HIGH AND LOW RESOLUTION STABLE ISOTOPE PROFILES OF HOLOCENE BIVALVE SHELLS FROM THE DOMINICAN REPUBLIC

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INTRODUCTION

The ITCZ is a narrow band of clouds and intense precipitation which circles the globe at very low latitudes. The ITCZ is the climatic equator and is generally positioned at the location of maximum surface temperature (Waliser and Gautier, 1993).

The mean ITCZ does not extend beyond 10˚N in the Caribbean ocean today, but there is increasing evidence that the character of the seasonal oscillation has changed as a result of orbital forcing. Changes in position of the mean ITCZ are important to document because its location and intensity essentially define the hydrologic budget in the tropics and have significant effects on atmospheric circulation and atmosphere-ocean interactions (Waliser and Gautier 1993). The generally observed trend is that the ITCZ occupied a more northward mean position during the Holocene thermal maximum between 10 and 5 ka,, when summer insolation was greater in the northern hemisphere than the southern hemisphere (Koutavas and Lynch-Stieglitz, 2004). Curtis and Hodell (1993) linked the intensity of the seasonal cycle to evidence for a wetter climate in the Caribbean region between 7 k.a. and 3.2 k.a. This finding has recently been corroborated by bivalve $\delta^{18}O$ values from Florida that provide evidence for increased seasonality at ~5 k.a. (Jones et al., 2005). Both studies conclude that the further northward migration of the ITCZ is related to increased seasonality throughout the northern tropics during this period.

This study attempts to further document the previously described phenomenon with low resolution stable isotopic trends and to gain additional insight with high resolution bivalve $\delta^{18}O$ and $\delta^{13}C$ profiles.

METHODS

Three transects through portions of the Holocene section, called sections J, K and L, which consist of dominantly *in situ A. cervicornis* in a carbonate mud matrix were selected for specimen collection. All three were located in the Las Clavellinas study site, at 18˚ 30’ 6.3” N, 71˚ 32’ 48.4” W.

The three sections were studied in detail, photographed in the field and then thoroughly sampled. Bivalves and barnacles were selected from bulk sediment samples taken from the gulley wall in 10 cm increments and were taken to the University of Saskatchewan for micro-milling. Bivalves were micro-milled parallel to growth bands using a computer-controlled device (described thoroughly in Wurster et. al., 1999). Three shells were milled at high resolution.

Six species of shallow marine bivalves were used in this study. *Arcopsis adamsi, Barbatia domingensis, Barbatia tenera* and *Barbatia candida* are bysally attatched epifaunal suspension feeders (Stanley, 1970). *Codakia* *orbiculata* and *Tellina gouldii* are infaunal deposit feeders (Stanley, 1970). Articulated specimens of *C. orbiculata, A. adamsi, Tellina gouldii,* and *B. candida* were identified in the field.

Isotopic analysis was performed at the University of Saskatchewan in an automated Kiel device attached to a Finnigan MAT 252 stable isotope ratio mass spectrometer.

After mirco-milling, three key bivalves were sent to Arizona Accelerator Mass Spectrometry (AMS) Laboratory at the University of Arizona for analysis for radiocarbon dating

RESULTS

Low-resolution data

SEM analysis of growth increments of *A. adamsi* and *B. candida* specimens from the same transects indicates that these small bivalves lived for approximately 1 year (Taggert, J., this volume). The range of $\delta^{18}O$ values observed in individual specimens is low and variable (Figure 1). The average range is 0.76‰ for *A. adamsi* and 1.11‰ for *Barbatia sp.*. The ranges do not change as a function of time, and consistent seasonal profiles are not visible in either carbon or oxygen data.

The $\delta^{13}C$ values are significantly higher on average in the younger section (K) than in the older sections (L and J) by 1.29‰, while the $\delta^{18}O$ values are lower on average in section K by 0.45‰, as confirmed by a two-sample t-test (Fig. 2)

High-resolution data

Years two and three of the profile for sample DR-LP show distinct seasonal $\delta^{18}O$ profiles which move from high to low values, showing variability of greater than 1 per mil (Fig. 3). There is one anomalously low $\delta^{18}O$ value at the end of year one which adds significantly to the overall variability of this bivalve's $\delta^{18}O$ profile. The carbon profile for this specimen appears to be positively and negatively correlated with the oxygen profile at different times.
Insert figure 3

Since no growth rate data is available for *Tellina gouldii*, the timescale of profiles DR-LT and DR-LD must be inferred. Both samples show variability on the order of 1 per mil in their oxygen profiles (Fig.9, 10). Specimen DR-LD has a relatively sinusoidal seasonal $\delta^{18}O$ profile towards the end of its life, while DR-LT shows two punctuated negative excursions in its $\delta^{18}O$ and $\delta^{13}C$ values at approximately the same stage in its life.

