Summary of Research Trip to Faga’alu Village, American Samoa, January 6-March 29, 2012

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Introduction

It is difficult to effectively manage land-based sources of pollution to coral reefs when the sources and quantities of pollutants have not been identified. Sedimentation has been identified as the key threat to coral reef health in the area of Faga’alu bay, in American Samoa. To assess the severity of the problem and the scope of work necessary for watershed and reef restoration, a key objective of this project is to measure sediment flux from the watershed and sedimentation rates on the reef. The goal of this fieldwork was to take simultaneous, targeted measurements of stream discharge, sediment flux, and nutrient loading to identify and quantify key sources of these pollutants during storm and inter-storm periods. We intend to relate the sediment flux from the stream to sedimentation rates measured on the reef with a circulation model currently being developed by collaborators at NOAA. The model of sediment dynamics in the Faga’alu reefs will be used to set goals for sediment mitigation in the watershed, and identify preferred sites for coral restoration and rehabilitation on the reef. The model framework developed during this project can tentatively be applied to other American Samoan watersheds, however this is difficult to do without local data on stream discharge and turbidity to constrain model estimates.

Watershed Description

Faga’alu, like many watersheds on Pacific high islands, is characterized by large areas of undisturbed, steeply-sloped, forested hillsides in the upper watershed, and relatively little flat area in the lower watershed that is urbanized or densely settled (Figure 1). Faga’alu is a narrow, V-shaped watershed covering approximately 2.48 km$^2$ from Mt. Matafao, the highest point on Tutuila (2,100ft.), to its’ outlet at the Pacific Ocean. Small tributaries from the hillsides feed a single perennial stream that runs the length of the watershed (~3 km), and several small ephemeral streams drain the lower portions of the watershed margins directly to the ocean. The main stream has a small dam above the village that was originally constructed to supply drinking water but has since been filled with sediment. The stream has been channelized with chain-link-stabilized rip-rap where it flows past the Lyndon Baines Johnson Tropical Medical Center (LBJ Hospital) to its’ outlet at the ocean.

Land-use/Land-cover

The predominant land cover in Faga’alu watershed is relatively undisturbed forest on the steep hillsides, though these are prone to natural landslides that can contribute large pulses of sediment during extreme storm events. In addition to some small, household gardens there are several agricultural areas on the steep hillsides, though these are relatively small banana or taro plantations with well-developed ground cover, and are currently receiving technical assistance from the Natural Resource Conservation Service (NRCS) to mitigate erosion problems. The few piggeries that are present in the watershed are regulated by the American Samoa Environmental Protection Agency (ASEPA) Piggery Compliance Program (PCP) and are generally compliant and well-managed. However, seepage from residential septic systems is a possible contributor of nitrogen, phosphorus, and bacteria to the stream and coastal waters. There are several small footpaths and dirt driveways, but dirt roads don’t appear to be a major contributor of sediment, especially after the completed paving of the village road in March of 2012. Much of the lower watershed is considered urbanized, with large areas of impervious surface associated with the LBJ Hospital and the numerous residences and businesses.

In addition to these common watershed disturbances that are normally associated with human settlement, Faga’alu is also home to a small, open-pit gravel quarry (currently ~5 acres) that has been in operation since the 1960’s. The quarry operators have installed some cursory sediment management
practices such as silt fences and settling ponds but they are unmaintained, ineffective, or inadequate to control the large amount of sediment mobilized by the intense tropical rains. While sediment mitigation such as replanting of riparian vegetation or wetland restoration could help slow the sediment flux to the reef, keeping the sediment from being mobilized into the stream in the first place would be much more effective, making the quarry the biggest opportunity for significant reductions in sediment loading to the coral reefs.

Reef Description

The Faga’alu reef is divided into Southern and Northern areas by an ‘ava, or channel (~20m deep), that runs roughly East-West from the stream outlet to the mouth of Pago Pago Harbor (Figure 1). The reefs are exposed to seasonal south swells and trade winds that pump clean seawater over the Southern reef crest into the reef flat/lagoon. This creates a Northward-flowing current from the open ocean towards the stream mouth and into the ‘ava, which then flows East out to Pago Pago Harbor, carrying suspended sediment and nutrients out to sea. This current scours the Southern reef clean and pushes most of the stream discharge towards the Northern reef where the highest sedimentation and coral degradation are evident. Corals along the Southern edge of the ‘ava and adjacent reef flat are still highly impacted by large sediment plumes that overwhelm the prevailing current during large floods, or when ocean swells and trade winds are calm and the lagoon current is weak. Sedimentation is evident all the way from the shallow reef flats around .5m deep to where the coral meets the seafloor at 20-30m. Though there is a general gradient of sedimentation decreasing away from the stream mouth and North to South, impacts are heterogeneous depending on small-scale reef topography and coral morphology, making it difficult to infer spatial patterns of impact from discrete point measurements. The sediment traps also collect calcareous sediments from the reef itself in addition to terrigenous sediment, making further analysis of sediment composition necessary to quantify the contribution from each source.

