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CENOZOIC EVOLUTION AND EXTINCTION OF MEGATOOTH SHARKS FROM STABLE ISOTOPE RATIOS IN BIOAPATITE

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The evolution and extinction of megatooth sharks, most notably *Otodus megalodon* (Lamniformes: Otodontidae), remain enigmatic. It has been proposed that the ability of megatooth sharks to thermoregulate acted as a key driver for the evolution of gigantism that impacted their ecological role and success in surviving environmental changes. Yet, despite advances in paleohistology, it is still unclear if, for example, *O. megalodon* was ectothermic or endothermic, and whether its thermophysiology could help to explain the iconic shark's demise during the Pliocene. Here we present novel geochemical constraints on the influence of ocean temperatures on modern shark tooth bioapatite 'clumped' isotope (δ_{47}) signatures, as well as evidence for thermoregulation in *O. megalodon* from both δ_{47} paleothermometry and phosphate oxygen isotope ratios. Our results show that *O. megalodon* maintained an overall warmer body temperature compared with ambient environment, providing new quantitative and experimental support of recent biophysical modeling studies that suggest endothermy was one of the key drivers for gigantism.

Trophic position is also fundamental characteristic of animals, yet is unknown in many extinct species. Here we reconstruct also the trophic level of extinct megatooth sharks through the Cenozoic by measuring various biogeochemical tracers of food web dynamics, including the $^{15}N/^{14}N$ of enamel-bound organic matter (δ^{15}NEB), and zinc (δ^{66}Zn) and calcium (δ^{44}Ca) isotope ratios. Very high (low) δ^{15}NEB (δ^{66}Zn, δ^{44}Ca) values in *O. megalodon* and chronospecies *O. chubutensis* indicate that they occupied a higher trophic level than is known for any marine species, extinct or extant. Collectively, these results help to contextualize current working hypotheses for the evolution and extinction of *O. megalodon*.