The Response of a Coral Reef to Sedimentation

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Abstract

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The objectives of this two-year study (1974-1976) were to examine the effects of sedimentation on the structure and function of San Cristobal Reef, a healthy coral reef off southwestern Puerto Rico; to obtain ecological data, particularly baseline data on sedimentation rates; to investigate the relationship of species diversity to stability; and to look for evidence of resistance to stress and resilience after stress in a complex ecosystem.

San Cristobal has a typical reef environment. Mean incident solar radiation ranged from 270 to 560 gcal/$cm^2 \cdot$ day. The extinction coefficient was 0.29. Bottom currents never exceeded 13 cm/sec. Mean surface water temperatures for each month fluctuated between 24.8 and 28.7 C, while salinity ranged from 33.6 to 36.7 ppt. About 900 mm of rain fell in 1975. Transparency varied from 5 to 14 m. Mean sedimentation rates were 1 to 21 mg/$cm^2 \cdot$ day, while suspended matter concentrations averaged 0.4 to 2.4 mg/l. Tropical Storm Eloise in September 1975 decreased the temperature, salinity, and light and increased the sedimentation and suspended matter concentrations at the reef. The reef was resistant to this transient stress.

A new upstream-downstream method with submerged channels was used to measure the metabolism of two 10 m x 2 m transects 4 m deep. Gross primary productivity was estimated at 2.5 g $0_2/m^2 \cdot$ day. Hourly rates of net productivity ranged from 0.03 to 1.85 g $0_2/m^2$. Respiration measurements made after shading one reef section were 0.26 to 0.48 g $0_2/m^2 \cdot$ hr.

To study the reef's response to the exclusion of light (a simulation of extreme turbidity), one of the metabolism transects was covered with black plastic for 5 weeks. This chronic stress significantly altered the structure and function of the reef section. For example, there was no measurable net productivity, all hard coral species became bleached, and the dominant coral, Acropora cervicornis, was killed by the shading although other corals later recovered partially. After shading ceased, net productivity in the stressed channel exceeded that in the control probably because of the abundant algae which colonized the dead coral. As of March 1977, no young corals had settled in the stressed channel.

Sediments were applied at different doses and frequencies to several coral species. Acropora palmata was the most sensitive to this stress. The other species were very resistant. Laboratory experiments on Agaricia agaricites and field experiments on Porites astreoides and Acropora cervicornis indicated that the application of sediments, particularly silt, lowered the net productivity of these colonies.

Acropora cervicornis had an average growth rate of 8.3 cm/yr at 2 m depth. Colonies at 4 m had lower rates.

Algae rapidly colonized calcium carbonate plates on the reef. The few corals observed settled only where sediments could not accumulate.

The reef slope had the highest diversity and species number. It is suggested that overall structural complexity, however, is less than in shallower areas which have greater energy input.

Different susceptibilities of reef organisms to stress, particularly the ability of

some species to withstand stress or to recover quickly after stress, provide a basis for system resilience. Diversity, therefore, appears to be associated with stability.

This study suggests that reefs are resistant to sedimentation up to certain critical thresholds. Information from this research and research by other scientists suggests that continual suspended matter concentrations of 10-20 mg/l or more and water transparency of less than 4 m are very detrimental. Single doses of sediments ranging from 200-1000 mg/cm^2 kill various coral species. Chronic sedimentation rates of this magnitude could destroy a reef.