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Coastal Iron-Manganese Concretions: Novel Archives of Environmental and Anthropogenic Forcings in Dynamic Coastal Ecosystems

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Coastal sea ecosystems worldwide are increasingly threatened by global change and anthropogenic activities. Understanding the gradual escalation of these threats is particularly challenging in dynamic coastal regions, which often lack thick sediment sequences of continuous deposition over centennial and longer timescales—the key archives of past environmental and climatic changes in the deep sea. Coastal iron-manganese concretions, biogeochemical precipitates formed on the seafloor, present a novel archive for recording environmental and anthropogenic forcings. These concretions grow in non-depositional coastal areas globally and faithfully capture numerous marine processes and environmental variability within their structure.

Despite their potential, establishing reliable geochronology for these precipitates has been difficult. In this study, we address this challenge by combining three independent methods: anthropogenic lead accumulation, cobalt chronometry, and radiocarbon dating. This approach allows us to develop a high-resolution Bayesian probabilistic age model for a rapidly growing shallow-marine iron-manganese concretion from the Baltic Sea. The concretion core formed at 10,490 ± 210 cal. BP, with surrounding material showing successively younger ages from approximately 7,500 years ago to recent decades at the concretion surface.

Through analyses of concretion microstructure, mineral magnetic properties, trace element behavior, and iron isotopic composition, we demonstrate that the concretion records environmental variability over the past ~7,000 years. This record captures both regional and local forcing processes, highlighting the potential of coastal iron-manganese concretions as valuable archives for understanding long-term environmental and anthropogenic impacts on coastal sea ecosystems.