LATE HOLOCENE CLIMATE 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 $\delta^{18}O$ values correlate strongly with sea surface temperature (SST) and sea surface salinity (SSS). Seasonal variations in skeletal $\delta^{18}O$ values are controlled primarily by changes in SST and secondarily by inferred changes in water $\delta^{18}O$ 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 $\delta^{18}O$ 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 $\delta^{18}O$ 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).
- **Preparation**: 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 II/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 quadrupole LA-ICP-MS to obtain Barium to Calcium ratios in the Stable Isotope Laboratory at the UC-Davis Earth and Planetary Sciences Department.

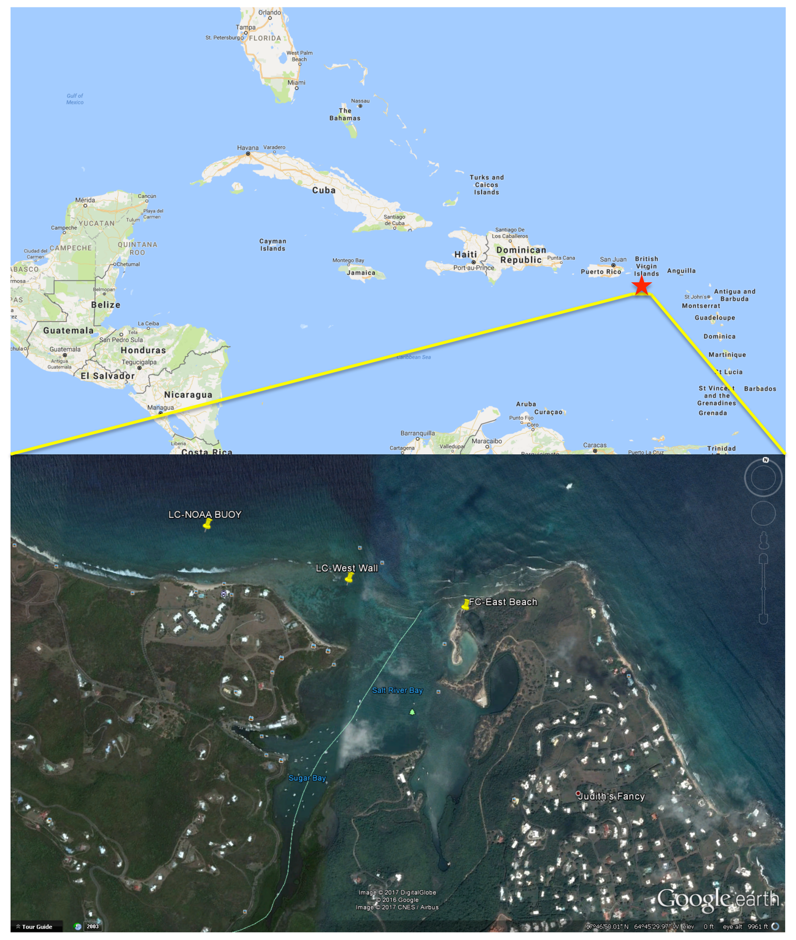

Figure 1: Map view of Caribbean Sea and Aerial photo of Salt River Bay National Historic Park and Ecological Preserve, St. Croix, USVI (Google Maps®, Google Earth®) 'LC' indicates the position of live coral sampling near the Salt River Canyon and the former NOAA buoy and the 'FC' indicates the location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

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

Results

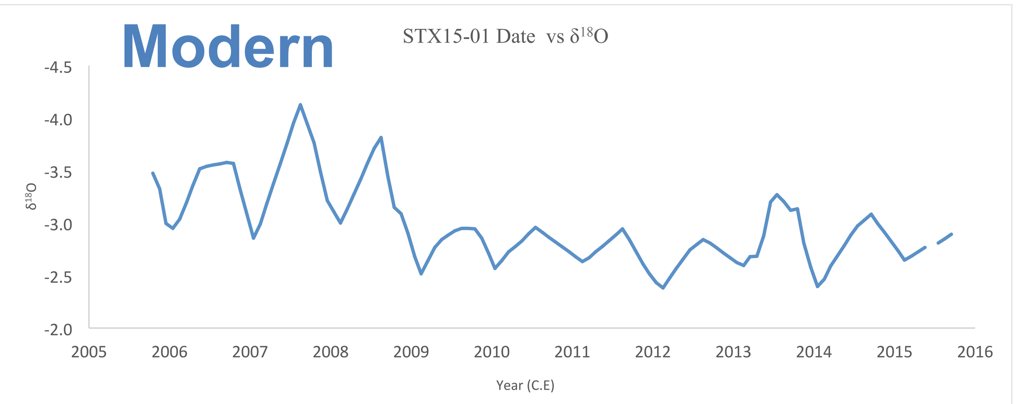

Figure 3: Stable oxygen isotope ($\delta^{18}O$) data for the STX15-01 coral core that dates from 2005 to 2015 C.E.

