Corals as Climate Recorders

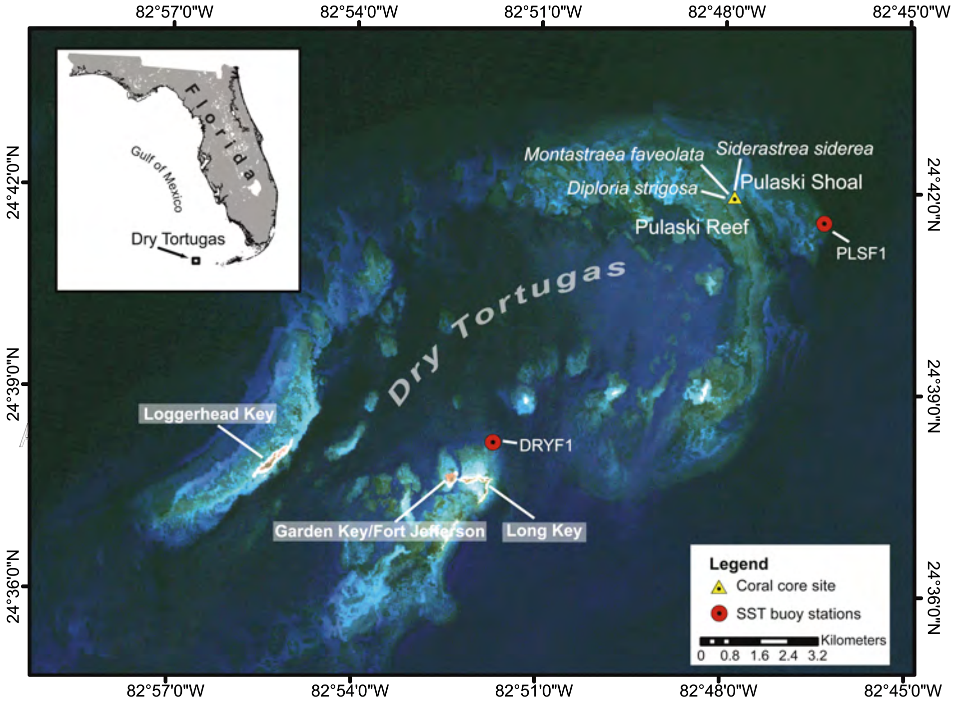

Figure 1. Map of the Dry Tortugas National Park. The coral locations and stations monitoring sea-surface temperature (SST) are denoted on the map by a yellow triangle and the red circles, respectively. Three species of corals (*Montastraea faveolata, Siderastrea siderea,* and *Diploria strigosa*) were collected from Pulaski Shoal in August 2008 for various climate analyses.

Figure 2. A USGS researcher takes a core of the coral species *Diploria strigosa*. A core barrel is used with a rotary coring device to obtain 4-inch-diameter cylinders of coral skeleton, typically of several feet in length. Photo credit: Kristine L. DeLong, Lousiana State University.

Corals deposit a skeleton made up of the mineral aragonite, which is a form of calcium carbonate ($CaCO_3$). X-radiographs of coral skeleton slabs show alternating light and dark layers (bands) that are the result of seasonal changes in growth rate and differences in skeletal density. A couplet of light and dark layers (bands) represents 1 year of growth and can be used to determine the age of the coral by counting back and down the coral from the known year it was sampled. Some of the larger (2 to 3 meters in length) living corals can be continuous environmental recorders of the past 100 to 500 years. Variations in the chemical and isotopic composition of the aragonite skeleton as well as changes in density and extension rates of the skeleton reflect changes in environmental factors such as seawater, temperature, salinity, and pH (acidity) as the coral grows.

The U.S. Geological Survey (USGS) Coral Reef Ecosystem Studies (CREST) Project is analyzing corals from various sites in the Caribbean region, Dry Tortugas National Park (figs. 1, 2), Biscayne National Park, other areas of the Florida Keys, and the Virgin Islands. The objective of this project is to develop records of past environmental change to better our understanding of climate variability. The records are being used to document changes over the last few centuries and to determine how corals and coral reefs have responded to any changes.

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Figure 3. Cores drilled from corals are drying on the table. Samples from the coral cores are analyzed to provide information on coral growth rates and variations in ocean temperature and salinity over time. Photo credit: Christopher D. Reich, USGS.

