

Elasmobranch community responses to early Eocene climate events in the North Sea Basin

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Modern marine ecosystems are undergoing rapid warming, acidification, and deoxygenation, driving unprecedented declines in large predators such as sharks and rays. Understanding how marine predator communities respond to extreme warming is therefore a pressing challenge. Yet experimental and short-term ecological studies cannot capture long-term, community-level resilience or collapse dynamics. Deep-time climate analogues provide a unique opportunity to address this gap.

Here, in a new research project, we investigate how elasmobranch (sharks and rays) communities in the North Sea Basin responded to multi-scale climate warming during the Early Eocene (ca. 53-49 Ma). This interval encompasses both the sustained extreme warmth of the Early Eocene Climatic Optimum (EECO), lasting for millions of years, and short-lived hyperthermal events occurring over tens of thousands of years. One of these short-term events is hyperthermal P (~51 Ma), during which the sea water temperature in the North Sea Basin potentially attained the highest temperatures of the entire Eocene (up to 32.1°C, KU Leuven unpublished data). Together, the EECO and hyperthermal P represent natural experiments in gradual versus abrupt climate forcing.

Using extensive museum and curated private collections from Belgium and the UK, we are compiling the first abundance-weighted, trait-based reconstruction of early Eocene elasmobranch communities. Assemblages are placed into a high-resolution stratigraphic and chemostratigraphic framework ($\delta^{13}\text{C}$, $\delta^{18}\text{O}$, Mg/Ca), enabling direct alignment of ecological change with climate dynamics. We quantify shifts in diversity, functional guild composition, body-size structure, and dental morphospace across pre-, syn- and post-warming intervals.

Our project tests three central hypotheses: (1) warming disproportionately impacts benthic and durophagous predators, driving trophic restructuring toward smaller pelagic mesopredators; (2) rapid warming induces reductions in mean body size and morphological disparity; and (3) short-term hyperthermals trigger faster and more abrupt ecological change than long-term background warming, potentially revealing ecological tipping points.

By integrating paleoecology, functional morphology and paleoclimate, this project will deliver the first multi-scale assessment of marine predator resilience under extreme warmth. Beyond advancing elasmobranch paleobiology, our results will provide a deep-time framework for interpreting modern extinction risk and functional vulnerability of marine predator guilds in a rapidly warming ocean.

Keywords

Elasmobranchs; Early Eocene; North Sea Basin; Paleoclimate Change; Early Eocene Climatic Optimum (EECO); Hyperthermal Events; Marine Predator Communities; Functional Traits; Community Ecology; Paleoecology; Body-size Evolution; Morphological Disparity