Freshwater input, upwelling, and the evolution of Caribbean coastal ecosystems on the Central American Isthmus

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Caribbean biota underwent major ecological and evolutionary transformation in the Plio-Pleistocene but a lack of detailed paleoenvironmental reconstruction prevents thorough resolution of cause and effect. To reveal ancient conditions in the southwestern Caribbean (SWC) we performed >4000 stable isotope analyses from 57 fossil serially-sampled gastropods. Specimens from 51-100 m paleodepth show a gradual increase in median $\delta^{18}O$ of about 0.6‰ from ~4.25 to 1.6 Ma, similar to the pattern for open ocean *G. sacculifer* $\delta^{18}O$ [1]. This trend reflects increasing Caribbean salinity resulting from the severance of interoceanic straits during the formation of the Central American Isthmus [1]. Specimens from 0-50 m paleo depth show similar $\delta^{18}O$ ranges for ~5.0-3.0 Ma and today [2] despite increasing seawater $\delta^{18}O$ with ice volume. This likely reflects the nearshore collection of modern specimens.

To quantify upwelling and freshwater input into Caribbean coastal shelf ecosystems over the last ~6 Ma, we use a 'baseline' approach that normalizes $\delta^{18}O$ gastropod values to open-ocean $\delta^{18}O$ from planktonic foraminifera. The influence of Pacific-like upwelling in the SWC was low and then negligible after 4.25 Ma. However, we discover that SWC coastal ecosystems were heavily influenced by seasonal freshening until ~2.5 Ma, after which time modern Caribbean conditions with low freshwater influence were established. The oligotrophic Caribbean and associated biota is therefore a result of not only oceanographic change causing declining upwelling, but also declining nutrients from terrestrial sources. We speculate that declining river-derived nutrients was the proximate driver of extinction and the proliferation of modern reef communities in the Caribbean after 2.5 Ma, and may have been caused by decreased rainfall due to a southward shift of the intertropical convergence zone with Northern Hemisphere glaciation.

[1] Haug et al. (2001) Geology **29**, 207-210. [2] Tao et al. (2013) Bull. Mar. Sci **89**, 815-835.