Title: Assessing ecosystem responses of the Hudson River Estuary, New York, to historical climate change through compound-specific isotope analysis and archival collections accessibility.

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Abstract. Over the last century, the Hudson River Estuary (HRE) and waterways surrounding New York City have undergone profound biological, chemical, and physical changes due to the expansion of human land use and global climate change. Historical environmental monitoring has revealed long-term changes to ambient water temperatures, expanding hypoxia, and increased sea level rise. However, historical reconstructions linking bioessential element cycling in the estuary (e.g., carbon and nitrogen "biogeochemistry"), ecosystem structure (*i.e.,* productivity regimes and species interactions), and productivity of key fisheries species have yet to be undertaken. The Hudson River Biological Monitoring Program (HRBMP) remains one of the longest-running fish monitoring programs in the United States (1974 - 2017) and houses a rich archive (> 50 million) of biological samples now curated by Stony Brook University. The biochemical composition of these specimens promises to yield diagnostic data pertaining to past biogeochemical and ecological regimes. When combined with the HRBMP's wealth of historical environmental water quality surveys, fisheries indices, and biodiversity data, this offers a rare opportunity to reconstruct the historical drivers and consequences of ecosystem change. Using compound-specific isotope analysis of carbon and nitrogen preserved within amino acids, the proposed work aims to reconstruct historical biogeochemistry and ecosystem structure of the HRE. Specifically, we aim to optimize sampling and analytical strategies to generate a series of pilot datasets from formalin-fixed specimens and archived fish scales, while also enhancing cyberinfrastructure associated with biological sample records. Data will support two collaborative research proposals to the National Science Foundation's *Organismal Response to Climate Change* (NSF-23-622) and *Infrastructure Capacity for Biological Collections* (NSF-23-580) solicitations. The proposed work directly supports several Climate Change Tiger Teams Initiatives including *Community and Ecosystem Resilience and The Warming Oceans, Modeling the Climate, and Effects of Climate Change*, unlocking one of New York's most diverse and valuable biological archives.