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Freshwater Pearl Mussels, *Margaritifera margaritifera*, from Sweden tell of past climates

Sven M. Baier (1), Bernd R. Schöne (1), Elena Dunca (2), Harry Mutvei (2), Jens Fiebig (1)

(1) Institute for Geology and Paleontology, Goethe University Frankfurt, Germany, (2) Museum of Natural History, Stockholm, Sweden

Variations in annual growth rates and stable isotopes of freshwater pearl mussels from northern Sweden were used for climate reconstructions. Our study is based on eighteen specimens of *Margaritifera margaritifera* collected alive from two localities in northern Sweden (Grundträsktjärnbäcken and Nuortejaurbäcken) during the 1990s. Shell powder samples taken from polished cross-sections by micromilling were analyzed for oxygen and carbon isotopes. Annual and daily growth increments provided a precise dating tool for isotope samples. Each isotope sample comprises about one to two weeks worth of growth. Shell oxygen isotopes resemble the temperature range of about 7 to 8˚C during the growing season and confirm the annual periodicity of shell formation. In addition, we determined the width of annual increments in shell cross-sections immersed in Mutvei's solution. Age-detrended, standardized and prewhitened annual increment chronologies of contemporaneous specimens show synchronous growth patterns and enabled the construction of a regional mean chronology stretching over 150 years. A strong positive correlation ($R2=0.60$, $p<0.0001$) exists between annual shell growth and summer temperature. Long-term trends in temperature and growth compare well to each other. A weak correlation was also found for shell growth and the summer North Atlantic Oscillation (NAO) index. We constructed a linear growth-temperature model that allows us to reconstruct summer air temperature from annual shell growth increments with a precision error of better than ± 0.95˚C (95% c.l.). Shell-based summer temperature reconstructions largely resemble and therefore verify tree-ring based reconstructions: Proxy (shells, trees) and available observational summer air temperature records from Scandinavia do not resemble the global surface temperature rise over the last 140 years. However, extremely cold

summer occurred less frequently after ca. 1930 than before. Our study demonstrated that Freshwater Pearl Mussels can provide an independent measure for temperature changes in the pre-instrumental era (subfossil shells) capable of verifying and complementing other proxy archives.