USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Delivery, deposition, and effects of land-based sediments on corals in St. John, U.S. Virgin Islands

Focus Category: M&P, SED, ECL

Key Words: Marine Resources, Watershed Management, Coral Reefs, Runoff, Sedimentation, Soil Erosion, Water Quality, Land-Water Interactions, Tropics.

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Total Non-Federal Funds: N/A

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Congressional District: N/A

Statement of critical water problems

In the Virgin Islands the economy is dependent upon clear coastal waters and healthy coral reefs for maintaining healthy fisheries and for providing the main attraction for tourism. The primary concern is that human activities in upstream areas of watersheds, from mountaintop to shoreline, are seriously affecting downstream water resources. Unpaved roads and clearing land for development cause high rates of erosion and contribute to the loss of precious topsoil. Runoff heavily laden with terrestrial sediments reduces marine water quality, and the subsequent sedimentation adversely affects the coastal marine environment.

The most effective way to manage downstream aquatic resources requires an integrative approach which links land use, erosion, sediment delivery, and the resultant effects on the marine environment. Unfortunately there is a paucity of studies that have been able to document each of the links from land use to the ultimate effect on the receiving waters and aquatic ecosystems. Thus there is an urgent need for a more integrated investigation of the cumulative effects of upstream activities on the health and sustainability of downstream marine resources.

Anticipated Results and Benefits

There have been a large number of studies that have examined various components of the terrestrial-aquatic system. This will be the first study to directly and quantitatively link land use, erosion rates, and sediment delivery to the resultant effects on the marine

environment. The collaborative approach will synergistically combine the ongoing erosion study with the proposed work on sediment deposition and effects on the marine environment.

Results from earlier work and the ongoing erosion study suggest that sediment delivery rates are substantially greater into Fish Bay than Lameshur Bay (MacDonald et al. 1997; Anderson and MacDonald 1998). Hence the coral reefs closest to the primary discharge location may already be subject to declining health and regeneration potential. Declining health will be recognized by a greater percentage of the coral colonies showing indications of old or recent mortality (partial or total). Declining regeneration potential will be recognized by reductions in coral recruitment and greater percent cover of macro-algae. A strong gradient of increasing coral health and regeneration potential with increasing distance from the Fish Bay watershed discharge point will confirm that terrigenous, anthropogenic sediment sources are having an adverse effect on marine ecosystems. The presence of a similar gradient in Lameshur Bay will indicate that even relatively low levels of terrigenous sediment can have an adverse effect, while the absence of such a gradient would effectively set a minimum acceptable sediment discharge rate.

The data to be collected under this project will help validate the sediment production and sediment delivery model now under development (MacDonald et al. 1998). A documentation of the linkage between sediment delivery and marine ecosystem health will help justify efforts to better control erosion and downstream sedimentation. Such an evaluation is critical to determining the potential for future development to adversely affect key marine resources. Hence the combination of marine and terrestrial data will provide government agencies with critical information for the management of Virgin Island watersheds, and possibly provide useful guidance for other locations.

The research to be conducted under this project will also be a key component in the training of undergraduate students at the University of the Virgin Islands and a Ph.D. student at Colorado State University. The results will be disseminated to both local resource managers and a broader scientific audience.

Nature, Scope and Objectives of Research

Recent reports of coral reef deterioration and death throughout the Caribbean and other parts of the world has focused attention on the potential contribution of human induced impacts. Of the multitude of human activities that affect coral reefs, overfishing, sedimentation and nutrient enrichment have the most significant impact (Roberts 1993). Although the synergistic effect of these three human disturbances can be severe, Sebens (1994) considered sedimentation to be the single greatest threat to coral reefs. Increased turbidity from clay and silt reduces light penetration essential for coral growth, while deposition of fine sediments increases coral energy costs, contributes to mortality due to suffocation, and reduces coral larvae settlement success (Rogers 1990, Roberts 1993, Sebens 1994). These cumulative effects reduce coral abundance and diversity and reduce the ability of coral reefs to recover from natural disturbances such as hurricanes.

Over the past several decades the Virgin Islands have witnessed rapid development of inland and coastal areas. The construction of unpaved roads and removal of the natural vegetation can greatly increase erosion rates relative to natural conditions. Recent studies on St. John, U.S. Virgin Islands, have identified the network of unpaved roads on St. John as the largest source of sediment (MacDonald et al. 1997, Anderson and MacDonald 1998, Ramos 1998). The unpaved roads are a chronic source of sediment due to traffic and regular grading. Preliminary results indicate that even small storms can generate surface runoff that erodes the road surface and delivers the sediment into the ditches and smaller channels. We now believe that the larger storms generate sufficient runoff to transport much of this eroded sediment through the channel network and into the bays surrounding St. John (MacDonald et al., 1998). This load of sand, silt, and clay poses a direct threat to the health of the corals and other reef organisms (Rogers 1990, Nemeth 1998a,b). Field observations and other studies indicate that simple erosion control practices, if installed correctly, can substantially reduce the erosion from construction sites (Wright 1997), but little attention has been paid to the much larger and continuing sediment loads from unpaved roads.

Environmental assessments are critical to evaluate the effects of land development on coral reefs. Although a number of studies have independently investigated various aspects of land practices on erosion (MacDonald et al. 1997) or the effects of sedimentation on corals (Rogers 1990), there is a lack of studies that rigorously and quantitatively link runoff and erosion processes in the terrestrial environment to the ecology of downstream aquatic systems. Such integrative studies can then provide resource managers with the data to more accurately predict the effects of increasing sediment loads on nearshore marine systems.

Given that an intensive field study of runoff and erosion is already underway on St. John, a relatively small infusion of additional funds will allow us to directly and quantitatively link upslope sediment production to the downstream marine environment that is of primary concern. Thus the primary goals of the proposed project are: (1) to intensify the assessment of sediment storage and delivery in the main guts into Fish and Lameshur Bays; and (2) quantify sediment deposition at different locations in these two bays; and (3) assess the health of marine ecosystems in the two bays and their condition relative to the measured sediment loadings.

With respect to the first goal, in most cases there is a strong reduction in the amount of sediment delivered with increasing drainage area (Walling, 1983). In most cases this reduction in sediment delivery is due to the storage of sediment in the channel and on the adjacent floodplains and terraces. However, the watersheds on St. John are relatively small, steep, and subject to very large runoff events. The channels (guts) are often confined and characterized by very coarse bed material (MacDonald et al., 1998). We therefore expect that, in contrast to other locations, most of the eroded sediment is ultimately delivered to the mouth of the guts rather than entering into long-term storage. This working assumption needs to be more rigorously evaluated by direct geomorphic investigations of the channels from the headwaters, where sediment is initially deposited, to the mouth of the guts.

The funds requested under this proposal will also allow us to more intensively sample the discharge of suspended sediment from the main guts during storm events. This greater intensity of sampling is needed to match the relatively high intensity sampling of sediment deposition in Fish and Lameshur Bays. Thus the objectives of the terrestrial component of this proposal are to: (1) Evaluate the potential and amount of sediment storage along the main guts feeding into Fish and Lameshur Bays; and (2) more intensively sample the suspended sediment concentrations and runoff from the main guts feeding into Fish and Lameshur Bays. The specific objectives of the marine research component are to:

1. Quantify the amount and types of sediment deposited within Fish and Lameshur bays;
2. Measure water quality within Fish and Lameshur bays;
3. Measure coral recruitment, percent algal cover, and composition of reef fishes at three sites within Fish and Lameshur pays; and
4. Assess present and recent coral reef condition in Fish and Lameshur Bays.