On the role of ocean anoxia in modulating Earth system recovery following mass extinction events

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Persistent ocean anoxia has long been recognized in rocks deposited after the end-Permian and end-Triassic mass extinction events, but its precise extent and duration has remained difficult to quantify because anoxia is largely known from local indicators. Here we use uranium isotope ($\delta^{238}U$) data from Permian-Triassic and Triassic-Jurassic boundary sections to quantify the global extent and duration of bottom water anoxia. In each case, $\delta^{238}U$ exhibits a negative excursion across the extinction interval of approximately 0.5‰, indicative of a global expansion in marine anoxia, followed by a gradual return to pre-extinction values during the next few million years. The more negative $\delta^{238}U$ values coincide with large perturbations to the global carbon and sulfur cycles as well as reductions in the diversity and sizes of benthic marine animals. Numerical models show that a shallow oxygen minimum zone (OMZ) can make the global carbon cycle more sensitive to forcing from factors such as variation in eustatic sea level, potentially explaining the coincidence of marine anoxia with large excursions in the carbon and sulfur isotope records. We hypothesize that the position of the OMZ modulated the biological and biogeochemical recoveries from these mass extinction events.