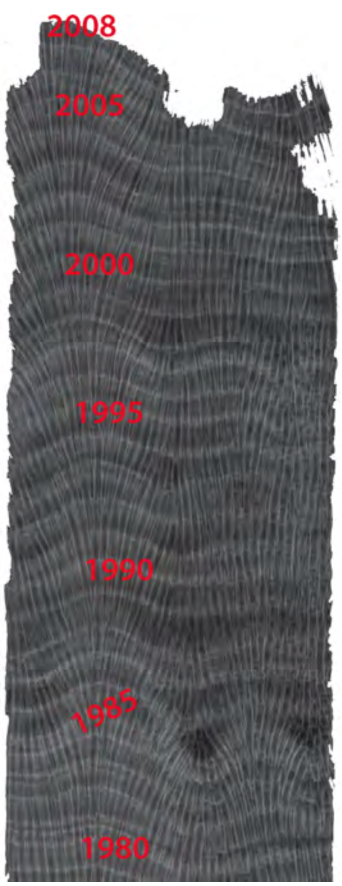

Figure 4. An x-ray of a *Montastraea faveolata* core slab. Notice the annual light and dark growth bands that have been counted and dated.

Current work focuses on developing temperature records from analyses of coral skeletons. Corals incorporate trace amounts of strontium (Sr) as a substitute for calcium (Ca) in their calcium carbonate ($CaCO_3$) skeletons, and the amount of strontium incorporated into the skeleton depends on the water temperature at the time of growth. The amount of strontium decreases as temperature increases, so that smaller strontium-to-calcium ratios (Sr/Ca) indicate warmer temperatures at the time of growth.

USGS researchers prepare coral cores (fig. 3) for sampling by sawing the cores into thin slabs, x-raying the slabs to better define the annual bands (fig. 4), and then using a computer-driven micro-drill to sample coral skeletons at approximately monthly intervals (fig. 5). The monthly samples are then analyzed for Sr/Ca (fig. 6) using an inductively coupled plasma optical emission spectrometer (ICP-OES) to generate a seasonally resolved sea-surface temperature record.

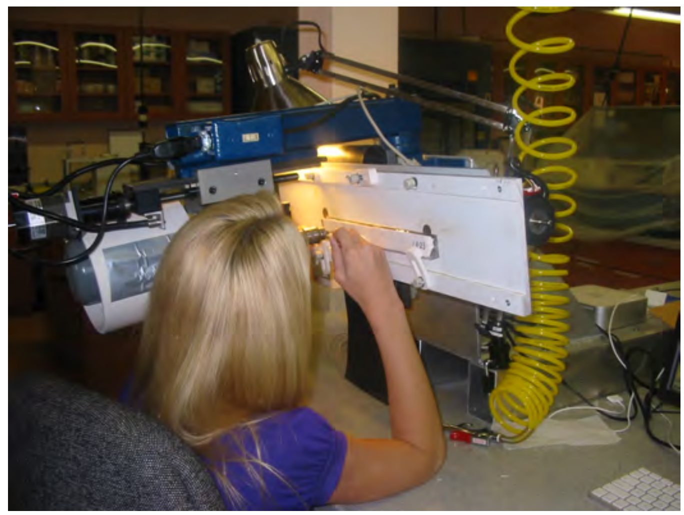

Figure 5. A chemist drills a slab of the coral *Montastraea faveolata* using a dental drill and collects the powder for Sr/Ca analysis. Photo credit: Jennifer A. Flannery, USGS.

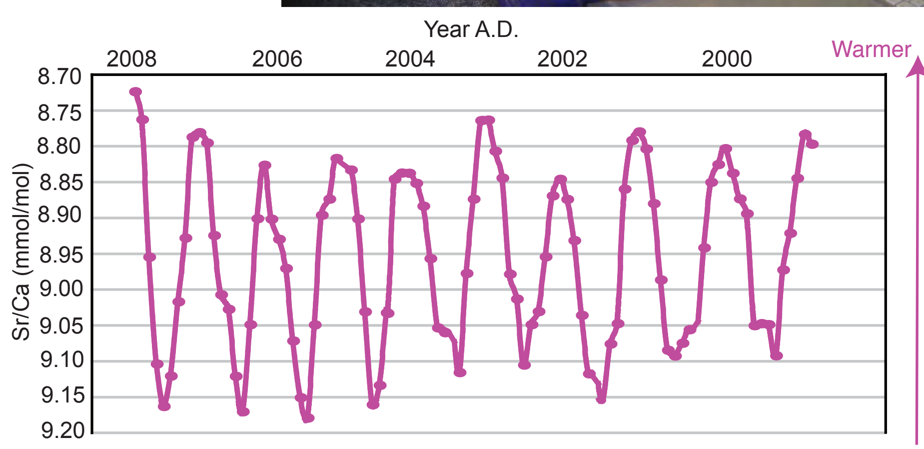

Figure 6. A record of Sr/Ca measurements from a *Siderastrea siderea* with corresponding ages, Dry Tortugas National Park. Note the annual seasonal cycles in the record from warmer temperatures to cooler temperatures. Filled circles indicate individual measurements.

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