# Title:

**“**Watershed and oceanic controls on spatial and temporal patterns of sediment accumulation in a fringing reef flat embayment”

# Outline:

*Goal for the manuscript:*

From dissertation proposal: Use measurements of monthly terrigenous sediment accumulation on the reef to develop a spatially distributed model of net sediment accumulation based on sediment input and water residence time in the Bay.

Or

Use measurements/models of sediment loading and hydrodynamic forcing to interpret temporal and spatial patterns of sediment accumulation.

*Motivation:*

“It is evident that the understanding of fine-grained terrestrial sediment plume transport, deposition, reworking, and advection out of coral reefs is key to helping establish monitoring programs to determine the effectiveness of land-based watershed restoration conducted to support coral reef ecosystem health.” (Storlazzi et al. 2015)

## INTRODUCTION

**Background of the problem:**

* Processes sediment affects corals:
  + Light attenuation
    - Higher concentrations, finer grain sizes and darker grain colors more effectively reduce PAR
    - Finer grains also remain suspended for longer (low settling velocity, low resuspension threshold) -> more exposure (duration x intensity)
* Complex sediment inputs and hydrodynamics control sediment dynamics, which control coral health
  + Sedimentation linked to watershed input but hydrodynamics can limit by prevention and resuspension
  + Sediment accumulation in tropics is controlled by interplay of sediment input and hydrodynamics
  + Given watershed disturbance, an integrated understanding of sediment from source to reef is needed
* Measuring sedimentation: physical methods and interpretation.
  + (Storlazzi et al. 2015): “it is necessary to specifically measure sediment grain size and composition collected using different tools and techniques (e.g., Storlazzi et al. 2011; Field et al. 2012) during experiments or monitoring programs established to monitor coral reef health or the effectiveness of restoration efforts.”
  + Discontinuous vs Quasi-continuous
  + Tube traps most common but maybe not relevant indicator? SedPods way forward?
  + Basics of sedimentation not known at study site
* Linking watershed inputs to sediment accumulation
* Thought: given the flow pattern observed in paper 2, could hydrodynamic conditions continue to exacerbate effects instead of flushing???

Examples of such studies include Storlazzi et al. (2004) and Presto et al. (2006) on the fringing reef of southern Molokai, Hawaii; Orpin et al. (1999) in the Great Barrier Reef lagoon; and Hoitink and Hoekstra (2003) in Indonesia. Collectively, results from these investigations show that fine sediments can be suspended under fair-weather conditions on reefs and in lagoons, net transport is a function of net current direction, fine sediments are effectively flushed from high-energy reef settings but aggregate in lower energy reef and lagoon environments, and that the orientation of the coast with respect to prevailing winds and waves is an important determinant on whether sediment is trapped or flushed from a reef system.

Furthermore, as noted earlier, mechanically derived size distributions do not reflect the hydrodynamic characteristics of heterogeneous carbonate deposits. –so can’t interpret fine/coarse in relation to hydrodynamic bc carbonates movement is altered strongly by shape and density, not just size

The major process controls on the formation and stability of reef sedimentary landforms are sediment supply and oceanographic regime. Wave

–Kench encycl. Entry

“Turbid-zone reef” or “Terrigenous sediment-influenced reef”

Corals can cope with large changes in fluvial sediment supply so hard to infer changes in sediment from coral. If they aren’t changing then so what, they’re coping with it. Have to identify coral are stressed by sediment.

-Perry encycl. Entry

Sediment decreases herbivory of algal turf (Bellwood and Fulton 2008) across coral reef depth gradient (Goatley and Bellwood 2012), and increased algal height can increase sediment trapping . Sediment can also decrease the growth of epilithic algae by developing black basal sediment layers high in hydrogen sulfide (Clausing et al. 2014), similar to the necrotic effects on corals (Weber et al. 2012). Under moderate sedimentation or high energy hydrodynamic conditions, herbivory can maintain short, healthy algal communities, but in slow-moving waters with high organic, terrigenous sediment the anoxic black basal layers are more common at shallower sediment depths (Clausing et al. 2014).

**Specific knowledge gap:**

Faga’alu is exposed to enhanced sediment input, hydrodynamics are heterogeneous, so where and when is sediment accumulation occurring?

**So we did “X” to learn “Y”:**

We monitored sediment input and modeled residence time over the reef, and monitored sediment accumulation in tubes and SedPods to determine:

1. How do flood-supplied terrigenous sediment and hydrodynamic conditions interact to control the gross and net rate of terrigenous sediment deposition at monthly time scales in a coral reef embayment?
2. What controls the spatial distribution of sediment accumulation, and can it be predicted by the flow velocities of water over the reef and distance from the stream mouth?

## MATERIALS AND METHODS

### Study Area

* Location, size, layout, depths, physical and biological characteristics of reef
* Description of seasonality and prevailing waves, winds, and tides
* Flood plume dynamics from Faga’alu Stream to Faga’alu Reef, and referring to other papers in Faga’alu
* Figure 2. Flood plume pictures in the bay
* Previous studies/data: Sabater unpubplished, Pilot study??
* Other on-going work includes sediment yield monitoring from watershed, sediment accumulation on the reef, and larger restoration efforts of USCRTF

### Methods

O*utline the methods used*

**Meteorological and oceanic forcing**

**Sediment input**

The average daily collection rate was calculated by measuring th total mass of sediment in the tube or on the pod, and dividing by the trap cross-sectional area and the duration of collection period (Storlazzi et al. 2009)

**Tubes**

30 cm long with an internal diameter of 5 cm; mounted on the side of a cinder block with the SedPod

(Bothner et al. 2006) found co-located Tubes differed by 11% on average

**SedPods**

10cm tall by 15.5 cm diameter; mounted on cinder block

**Residence time of sediment?**

**Analytical methods**

In the laboratory, sediments accumulated in the sediment-trap tubes and on the SedPods was analyzed for grain size and composition. Sediment grain size analysis was conducted by wet-sieving the bulk sediment sample into coarse (2mm to 63 um) and fine fractions (<63 um)((Storlazzi et al. 2009) says “sand” and “mud”). Coarse and fine fractions were filtered onto 3 um filter paper, rinsed with distilled water, and dried. Coarse and fine fractions were analyzed separately for sediment composition, using the Loss On Ignition method (combusting 3 hours at 550 C for % organic; 950 C for 3 hours for % carbonate)(Heiri et al. 2001). The proportion (%) of terrigenous sediment was then determined by subtraction from the % organic and % carbonate and multiplied by the sediment accumulation rate to get the rate of terrigenous sediment accumulation in the trap tubes (Gray et al. 2012).

## RESULTS

*Results are the data - not methods. You can compare the results to other studies to put them in context, but don't explain why you think you're seeing the patterns you're seeing - that's for the Discussion.*

## DISCUSSION

*The Discussion is where you first discuss how well the Lagrangian and Eulerian methods compare, then characterize the findings by the different types of forcing and why you think you're seeing these patterns you see in the data. You then can discuss the relevance to residence times and what they mean for sediment, nutrient uptake, etc.*

Kench 1998 showed at narrow, energetic part of reef there was bioclastic sediment mobility under fair-weather conditions; may be happening at 3A and B

Bothner 2006 found trap collection was higher following rainfall events but not always and not linearly related

*Wrap it all up with the big take-away message* *No Conclusion in “Coral Reefs”, give big take-away message*

**Take-away message**