What drove nannoplankton evolution and community dynamics through the Paleogene?

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Cenozoic calcareous nannoplankton records reveal profound changes in diversity, morphology, and community composition, but what were the primary controls on these parameters through time since the dramatic taxonomic reset at the Cretaceous/Paleogene mass extinction 66 million years ago? Here we will examine the evolution of nannoplankton through the first 44 million years of the Cenozoic (Danian to Aquitanian), using a range of approaches that include biometry (liths and coccospheres) and long time series community analyses. Our dataset spans the time interval that saw recovery of nannoplankton communities following the devastating mass extinction and their co-evolution alongside profound extrinsic changes as the Earth system shifted from warm early Paleogene greenhouse climates to cooler temperatures of the Oligocene coolhouse (~33 Ma). We will show that in the first two million years after the mass extinction there was exceptional community variability, predominantly in small lith and cell sizes, and unusual trophic strategies, most notably mixotrophy in the most widespread and dominant taxa. A rapid regime change occurred after this, associated with rising species richness, rapidly increasing cell sizes, diversifying trophic strategies, and the emergence of a stable background community state. These biotic shifts were reflected in broader biogeochemical changes, such as recovery of biological pump function and increasing food web complexity. Our subsequent time-series community records demonstrate an enduring stability and resilience despite long-term changes in climate, but this stability was punctuated by ephemeral excursions of above background levels of disruption, associated with both warming (e.g., the early Eocene hyperthermals) and cooling events (e.g., the Eocene–Oligocene transition and several Oligocene glaciations). These transient community perturbations show threshold behavior that can be linked to magnitudes of temperature change, and they scale with environmental parameters, in particular rising and falling temperature. These relationships hold for plankton communities through the entire Paleocene to Early Miocene record with temperature being the primary driver, modulating communities in a similar way regardless of the greenhouse or icehouse background climate state.