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For a Diver Every day is Ocean Day

Geology and Human Activity in the Florida Keys

USGS Fact Sheet

Gene Shinn

"Live corals on the east side of the Florida Keys are mysteriously dying and algae are taking over that eco-niche. U.S. Geological Survey (USGS) studies and mapping of the Keys and the reef tract suggest that a number of natural factors, combined with effects of human activity, may contribute to the corals' demise. A complete geological study of this ecosystem would provide the kind of information environmental managers need to determine the extent of damage to reefs resulting from human activity."
- E. A. (Gene) Shinn, U.S. Geological Survey

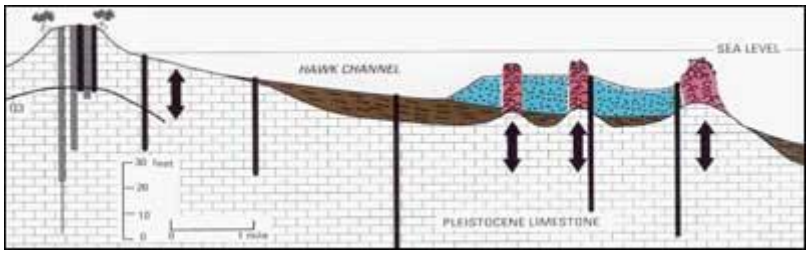
Coral reefs of the Florida Keys are suffering and have in many places been replaced by algae known to thrive on nutrients from treated sewage.

Widespread loss of nearshore and offshore corals on the Atlantic side of the Keys is well documented, as is their replacement with fleshy algae, which are known to flourish in elevated concentrations of phosphate and nitrate. These chemicals, byproducts of the treatment of human sewage, are not considered to be contaminants, but to be nutrients. Sewage treated on land is purified to near-potable water quality and is discarded in a series of perhaps as many as 1,000 shallow disposal wells and maybe ten times that number of septic tanks along the Keys. Nutrient-rich disposal water is released at depths ranging from 30 to 90 feet and it is believed to migrate seaward towards the corals.

USGS scientists recently drilled numerous cores on the Keys and in the coral reef tract to study how geology controlled movement of well water.

This study completed 21 holes ranging in depth from 8 feet to 65 feet on 3 transects, averaging 7 wells each. The project was designed to allow any flow of nutrient-rich water to be tracked from areas of the disposal wells to the

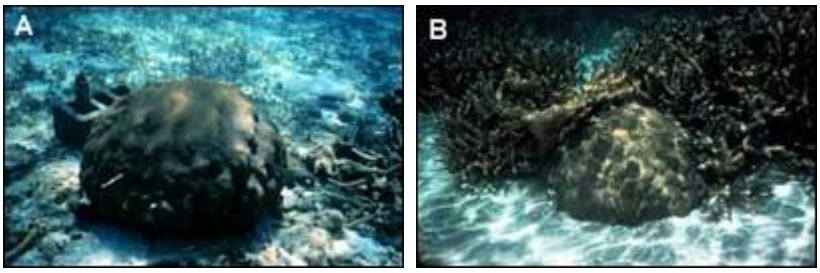
offshore reefs. This USGS research is supported in part by the **Florida Department of Environmental Protection** and the **U.S. Environmental Protection Agency**. Technical cooperation is also provided by Harold Hudson and Billy Causey at the Marine Sanctuary Program, Key Largo, and by Dr. Steven Miller and his colleagues at the **National Undersea Research Center**, all of the **National Oceanic and Atmospheric Administration**.



A schematic cross section of the Florida reef tract off Key Largo shows onshore treated-sewage effluent-injection wells (grey) and offshore monitoring wells (black). Water level in all wells fluctuates with the tides, causing flow of water from the underlying limestone, as shown by arrows. Young sediments (mud shown in brown and lime sands in yellow) retard flow of water from the underlying limestone. Reefs (shown in red) are extremely porous and are likely to provide outlets for ground water forced from the limestone by changing tidal levels. Should injected sewage water migrate laterally offshore, it may eventually encounter live corals through the process of tidal pumping. [larger version]

USGS geologic cross sections indicate that water from disposal wells could significantly impact specific areas of the Florida reefs.

Most of the bedrock underlying the Keys is highly porous limestone; the remains of ancient reefs through which contaminated waters can easily flow. Much of the disposal water, however, is released at a depth below a relatively impermeable layer known as the Q3 unconformity. Contaminated water does not readily penetrate this layer. In those areas where the Q3 layer is absent, or poorly developed, an equally impermeable layer of lime mud can trap ground water below and allow it to migrate laterally. Leakage is more likely where this mud is absent. Preliminary results of USGS studies indicate that ground waters beneath the reefs do contain nutrients, principally ammonia, at levels many times higher than that of normal seawater. Tidal pumping can allow these nutrient-rich ground waters to seep into the water columns, especially in areas where a mud layer is absent. In a sense, the rocks "breathe" water with each change of the tide.



1961 1971

1976 1992

A series of photographs showing 31 years of change at Grecian Rocks Reef off north Key Largo. **A.** A massive head coral, *Montastraea annularis*, photographed in May 1961, is located in the center of a sand hole. The 10-centimeter-long stainless steel pins were part of a growth-rate study. The cinder block holds a tubular sediment trap. [larger version] **B.** The same colony of *M. annularis*, shown in 1971, is being encroached upon by the branching coral *Acropora cervicornis*. Note the healthy live colony of the bladed elkhorn coral *A. palmata*. [larger version] **C.** In 1976, the same colony of *M. annularis* is nearly overgrown by the *A. cervicornis*, and the *A. palmata* is mostly dead except for a small portion under the diver's light. The view is at a 90° angle from first photo. [larger version] **D.** The same colony of *M. annularis* photographed in 1992. Only a small portion of the *Montastraea* remains alive. All of the *A. palmata* and engulfing *A. cervicornis* colonies are dead and are covered by algae. [larger version]

Other contributing causes of reef morbidity are natural events that may have recurred frequently in the recent geologic past.

Some natural events like hurricanes can have a more severe impact on the health of coral reefs in a shorter period of time than adverse human activity. Other events not related to sewage disposal include a mysterious epidemic that has nearly eliminated the algae-eating urchin, *Diadema*. Harvesting has reduced certain fish that control algae on the coral reefs. A slight increase in the temperature of Atlantic waters during the 1980's may have placed many coral species at risk. However, the temperature of Gulf of Mexico waters as they flow through tidal passes to the Atlantic side of the Keys periodically tend to be more saline during dry spells and are generally too cold for corals to

tolerate well. The waters are often laden with silt. In these areas, the slightly higher elevation of Gulf waters may produce a hydraulic gradient sufficient to create a net flow toward the Atlantic across significant portions of the reef tract.

USGS scientists plan an expansion of the well study to map flow directions in ground waters beneath the reefs.

Additional well transects perpendicular to the Keys and in Florida Bay would provide new opportunities to understand circulation patterns beneath Florida Bay, the Keys, and the reef tract. USGS researchers plan to add identifiable dyes and pressure sensors to certain wells to trace subsurface water movement. A map of relative concentrations of these dyes in adjacent wells will yield a more complete understanding of the direction of flow. Complete analyses of waters recovered from test wells may provide an estimate of how much disposal water reappears in the environment as well as an idea of the location from which it is escaping. Using this information, environmental managers and engineers may decide to seek alternate solutions to the disposal of treated sewage water.

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The only thing necessary for the triumph of evil is that good men do nothing"....*Edmund Burke*

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