Sedimentation Stress

In Faga’alu we have identified sediment as the key threat to coral health and we have identified the quarry as the main, but not the only source of increased sediment to the stream. Increased sediment stresses corals by decreasing light for photosynthesis, blocking sites for larvae recruitment, outright smothering, and forcing the corals to use energy to clean themselves instead of growth. The Faga’alu reef is heavily impacted by sedimentation but not totally destroyed, making it a good candidate for watershed and reef restoration. Rather than recommending a shutdown of the quarry, however, we acknowledge that human development is inevitable and to support infrastructure improvements it is necessary to disturb the landscape to extract building materials like gravel. Given the tractable scale of the issue, and the willingness of local stakeholders to collaborate and work together, I believe it is possible to implement existing sediment mitigation technology to significantly reduce the sediment loading in the stream. It is unlikely that sediment flux can be reduced to pre-disturbance levels but it is possible that sediment can be reduced to a level where sediment-resistant species of coral can be rehabilitated in the impacted areas.

Specific objectives of this fieldwork were:

- Perform a reconnaissance-level watershed assessment of Faga’alu watershed (2.48km$^2$) that drains to a priority coral reef site through existing GIS layers (http://gis.doc.as) and in situ observations.
- Quantify sediment and nutrient loading during storm and inter-storm periods at strategic locations within the watershed (unpaved and paved roads, residential areas etc.) using lab analysis of water samples and continuous monitoring of flow, stage, and turbidity.
Monitor sedimentation at 9 key locations on the reef (1-15m) with 1) tube traps to capture suspended sediments in the water column 2) tiles to measure sedimentation on bare surfaces, and 3) astroturf mats to measure sedimentation on textured surfaces.

Use the data gathered to develop a sediment budget and a watershed modeling framework to identify major sources of the sediment and nutrients delivered to the coral reefs.

Build the environmental monitoring capacity of local agencies and an intern from American Samoa Community College, Rocco Tinitali.

Data Collection and Analysis

Water quantity

Tipping-bucket raingauges were installed at 4 locations throughout the watershed (see map) to measure precipitation input and determine a runoff coefficient for this watershed. Daily precipitation ranged from 0-79 mm. Stream discharge was calculated using manual flow measurements and three pressure transducers installed in key locations in the watershed: 1) at the outlet of the undisturbed watershed, 2) just below the quarry, and 3) near the stream outlet to the ocean, just above the influence of the high tide (Figure 1). A weather station was installed to provide barometric pressure data to calculate water depth from the pressure transducers. A stage/discharge relationship was determined from in situ flow measurements at each location to get continuous discharge volume from the measured stage height. Stage height at the LBJ Hospital Bridge, nearest to the stream outlet, ranged from 5-37 cm, corresponding to discharge of 26-1,650 L/sec during the study period.

Water quality

Grab samples were collected during storm and inter-storm periods and filtered for Total Suspended Solids (TSS) using gravimetric methods at the Dept. of Marine and Wildlife Resources (DMWR) laboratory. Sub-samples were frozen and transported to UC Santa Barbara for further analysis of dissolved, particulate, and total Nitrogen. Turbidimeters were installed at two locations, 1) above the quarry at the dam and 2) at the LBJ Hospital Bridge, to continuously monitor turbidity and relate that to TSS measurements for a continuous record of sediment concentration.

Synthesizing the quantity of discharge and the concentration of TSS yields continuous measurements of sediment flux at 1) the dam, the outlet of the undisturbed upstream watershed, and at 2) the LBJ Bridge, near the outlet to the ocean (Figure 1).

Reef Sedimentation

The main objective of this study is to quantify the amount of sediment flux to the Faga’alu reefs, but the ocean conditions can significantly alter the spatial pattern and severity of sedimentation on the corals themselves. To relate the sediment flux from the watershed to actual impacts on the reef, nine sediment traps were deployed along observed sedimentation gradients. While most researchers have used tube traps to measure sediment in the deep ocean and on coral reefs, the surface texture of the corals has a strong influence on how much sediment is retained on the coral surface. To gauge
differences between sediment settling out of the water column in the tube trap and what actually settles on the corals, each sediment trap was equipped with a tube, a smooth ceramic tile, and an astroturf mat (Figure 3). The astroturf mats showed significantly more sediment retention than either the tube or the tile, indicating that micro-topography of the coral structure can significantly increase sedimentation stress.

**Future Work**

We are currently running the nutrient sample analysis and synthesizing and analyzing the data collected on the field trip to develop the sediment and nutrient budgets. Restoration efforts are currently being coordinated with local agencies with sediment mitigation focused on revegetation of the quarry and riparian zone, and coral rehabilitation focused on the North reef and ‘ava corridor. While coral gardening and outplanting would speed up the reef recovery, this effort must be preempted by a significant reduction in sediment loading. To address pollution from the village itself, the village of Faga’alu has recently finalized a community-based plan for Watershed Management and Conservation to address the impacts of land-based sources of sediment, nutrient, and solid waste pollution.

**Funding Sources and Collaborators**

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Figure 1. Locations of hydrological instruments (pressure transducers, raingauges, turbidimeters) in the watershed and sediment traps deployed on the reef.

Figure 2. Turbid plume flowing from Faga’alu stream during a strong rain event.

Figure 3. Collecting sediment samples from the Northern reef. Each sediment trap is equipped with a tube, a tile and an astroturf mat.