Effects of temperature and salinity on growth and toxin production of the cyanobacterium Microcystis aeruginosa (PCC7806) under estuarine conditions

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Coastal ecosystems, which act as essential connectors between inland waters and ocean systems, are now encountering unparalleled challenges fueled by human activities and climate change. *Microcystis aeruginosa* is recognized as a harmful cyanobacterial species with its ability to produce microcystins (MCs) and its tendency to bloom in estuarine environments. Although previous research has shown the impact of individual environmental conditions on the growth or toxin production of *M. aeruginosa,* the possible interactive effects and resulting changes in its toxicity remain uncertain. In this study, we initially conducted an orthogonal growth experiment to evaluate the effects of variations in temperature, salinity, pH, and nutrient conditions. This was followed by a full-factorial growth experiment, with temperature and salinity as primary variables. We measured intracellular and extracellular MCs content, along with phycocyanin levels, during both exponential and stationary growth phases. Toxicity was evaluated by examining mortality and swimming behavior in two estuarine copepod species: the harpacticoid *Nitokra spinipes* and the calanoid *Acartia tonsa*. Results indicated that both growth and MCs production were significantly induced by increasing temperatures (15 to 28 °C), but were reduced with elevated salinity levels (8 to 16 ppt). Furthermore, cell density and growth rate showed a strong correlation with both intracellular and extracellular MCs levels. A significant interaction between temperature and salinity was detected, while no correlation was observed between intracellular MCs and phycocyanin levels. Lastly, exposure to *M. aeruginosa* led to reduced swimming speed, higher inactivity, and increased mortality in *A. tonsa* compared to the non-toxic *Rhodomonas salina*, while *N. spinipes* showed no sensitivity to *M. aeruginosa* at environmentally relevant concentrations. This study emphasizes the combined effects of temperature and salinity on *M. aeruginosa* growth and toxin production, shedding light on potential risks associated with future blooms under changing climate conditions.

Keywords
Cyanobacterium, Microcystin, Copepod, Toxicity, HAB