Acute toxicity of harmful algae on marine zooplankton in the context of climate change

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The increase in human activities and their expansion into oceans and lakes have significantly disturbed aquatic environments. For instance, continuously increasing greenhouse gas emissions have resulted climate change, affecting the temperature, salinity, and pH levels in water bodies. Additionally, the overuse of agricultural fertilizers has altered the nutrient content in most of these environments. Harmful algal blooms are proliferated algae densities that are often able to produce different kinds of toxic metabolites. An increasing number of harmful algal blooms have been recorded in the last decades due to anthropogenic pressure. Some studies have even found that cyanobacteria that originally lived in freshwater environments are invading estuaries. Research has established that sudden increases in nutrients contribute to HAB occurrence and it has also linked warming temperatures to individual events. Zooplankton, vital to aquatic ecosystems, connect producers and higher-level organisms in food webs as both consumers and prey. Not much is known about the toxicity of these toxic blooms on zooplankton communities in different climate change scenarios. Therefore, in this study, we investigated the impact of climate change proxies on the toxicity of harmful algae to a harpacticoid and a calanoid copepod—*Nitokra spinipes* and *Acartia clausi*, respectively . We constructed a series of laboratory experiments with relevant temperature, salinity, pH and nutrient conditions, focusing on two microalga species the dinoflagellate *Alexandrium ostenfeldii* and the cyanobacteria *Microcystis aeruginosa*. After collecting algae, grown in these different scenarios, we assessed their toxicity in these copepods, studying mortality, swimming behaviour and ingestion rate. First, we observed variations in mortality rates, swimming speeds, and swimming distance between *N. spinipes* and *A. clausi* exposed to the same toxic algae, indicating an interspecies difference in sensitivity towards HAB blooms. Moreover, both *N. spinipes* and *A. clausi* exhibited varying sensitivities to algae grown under different conditions, suggesting that environmental factors indeed influence algal toxin production. These results provide better insights into environmental consequences of harmful algae blooms on the marine food web in the warming future.

Keywords
Harmful Algae Blooms; Ocean Acidification; Eutrophication; Ocean Warming; Copepods; Marine Food Web Dynamics