochemistry. In this study, triplicate mesocosms were adjusted at starting CO_2 levels corresponding to present-day, 2 times and 3 times present CO_2 concentrations (pCO_2 $\sim$ 375, 750, and 1150 ppm, respectively). Over a 24 day period, the development and decline of a phytoplankton bloom was closely monitored in the 9 mesocosms. The drawdown of inorganic nutrients and the build-up of phytoplankton biomass showed no significant difference between CO_2 treatments. Unlike previous experiments, phytoplankton biomass peaked well before nitrate and phosphate were exhausted, which may be attributed to unfavourable weather conditions (low irradiances). The development of the phytoplankton community, which was dominated by diatoms, chlorophytes and prymnesiophytes, was nearly identical in all CO_2 treatments. Similarly, bacterial abundance and activity and zooplankton development and feeding rates were unaffected by CO_2 enrichment (see companion papers).

Despite the similarity in bulk ecosystem parameters, significant differences between CO_2 treatments were observed in the production of 2 volatile organic compounds (see companion papers). Treatment-related differences were also obtained with regard to inorganic carbon drawdown, indicating an increase in the stoichiometric C:N:P ratio of primary produced organic matter with increasing pCO_2. The results of this study demonstrate the suitability of mesocosm perturbation studies to examine the effects of ocean change on natural pelagic ecosystems.