DISCUSSION

The projected $\delta^{18}O$ values based on modern temperature data are all between -1 and 0‰ with a range of 0.77‰ (Fig. 4). This is the range we would expect to see if temperature were the only control. The majority of actual $\delta^{18}O$ values from this study are between .5 and 1.5 ‰, implying that the water in which the bivalves lived was 1.5‰ higher than today on average. This is indicative of a highly evaporative environment, although the salinity in the basin did not increase enough to limit coral growth.

Low-resolution data

Since many bivalve species dramatically change shell growth rates throughout the year (Rhoads and Lutz, 1998; Goodwin et al., 2003), we conclude that the *Barbatia* sp. secrete their shells throughout a larger portion of the year because they contain larger ranges in $\delta^{18}O$ profiles than the *A. adamsi* specimens. The 1.1‰ average range is thus the closest approximation of ambient conditions. Since

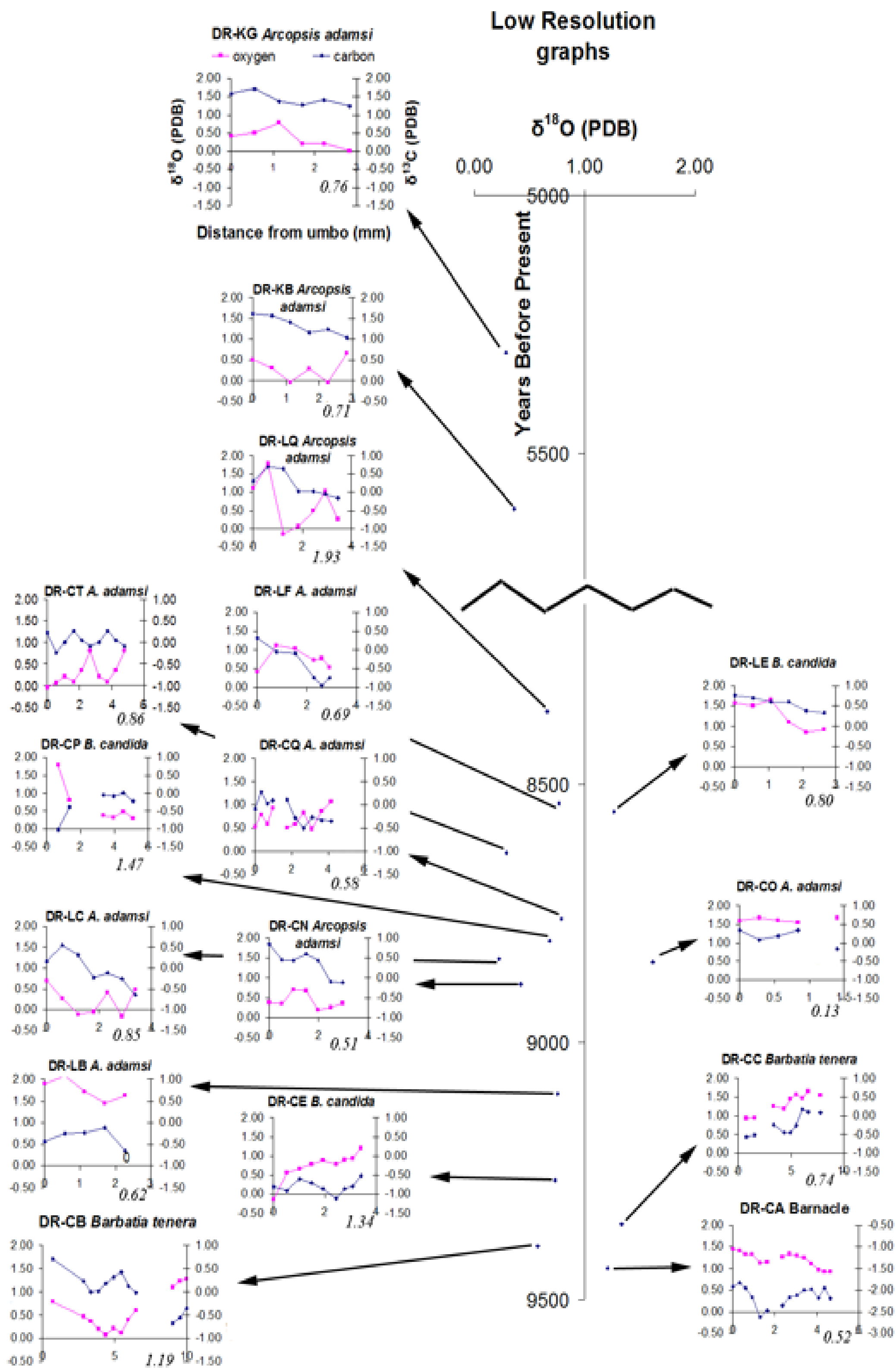

Figure 1: Low-resolution bivalve and barnacle stable isotope profiles. All isotopic ratios reported in per mil (‰) units. Range of d18O (‰ PDB) values displayed in italics.

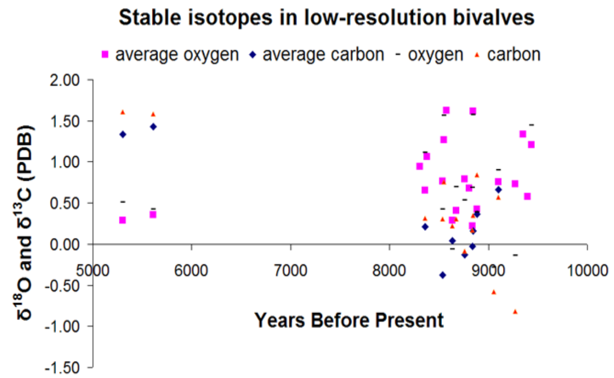

Figure 2: Low-resolution stable isotope data and specimen averages for bivalves.

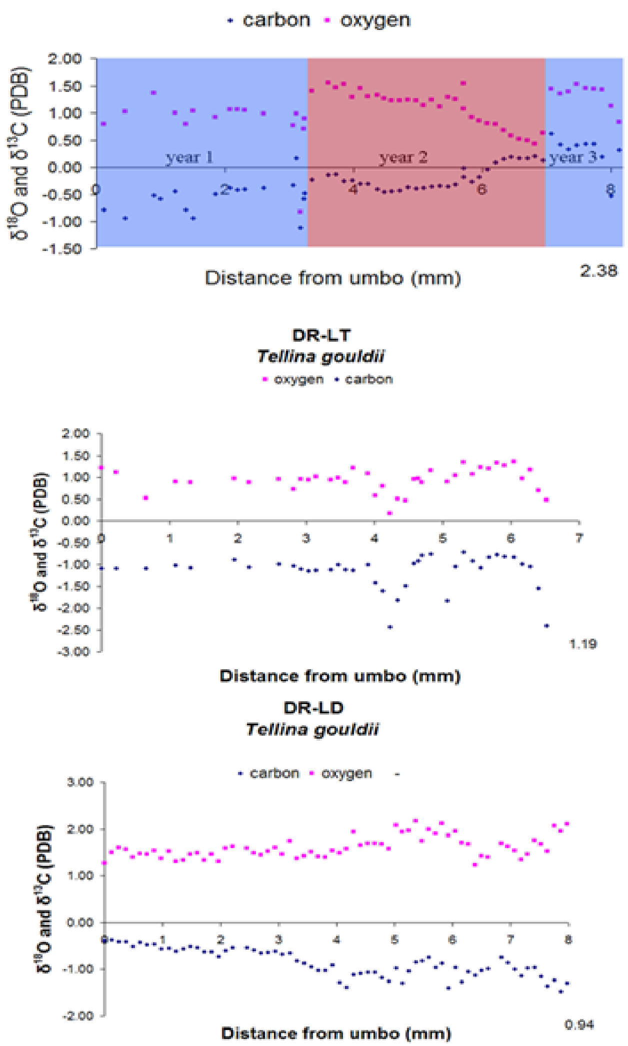

Figure 3: Stable isotope profiles of high-resolution bivalves. Range of d18O values is displayed in lower right hand corner of graph. Specimen DR-LP was found articulated in the field. Annual growth cessations marked by growth ridges on shell exterior of DR-LP. Approximate ages: DR-LT - 8,300 years BP, DR-LP - 8380 years BP. DR-LD Radiocarbon age: 8577 +/- 52 years BP.

