

Coastal Geology and National Parklands:

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More than 50 percent of all Americans live within 50 miles of our Nation's oceans or the Great Lakes. As population increases along the coasts, so does pressure on coastal resources. More than a dozen National Parks and the many national seashore areas share common concerns with the USGS Coastal Geology Program about the impacts of man and nature on these sensitive areas. Coastal environments are typically in a continual process of change. This change may be so slow as to be imperceptible on the human scale, becoming apparent only over periods of geologic time. Or, coastal change may be catastrophic and as violent as recently exemplified by Hurricane Andrew. Nature presents the challenge to humankind of incorporating these processes of change into plans for conservation and preservation.

Geological processes play important roles in coastal evolution and ecosystems. In many

areas, coastal erosion is the most visible coastal process. Erosion presents a hazard along developed coasts and is a process which modifies many undeveloped coastal areas. Less apparent, but no less important, pollutants associated with fine-grained sediments travel through coastal systems to accumulate in low energy areas such as coastal swamps and lagoon floors. Coastal wetlands, important nurseries for marine and terrestrial wildlife, are altered by natural sedimentation and infilling, by sea-level change and by erosion of protective barrier islands. A thorough understanding of these coastal processes is required to accurately predict their future effects and to evaluate the success of management plans.

Issues concerning coastal geology and pollution merge in peninsular Florida where urban and agricultural demands impact the Everglades and Biscayne NPs. In Florida, as well as in

many other states, the USGS Coastal Program and the NPS have obvious common ground for coastal research. Additionally, because of its tropical climate, coastal issues in south Florida have counterparts in National Park areas of Puerto Rico, U.S. Virgin Islands, Guam, and other tropical regions associated with the United States.

One example of coastal research sponsored jointly by the USGS and NPS examines the history of runoff in southeastern Florida. Runoff is an important environmental variable in coastal systems. In south Florida, runoff strongly influences the salinity of nearshore environments. Natural and anthropogenic nutrients are brought to coastal water bodies by runoff. Increasingly, human-made (anthropogenic) pollutants such as heavy metals may also be intro-

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An Example from Biscayne NP

duced with runoff. Understanding the history of runoff in Biscayne NP provides valuable evidence of the tolerance of tropical coastal ecosystems to influences from adjacent land areas.

Arguably the greatest anthropogenic impact in south Florida is the modification of its natural hydrogeology by a system of canals, salinity barriers, impoundment dams, water conservation areas, and pumping stations (Klein, 1973). The "drainage" of the Everglades for agricultural use began at the turn of the century. Disastrous floods in 1926 and 1928 prompted continued modification for flood control, as did the 1947 flood which heralded the establishment of the Florida Water Management Districts (Huser, 1989). By the time Everglades Park was established, the opportunity to collect detailed information about the natural state of south Florida hydrogeology had passed. Knowledge of the natural state of south Florida hydrogeology must be reconstructed through historical records, geological records, and modeling efforts.

During the rainy summer and fall, the water table in the Everglades rises above the ground and runoff occurs as sheet flow over topographic low areas along the coast. Prior to this century, most of the flow was to Florida Bay and the Gulf of Mexico. Eastward flow was blocked by a topographic feature known as the Atlantic Coastal Ridge. Most development after 1900 has taken place on the relatively high ground of the ridge which attains elevations of 8 meters above sea level. Drainage of the Everglades was facilitated by dredging canals through the ridge. Many of these canals drain into the Atlantic though Biscayne Bay. During the dry winter months saltwater intrusion is prevented by salinity gates at the canal mouths and by maintaining water levels in the canals from impoundments inland.

Florida groundwater typically contains dissolved soil acids that fluoresce in the visible range when excited by ultraviolet light (Averett and others, 1987). During times of increased runoff from the land, these fluorescent compounds mix with coastal marine waters and are transported to nearshore reefs. There, the soil acids are incorporated into the growing coral skeletons and preserved in the aragonite skeletal matrix. Several species of corals produce annual density variations in their skeletons which, like tree rings, can be used to date skeletal intervals. This science, known as sclerochronology, has shown that some coral species may grow for several centuries (Hudson and others, 1976), and may provide a record of runoff from adjacent land areas based on fluorescence data.

