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Pitfalls in reconstructing seasonality from oxygen isotope records in *Mercenaria* shells: a case study from coastal archaeological deposits, SW Florida, USA

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The hard clam, *Mercenaria* spp., occurs in estuarine to marine habitats and are well-known recorders of environmental and ecological information based on variability in oxygen isotope ratios preserved in their shells. Their utility as paleoenvironmental and paleoclimate archives lies in the ability to constrain either temperature or the oxygen isotope ratio of the ambient water. Here, we present a case study illustrating the pitfalls associated with interpreting oxygen isotope data from *Mercenaria* shells from habitats experiencing both seasonal temperature variation and unpredictable variation in the oxygen isotope ratio of water.

Coastal southwest Florida contains numerous archaeological deposits rich in molluscan hard part remains of species that potentially record pre-industrial climate change. Today, this area has a subtropical climate where temperature varies from 18.1$\pm$2.0 to 28.2$\pm$0.6ºC, and there is a wet and dry season. The wet season occurs from June to October and the dry season is from December to April. Because of the predictable seasonal variation in precipitation, we assumed the oxygen isotope ratios of ambient water during the summer (wet) and winter (dry) seasons could be constrained to estimate amplitudes of seasonal growth temperature. Archeaological deposits accumulated by the pre-European Calusa people contain an abundant assortment of molluscan remains, including shells of $M.$ *campechiensis*. Five cultural periods were identified in these deposits that more or less correspond to the timing of the Late Holocene Eu-

ropean climate intervals: Roman Warm Period, Vandal Minimum, Medieval Warm Period, and Little Ice Age. Using AMS radiocarbon dating, we selected eight shells from the Vandal Minimum interval (500-800 CE) for isotopic analysis to test the utility of this bivalve to record climate conditions hypothesized as colder than today. These data were compared to six live-collected individuals. In general, the amplitudes of oxygen isotope ratios from the Vandal Minimum shells were less than those recorded in modern shells. This finding may reflect a decrease in the seasonal variation of temperature, precipitation, or a combination. Estimating growth temperature by assuming summer, wet (-1 per mil) and winter, dry (+1 per mil) water values produced unsatisfactory results. After collecting fortnightly water samples for oxygen isotope analysis over a two-year period, we discovered that intra-annual variation in the oxygen isotope ratios of the local water was more complicated than simply differences during the wet and dry seasons. There is a lag between the onset of the dry season and the response time of the oxygen isotope ratios of water post wet season. Moreover, the timing and nature (isotopic composition) of the response varied between years. We suspect evaporation and groundwater contributions may complicate the inter- and intra-annual variability in the oxygen isotope ratios of ambient water. Given this complication, deciphering the oxygen isotope records preserved in the archaeological *Mercenaria* shells for environmental reconstruction is difficult.