



# **Mālama Pu‘uloa**

Sedimentation Experimental Design

# Preface

This document was developed to provide information on a sedimentation experimental design for Kapapahu Point park, as well as a printable data sheet and rough budget. This information is intended to educate users about the impacts mangrove removal will have on the sedimentation in the surrounding area.

Tracking sedimentation changes overtime is important to understand how much sediment will be deposited in the surrounding areas. Mangroves are known to change the physical and chemical characteristics of sediment, therefore tracking the changes in sediment elevation is a good baseline to plan effective restoration and management plans.

## Included in this document:

- Background information of mangroves in Hawaii
- Case study summaries of how sedimentation was affected by mangrove removal
- Methods for sedimentation experimental design
- Budget
- Printable Sediment Pin Datasheet

## About the Authors

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# Background Information

Mangrove (*Rhizophora mangle*) was introduced to Molokai in 1902 to reduce sedimentation and ended up invading all the main Hawaiian islands by negatively altering ecosystems and competing with native species for space and resources (Allen 1998). Mangroves in Hawai'i also reduce ecosystem function by occupying habitat for four endangered endemic Hawaiian birds: 'ae'o (Hawaiian stilt; *Himantopus mexicanus knudseni*), 'alae 'ula (Hawaiian gallinule or moorhen; *Gallinula galeata sandvicensis*), 'alae ke'oke'o (Hawaiian coot; *Fulica alai*) and koloa (Hawaiian duck; *Anas wyvilliana*; (Allen 1998). Further, mangrove degrades culturally important sites such as loko i'a, or fishponds (Ewel & Bigelow 1996, Allen 1998).

In other parts of the world where mangrove is native, they are considered essential habitats that store carbon and trap sediments (Soper et al. 2019). Mangroves are able to store large amounts of carbon from the atmosphere in live trees and detrital biomass (Soper et al. 2019). Large amounts of carbon can also be stored in the sediment and soil through the daily deposition of organic carbon from rivers and oceanic floods (Soper et al. 2019). Mangroves are also able to trap sediments with their tangled root systems. Therefore, when mangroves are removed, large amounts of sediment can become loose and wash away.

These small changes in the elevation of sedimentation in mangrove ecosystems can have large changes in hydroperiod, tidal inundation, flushing, and circulation (NPS.gov). These large changes can then impact coastal vegetation and marine life in the surrounding bodies of water (NPS.gov). Thus, it is important to monitor how the sediment elevation will change overtime in an area that has recently been cleared of mangroves.

## Definitions:

- **Hydroperiod:** number of days per year that an area of land is wet or the length of time that there is standing water at a location
- **Tidal Inundation:** amount of water that occurs above normally dry ground as a result of flooding; commonly referenced to the average daily highest tide or Mean Higher High Water (MHHW) tidal datum
- **Flushing:** process of the sediment removal by scouring sediment deposits or passing incoming sediment-laden flow through a reservoir

# Case Study #1

Alfaro, A. C. (2010). Effects of mangrove removal on benthic communities and sediment characteristics at Mangawhai Harbour, northern New Zealand. *ICES Journal of Marine Science*, 67(6), 1087–1104.  
<https://doi.org/10.1093/icesjms/fsq034>

## Purpose:

In this experiment, the researchers recorded faunal and sediment characteristics before and after the mangrove removal event. These characteristics were monitored for 3 years and compared with undisturbed sites.

## Results/Discussion:

The researchers found that the sediment composition changed immediately after mangrove removal. Effectively, an increase in sand composition was observed to suggest that the sediment particle size changed from a high silt composition to a coarser sediment. Not only did the particle size change from high silt to a coarser sediment, but there was also an increase in total organic content. Generally, the mangrove habitats had a higher organic content compared to the marsh grass, sandflat, and channel habitats tested. This could be due to mangroves' ability to sequester large amounts of carbon. Overall, the removal of mangroves altered the physical and chemical structure of sediments, and the macrofauna within the habitat in a way that suggests a transformation from a mangrove habitat to a mudflat habitat will immediately increase species abundance and diversity. After mangrove removal, this alteration continued to change over the next 2.5 years.

# Case Study #2

Demopoulos, A., & Smith, C. (2010). Invasive mangroves alter macrofaunal community structure and facilitate opportunistic exotics. *Marine Ecology Progress Series*, 404, 51–67. <https://doi.org/10.3354/meps08483>

## Purpose:

In this study, researchers conducted a case study of 2 *Rhizophora mangle* habitats in Hawai'i, comparing habitat parameters and macrofaunal community structure in introduced mangroves and nearby control sandflats at a similar tidal elevation. One of the sites was located in Pu'uloa (Pearl Harbor), O'ahu.

## Results/Discussion:

The researchers found that the presence of mangroves was associated with an enhancement of root material, increased below ground plant biomass, higher pore-water salinities and sediment organic carbon content, and reduced sediment grain size. For example, mangrove invasions significantly alter the physical environment of non-vegetated tidal flats by decreasing sediment grain size and increasing sediment organic carbon content. The pore water salinity was highest in the mangrove sediments and any adjacent sandflats, which indicates mangroves have influence on environmental parameters that can extend beyond the mangrove forest boundary. As climate and land-use patterns change worldwide, mangrove distributions are likely to increase due to subtropical climate zones expanding and an increase in coastal sedimentation. These changes can lead to alterations in benthic ecosystem structure and function, which can potentially facilitate exotic species invasions. The researchers also found a dominance of cryptogenic and introduced species in the Hawaiian mangrove sediments, which indicates that mangrove invasions can facilitate the persistence and spread of introduced species, negatively impacting the ~500 endemic estuarine and marine species in Hawaii.

