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Modelling the impact of the end-Cretaceous plankton extinction on the marine carbon cycle

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Marine plankton and climate are intimately linked through the cycling of nutrients and carbon in the ocean. Plankton communities are predicted to be impacted by climate change leading to changes in inorganic and organic carbon cycling. However, experiments on single species are difficult to upscale to ecosystem-scale responses and the implications for ocean chemistry. Mass extinctions of plankton in the geological record provide a geological analogue with which to assess the impact of a loss of marine plankton on the carbon cycle.

Here we use a novel size-structured plankton community model coupled with an Earth System model to assess the impact across the most important extinction for plankton in the last 100 M years: the Cretaceous Paleogene boundary (K-Pg). The model predicts emergent plankton communities by linking ecophysiological traits of plankton, such as nutrient uptake and grazing rates, to organism size via allometric relationships. We explore the effect of key features of the K-Pg extinction event in the model by removing the largest plankton, varying zooplankton grazing pressure and changing responses of calcification. In contrast to common interpretations of the geological record, we find ecosystems populated by small plankton can potentially export similar amounts of organic carbon as pre-extinction ecosystems. Differences in the spatial variability in export also leads to significant changes in oxygen and carbon isotopes. These changes interact with the inorganic carbon cycle, alongside impacts on calcification, to drive longer-term changes in the carbon cycle.