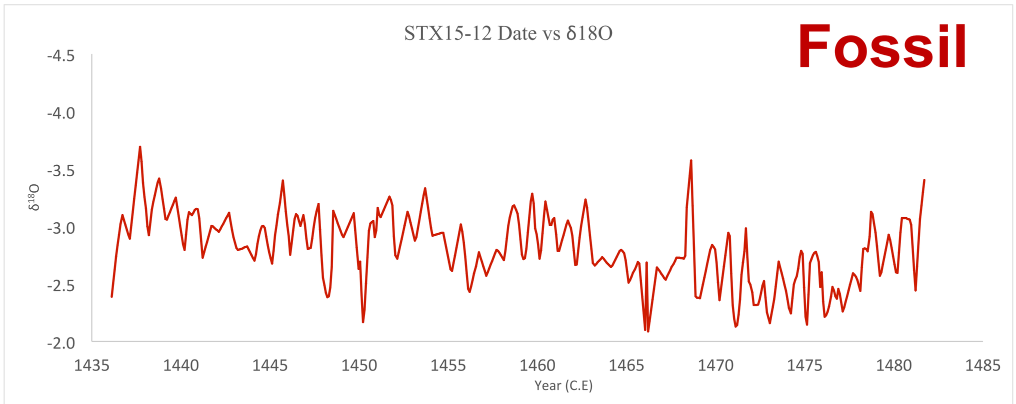

Figure 4: Stable oxygen isotope ($\delta^{18}O$) data for the STX15-12 coral core that dates from 1436 to 1482 C.E. Different colors represent different sampling paths.

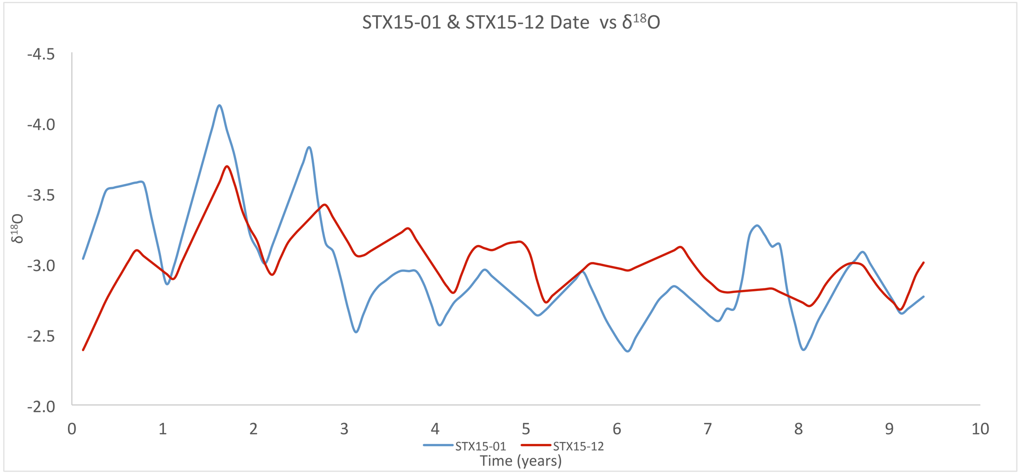

Figure 5: Comparison of Stable oxygen isotope ($\delta^{18}O$) data from STX15-01 and STX15-12 coral cores.

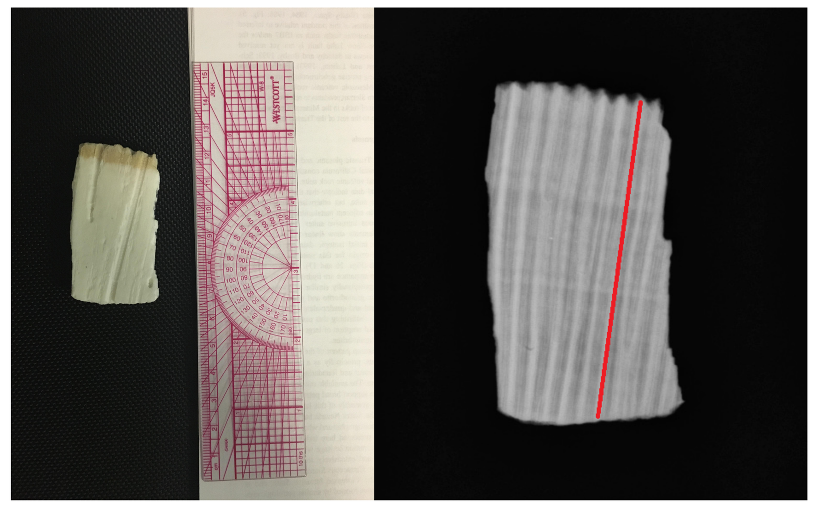

Figure 6: On the left is the coral STX15-01 after being milled for Gasbench IRMS. On the right is the approximate LA-ICP-MS path of STX15-01 overlain on x-ray image of coral slab.