Figure 1 illustrates density and fluorescent images for a coral sample from Biscayne NP. The figure represents a portion of a coral record that spans 117 years. Image analysis of the entire record provides a relative fluorescence record for more than a century shown in Figure 2. The record can be divided into three time periods. The period 1870 - 1920 is characterized by low fluorescence punctuated by occasional years of high fluorescence. This pattern is similar to the pattern of measured rainfall in south Florida and is thought to represent the natural variability of runoff. The years from 1920 to 1955 span the drainage and flood con-

trol periods and reflect frequent high runoff years associated with dredging. During the late 1950s and 1960s water management practices were instituted to conserve runoff during the wet season to maintain dry season water levels. This period is recognized in the fluorescence record by the absence of years characterized by high fluorescence from about 1955 to 1987. Coral fluorescence therefore provides a proxy record of runoff into Biscayne NP and a measure of the natural variability in the south Florida hydrogeological system before it was altered.

Coral fluorescence provides a geological avenue for the investigation of freshwater influxes into coastal reef ecosystems. Other projects within the USGS Coastal Program carry out applied research on a variety of problems related to coastal erosion and pollution. Readers are encouraged to browse Sallenger and others (1992) for a more complete description of program activities.

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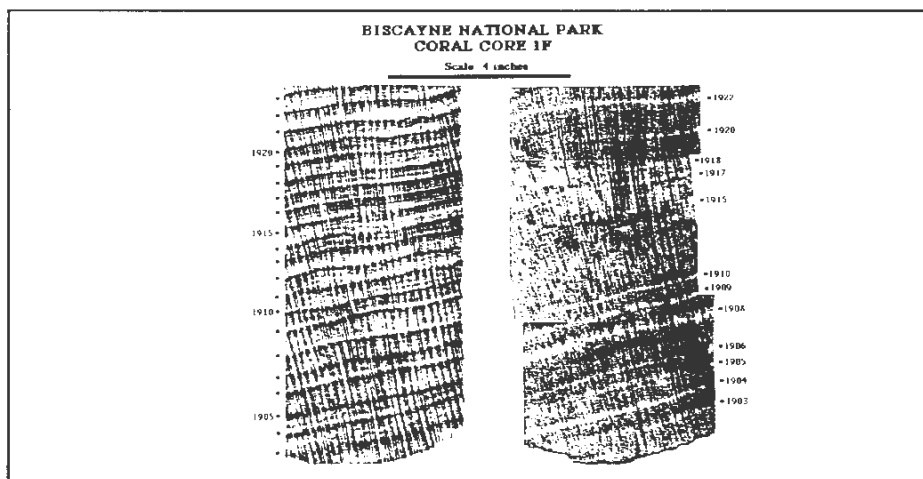


Figure 1. Images of coral skeleton samples. Image on the left is an x-radiograph revealing density variations that define annual banding in this sample of *Montastrea annularis*. Image on the right is the same sample in short-wave UV light. Light bands are fluorescing and are given dates based on density bands exhibited by the x-radiograph. Annual growth increment averages 1 cm.

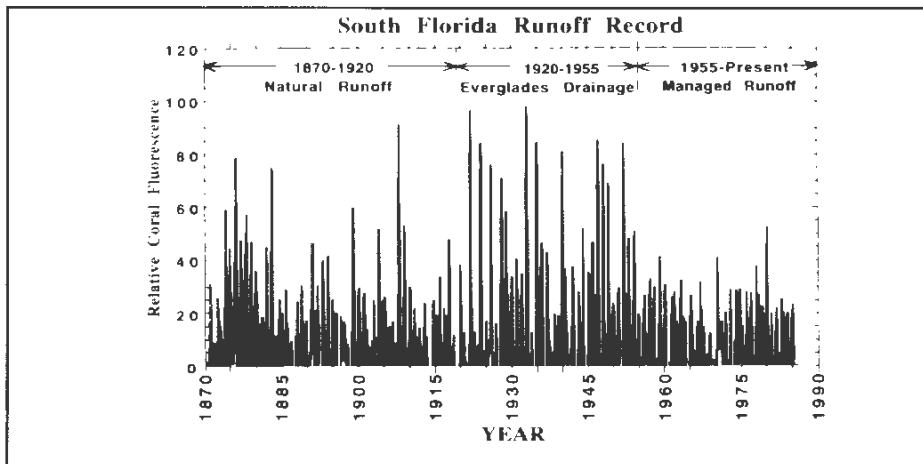


Figure 2. Plot of the relative fluorescence of annual skeletal growth intervals between 1870 and 1987. Fluorescence intensity is a proxy for fresh-water runoff from south Florida into Biscayne NP nearshore reefs.