Evaluating the acute toxicity of marine phycotoxin mixtures on copepods across various life stages

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The expansion of human activities into oceans and lakes has profoundly disrupted aquatic ecosystems. Over recent decades, HAB occurrences have increased due to mounting anthropogenic pressures. Harmful algal blooms (HABs) are a phenomenon occurring hen certain primary producers, capable of generating toxic metabolites (phycotoxins) proliferate excessively. These phycotoxins can accumulate in fish and shellfish, subsequently moving up the food web and adversely affecting organisms at higher trophic levels, ultimately posing significant risks to human health. Phycotoxins are classified into five main groups based on their effects: paralytic shellfish poisoning (PSP), amnesic shellfish poisoning (ASP), neurotoxic shellfish poisoning (NSP), diarrhetic shellfish poisoning (DSP), and azaspiracid poisoning (AZP). While the individual effects of these toxins are well-documented, the combined effects on the marine food chain remain less understood. Copepods are key primary consumers in marine ecosystems, acting as vital links to higher trophic levels, such as planktivorous fish. They also play an essential role in oceanic biogeochemical cycling, for example through carbon C and nitrogen export to deeper waters. This study, therefore, examines the effects of mixed phycotoxin exposure on two copepod species: the epibenthic copepod *Nitokra spinipes* and the planktonic copepod *Acartia clausi*. We investigated the impacts of two harmful algal species, *Protoceratium reticulatum* and *Alexandrium minumtum*, using a full factorial design that included environmentally relevant concentrations of both living algae, as well as their extracts. After 48 hours of exposure to these mixtures, we evaluated the response of adult copepods for swimming speed, inactivity, and mortality using the ZebraBox™ device, while naupliar immobility was assessed under a light microscope. Our research aims to enhance understanding of the impacts and mechanisms of mixed HAB exposure on copepods, contributing to broader insights into potential risks to ecosystems and human health.

Keywords
Harmful Algae, Copepod, Mixed Exposure, Toxicity