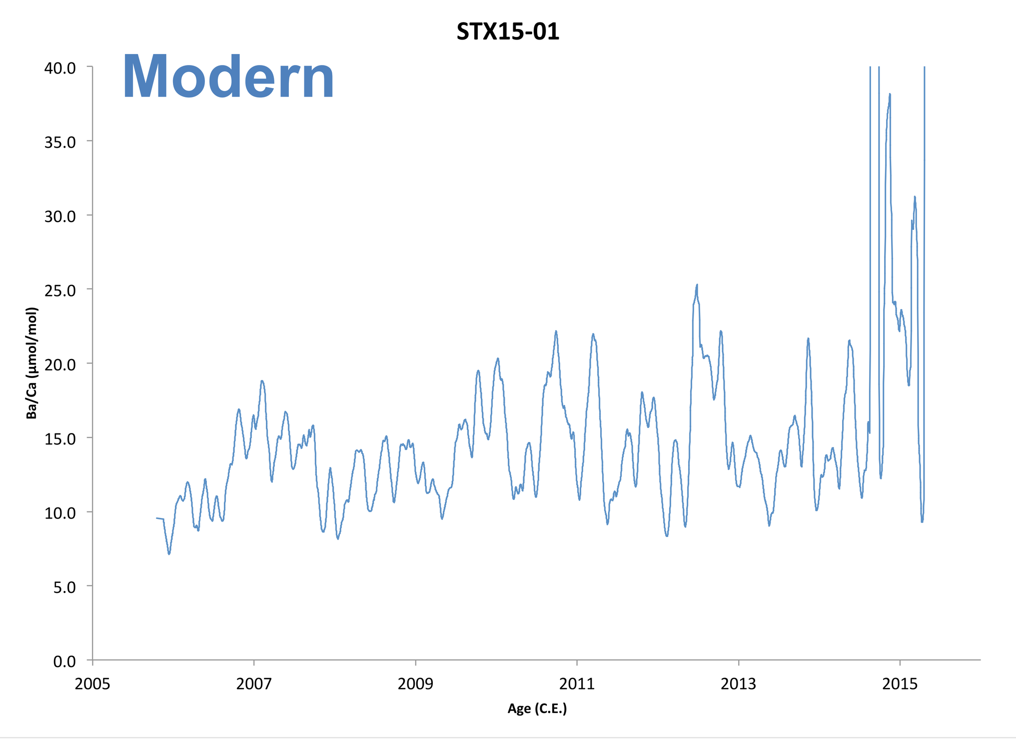

Figure 7: Barium to calcium ratios for the STX15-01 coral core that dates from 2005 to 2015 C.E (Lane, 2016).