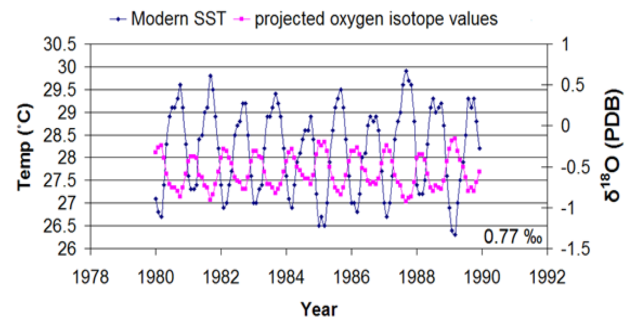

Figure 4: Sea surface temperature data proximal to the Enriquillo valley. Projected d18O values based on aragonite temperature equation from Grossman and Ku (1986), assuming d18O of ambient seawater to be 1 per mil (VSMOW). Range of d18O values is displayed in lower right hand corner of graph in per mil units.

this is much larger than the projected range of 0.77‰, there was likely a significant rainy season in Hispaniola during the mid-Holocene.

The relatively low $\delta^{18}O$ values in the young section are synchronous with the lowest $\delta^{18}O$ values in the Haitian ostracode core data from Curtis and Hodell (1993) (Fig. 5). Since the 0.45‰ average decrease would correspond to a ~2˚C increase in temperature, we conclude that this change is due primarily to an increase in precipitation which is the result of the farther northward migration of the ITCZ.

The $\delta^{13}C$ values are significantly higher on average in the younger section than the older sections, the opposite of what would be expected if increased precipitation induced the influx of relatively negative terrestrial carbon via runoff. This trend could be the result of greatly increased productivity but may also be due to metabolic affects.

High-resolution data

In sample DR-LP, the profile of year 2 provides further evidence for a significant rainy season because the range of $\delta^{18}O$ values is greater than 1‰. It is clear that this species stops

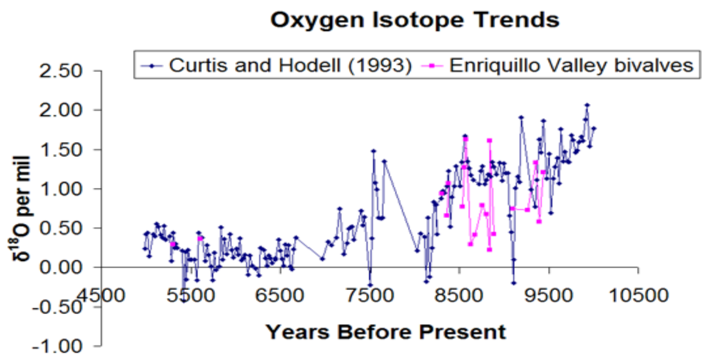

Figure 5: Mean d^{18}O values of all samples taken form each high and low-resolution bivalve plotted with ostracode core data from Lake Miragoane in Haiti (Curtis and Hodell, 1993).

shell secretion during wet summer months, and continues growth during cooler, dryer months. Both *Tellina gouldii* specimens appear to grow most quickly during the first year, as expected. Sample DR-LD appears to have lived through two winters and also shows a δ^{18}O range that may be too large to be the result of temperature alone. It is unclear whether the weak rainy season of today could create such variations, but the data from Curtis and Hodell (1993) indicates that there was greater precipitation on average than today throughout this period, implying that the rainy season was more powerful than today. Moreover, the possibility of a monsoon-like rainy season cannot be ruled out, because bivalve δ^{18}O profiles from Bemis and Geary (1996) off the coast of Panama, a location within the seasonal range of the ITCZ, had similar ranges.

Since specimen DR-LT is the same size and species as specimen DR-LD, the negative peaks in its δ^{18}O profile could be interpreted as partially created seasonal precipitation anomalies, providing evidence that deep convection systems of the ITCZ did at one point form over Hispaniola. Because terrestrial carbon is relatively light, the negative carbon peaks suggest there was extensive runoff.

Because of the ambiguous timescale of the profiles, it cannot be determined whether this is the fingerprint of the ITCZ of if these are merely storm events.

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