LATE HOLOCENE CLIMATIC VARIABILITY FROM ST. CROIX, USVI REEF CORALS

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Abstract

We present a multi-century climate record using the skeletal geochemistry of Siderastrea siderea and Orbicella faveolata corals collected near Salt River Bay, St. Croix, USVI. Samples ranging in age from modern to approximately 2100 years old were collected, slabbed, and milled with each coral representing approximately 25 to 40 years of growth. Skeletal δ¹⁸O values correlate strongly with sea surface temperature (SST) and sea surface salinity (SSS). Seasonal variations in skeletal δ¹⁸O values are controlled primarily by changes in SST and secondarily by inferred changes in water δ¹⁸O due to precipitation and runoff. Analysis of these variations in the St. Croix corals indicates that SST and SSS have either been stable over the last several centuries or that some other process is masking the δ¹⁸O signal. Samples were also analyzed with Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) for trace element geochemistry. Unusually high ratios of Ba/Ca correspond with an influx of sediment typically associated with increased runoff from storm events. An increase in average Ba/Ca values when skeletal δ¹⁸O values are static is likely a result of drier atmospheric conditions and increased anthropogenic sediment flux.

Methods

• Study Area: Samples were collected and cored near the mouth of Salt River Bay on the island of St. Croix, USVI (Figures 1 and 2).
• Preparartion: Each core was slabbed and sonicated before being x-rayed, U-Th dated (Table 2), and micro-milled at 0.5 mm increments.
• Stable Isotope Data: Milled coral material was analyzed on a Thermo Gasbench III interfaced with a Thermo Delta V Plus Isotope Ratio Mass Spectrometer (IRMS) at the Center for Marine Science, University of North Carolina, Wilmington (UNCW CMS).
• Ba/Ca Data: Corals were analyzed with an Agilent 7700x LA-ICP-MS to obtain Barium to Calcium ratios in the Stable Isotope Laboratory at the UC-Davis Earth and Planetary Sciences Department.

Figure 1: Map view of Caribbean Sea and aerial photo of Salt River Bay National Historic Park and Ecological Preserve, St. Croix, USVI (Google Maps®, Google Earth®). "LC" indicates the position of live coral sampling near the Salt River Canyon and the former NOAA buoy and the "TC" indicates the location where multiple sub-fossil coral heads that had been washed ashore at East Beach were sampled for analysis (Modified from Lane, 2016.)

Results

Figure 2: Image showing the core of sub-fossil coral on East Beach.

Stable Isotope Data

Stable isotope values vary on a seasonal basis, influenced by SSS and SST, in both the modern and sub-fossil coral cores (Figures 3, 4, and 5). SSTX15-01 and STX15-12 are similarly depleted in δ¹⁸O. Every 0.2‰ depletion in δ¹⁸O of coralline aragonite correlates with a 1°C increase in SST (Guzman, Tudhope; 1998). Interpretation of this data suggests that either SST and SSS have remained static since the 15th century or some other forcing is at work.

Stable Isotope Data

• Skeletal δ¹⁸O values vary on a seasonal basis, influenced by SSS and SST, in both the modern and subfossil coral cores (Figures 3, 4, and 5). SSTX15-01 and STX15-12 are similarly depleted in δ¹⁸O. Every 0.2‰ depletion in δ¹⁸O of coralline aragonite correlates with a 1°C increase in SST (Guzman, Tudhope; 1998). Interpretation of this data suggests that either SST and SSS have remained static since the 15th century or some other forcing is at work.

• Various forcings in opposite directions (SST and SSS) are likely responsible for the depletion of δ¹⁸O values in coral skeletal material.

• Global climatic trends point to a warming of the planet, thus a decrease in SST is an unlikely culprit.

• Increased Ba/Ca values indicate that modern sediment flux exceeds that of 15th century runoff.

• Increased human activity on the island over the last several centuries has likely contributed to an increase in sediment flux to the local reefs.

• Further analysis of the other corals collected in 2015 and several other corals collected in 2016 would provide the resolution necessary to establish a comprehensive record of climate variability in St. Croix.

Future Work

• Additional corals were collected during the May 2016 field season. These corals have yet to be analyzed.

• Additional isotopic and trace element geochemistry will be performed on additional STX15 coral samples.

Acknowledgements

We thank Dr. Douglas Gamble, Dr. Scott Nooner, Konrad Grococki, Sarah Kwon, and Audrey Taylor of UNCW for assistance in the field. We thank Kim Duemerehn of the UNCW CMS for assistance in the laboratory. We thank Dr. Randy Hills-Stare of the National Park Service for access to the field area. We thank Dr. Howie Spruoz of University of California, Davis for access to the Stable Isotope Laboratory. We thank Dr. River Shen of National Taiwan University for radiometric dating. We thank Steve Rounds for making thin sections.

References


Figure 3: Stable oxygen isotope (δ¹⁸O) data for the STLX1-01 core that dates from 2005 to 2015 C.E.

Figure 4: Stable oxygen isotope (δ¹⁸O) data for the STLX1-12 core that dates from 1435 to 1440 C.E. Different color represents different sampling paths.

Figure 5: Comparison of Stable oxygen isotope (δ¹⁸O) data from STLX1-01 and STLX1-12 coral cores.

Figure 6: On the left is the coral STLX1-01 after being polished for Gasbench IRMS. On the right is the approximate LA-ICP-MS path of STLX1-01 overlain on x-y image of coral slab.

Figure 7: Barium to calcium ratios for the STLX1-12 coral core that dates from 1435 to 1440 C.E (Lane, 2016).

Figure 8: Barium to calcium ratios for the STLX1-12 coral core that dates from 1435 to 1440 C.E (Lane, 2016).

Table 1: Yearly average precipitation records from 2005-2016 on the island of St. Croix.

Table 2: Chart showing the Uranium-Thorium dates of the 10 modern and subfossil corals collected in 2015.

Table 3: Comparison of Stable oxygen isotope (δ¹⁸O) data from STLX1-01 and STLX1-12 coral cores.