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Perspective

Ocean Acidification and Its Effects on Marine Organisms and Phytoplankton Cells

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DESCRIPTION

Rising CO_2 levels in the atmosphere are causing Ocean Acidification (OA), which alters carbonate chemistry and has consequences for marine organisms. They show that OA increases the production of phenolic compounds in phytoplankton grown in elevated CO_2 concentrations projected for the end of the century by 46%-212% when compared to the ambient CO_2 level.

At the same time, under elevated CO_2 concentrations, mitochondrial respiration rate increases by 130%-160% in a single species or mixed phytoplankton assemblage. When fed phytoplankton cells grown in OA, zooplankton assemblages have a 28%-48% increase in phenolic compound content.

The functional consequences of increased phenolic compound accumulation in primary and secondary producers have the potential to have profound consequences for marine ecosystems and seafood quality, with the possibility that fishery industries will be influenced as a result of progressive ocean changes. Increasing atmospheric CO_2 levels are still causing global warming, with increasing oceanic CO_2 uptake playing a significant role in mitigating the extent of this increase.

However, rapid CO_2 dissolution into seawater is also causing OA, which gradually alters marine chemical environments, affecting many organisms.

While the physiological and ecological effects of ocean climate change on primary producers have been extensively studied little is known about the molecular aspects and/or metabolic pathways that underpin phytoplankton responses to OA3. Furthermore, there is growing concern about the need to link data from mono specific laboratory studies with data from natural communities, as well as data from multiple stress or conditions. Furthermore, the effects of OA on energy transfer, food quality, and the food web are still poorly understood.

Based on the results of the proteomics study with *Emiliania huxleyi* and the physiological results of the mono specific study, microcosm and mesocosm tests with mixed phytoplankton species or natural phytoplankton assemblages, the current study suggests that OA enhanced a novel phenolic compound metabolism pathway involving-oxidation and the Krebs cycle. While the effects of OA on mitochondrial respiration are controversial rising pCO2 and decreasing pH in seawater disrupt phytoplankton cytoplasmic acid-base balance, requiring extra energy to maintain cell homoeostasis or positive H^+ efflux12.

Increased photo-respiratory carbon loss in high CO_2 grown cells necessitates the expenditure of additional energy for photo-protection. As a result, extra energy is required to maintain homoeostasis when phytoplankton cells are perturbed by changes in seawater chemistry. In this study, they demonstrated that OA increased-oxidation and the Krebs cycle, which could meet any extra energetic demand to allow phytoplankton to tolerate acidic stress. Increased phenolic compounds in coccolithophores may not only reflect a way to deal with any extra energetic demand caused by OA, but may also act as repellents to protect them from grazers because the cells calcify less under OA1.

Higher plants increase their production of phenolic compounds to deter grazers, which is a well-known phenomenon. Their discovery that phytoplankton increased their production of these compounds in the presence of high CO_2 levels has implications for grazers, though the mechanism by which phytoplankton species or assemblages up regulate phenolic biosynthesis in response to increased pCO2 levels is not immediately clear. In contrast to their findings, a recent study found lower levels of these compounds in sea grasses exposed to high CO_2/low pH near a natural CO_2 vent. OA has been shown to significantly alter diatom fatty acid content and composition.

Increased cellular phenolic compounds which are also linked to fatty acid metabolism *via* -oxidation would reduce the nutritional value of these organisms even further. Because phenolic compounds are highly toxic and found in marine systems increasing their content in primary producers would undoubtedly have a significant impact on food webs and carbon cycles. Furthermore, because phenolics have antimicrobial properties, biogeochemical cycles in the oceans may be affected.

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