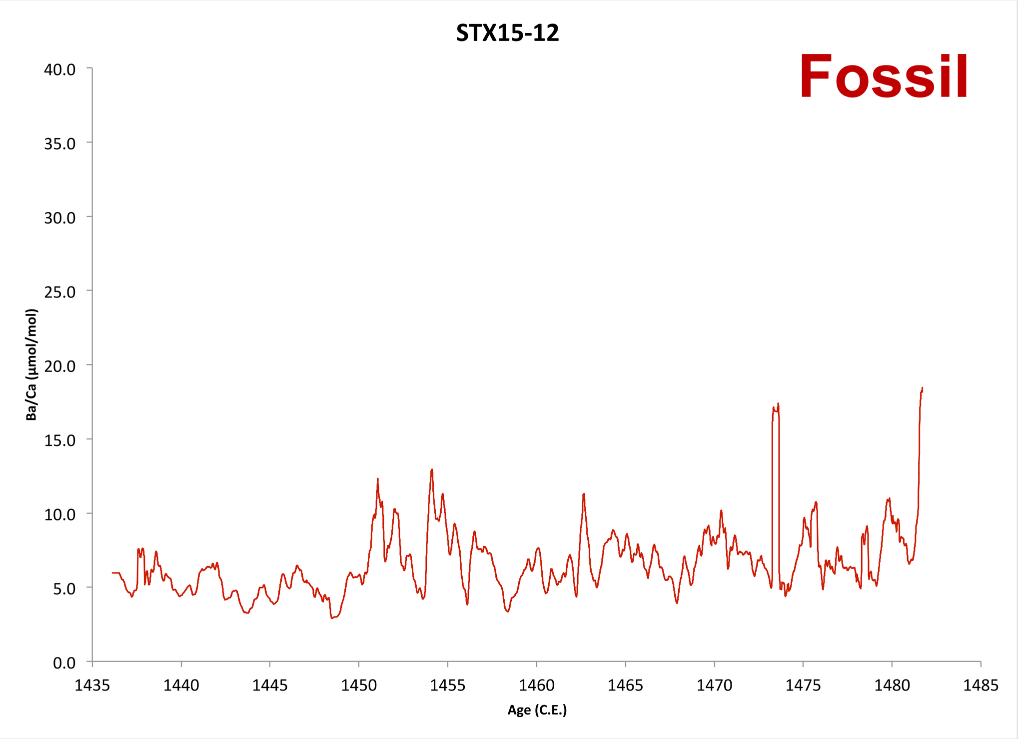

Figure 8: Barium to calcium ratios for the STX15-12 coral core that dates from 1436 to 1482 C.E (Lane, 2016).

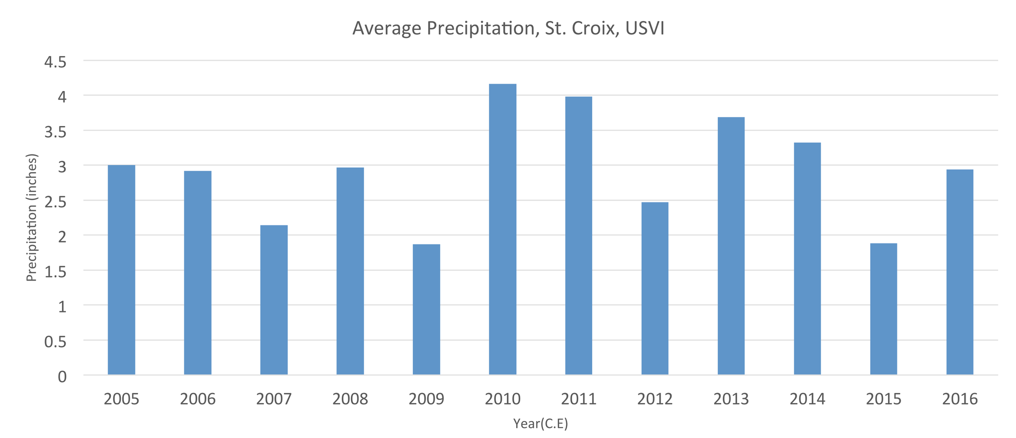

Table 1: Yearly average precipitation records from 2005-2016 on the island of St. Croix.

Sample ID	Age (Years before present)	Error
STX15-5	80.7	± 1.5
STX15-6	34.6	± 1.2
STX15-7A	25.21	± 0.95
STX15-8	1,182.2	± 9.3
STX15-9	153.5	± 3.3
STX15-10	2,300	± 35
STX15-11	1,862	± 42
STX15-12	580.1	± 9.3
STX15-13	2,978	± 12
STX15-14	2,141.9	± 8.7

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

Discussion

Stable Isotope Data

- Skeletal $\delta^{18}O$ values vary on a seasonal basis, influenced by SSS and SST, in both the modern and subfossil coral cores (Figures 3, 4, and 5).
- STX15-01 and STX15-12 are similarly depleted in $\delta^{18}O$. Every 0.2‰ depletion in $\delta^{18}O$ 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.

Ba/Ca Data

- Significant barium replacement of calcium during the precipitation of aragonite from seawater indicates an increase in the amount of suspended sediment in the water column (McCulloch, et al; 2003).
- Increased sediment load can result from increased amounts of natural runoff or anthropogenic activity (Saha, et al; 2016).
- Note the difference in average values of Ba/Ca ratios between the 15th century coral STX15-12 and the modern day STX15-01 (Figures 7 and 8).

Conclusions

- Various forcings in opposite directions (SST and SSS) are likely responsible for the depletion of $\delta^{18}O$ 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 cores have yet to be analyzed
- Additional isotope and trace element geochemistry will be performed on additional STX15 coral samples.

Acknowledgements

We thank Dr. Douglas Gamble, Dr. Scott Nooner, Konrad Grochocki, Sarah Kwon, and Audrey Taylor of UNCW for assistance in the field. We thank Kim Duernberger of the UNCW CMS for assistance in the laboratory. We thank Dr. Zandy Hillis-Starr of the National Park Service for access to the field area. We thank Dr. Howie Spero 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.

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