

Environmental range of the oxygen, carbon, and nitrogen Isotopes of the phosphatic brachiopod, *Lingula* and the importance of intertidal life for interpreting past ocean chemistry

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The spectacularly successful biomineralization by the inarticulate brachiopod, *Lingula*, to harden its shell with calcium phosphate has an unbroken history that dates back to the Cambrian. In the longstanding efforts to interpret past sea water temperatures, this animal has played a significant role in oxygen isotope studies. In this work, the oxygen isotopic composition of apatite phosphate, the included oxygen in associate carbonate, the $\delta^{18}\text{O}$ of bulk biomass from both shell chitin and lophophore tissue as well as the $\delta^{18}\text{O}$ of DNA are reported from three populations of living *Lingula* found in Japan, Hawaii, and Australia. Each location has a separate and unique isotopic niche that is offset by a similar magnitude and direction for each of the oxygen isotopic sources. The environmental impacts on the three populations of *Lingula* are further illustrated in the carbon and nitrogen isotopic compositions of several tissues and in the compound specific amino acids of the pedicle. Taken as a whole, the isotopic data from these living organisms indicate that the intertidal milieu of *Lingula* should be considered when interpreting fossil shell oxygen isotope data. These insights from modern organisms will be applied to fossil shell material from the Eau Claire Formation of Wisconsin.