# Sedimentation Experimental Design

We propose the following sedimentation experimental design for Malama Pu'uloa to conduct at Kapapahu Point park to monitor sediment levels over time. This experiment will help the organization understand how mangrove removal will affect the surrounding mudflats, and ultimately, the culturally significant oyster beds. After reading through the introduction and case study summaries, it's important to monitor sedimentation levels after mangrove removal because the physical and chemical composition of the sediment can change and impact the surrounding ecosystem for years to come. Therefore, this sedimentation experimental design has the potential to be the stepping stone for creating a baseline of sediment change at this location, which has implications for effective restoration plans.

## Purpose/Objective:

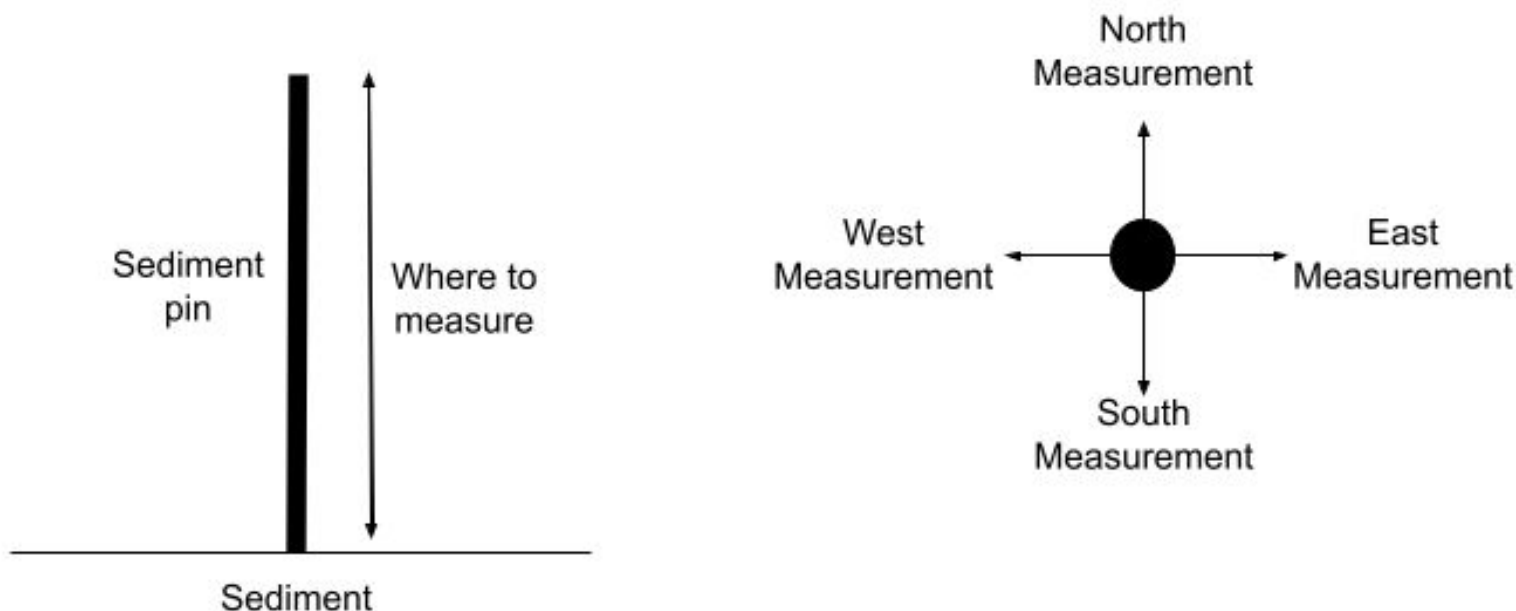
Sedimentation pins are used to track sediment changes at discrete locations overtime. The sediment accumulation is monitored through time by measuring the distance from the top of the sediment pin to the surface of the sediment below. Measurements are typically taken semiannually.

# Methods - Installation

1. Select an area where mangroves will be removed from to measure the change in sedimentation.
2. Installation considerations:
  - a. The pipe should be cut to an appropriate length for the anticipated water depth and substrate conditions. The pipe must be visible above the waterline at high tide. The sediment pins that will only be accessed during low tide may be shorter to create a lower profile.
  - b. The spatial distribution of the sediment pins should represent the topography, expected/planned environmental development, and water flow dynamics of a project site.
  - c. Do not place pins in channels or areas that are anticipated to have strong currents that may cause artificial erosion around the pin. If possible, PVC pipes should be placed before the removal of any surrounding structures that could affect the sedimentation levels (ex: rock walls).
3. Drive the PVC pipes into the ground at least 3 feet. If needed, two pieces of PVC pipe may be connected using couplers to increase sediment pin length.
4. Label sediment pins with a paint pen.
5. Take baseline sediment pin reading (see “Taking Measurements” section).
6. Record GPS coordinates of the sediment pin.
7. Survey the elevation of the sediment pin. The comparison of pin elevations over time will allow determination of vertical pin movement and an accurate representation of sediment loss or gain. Measurements of the change in sedimentation can be taken every six months, or more often if desired.

# Methods - Taking Measurements

1. Gently set the measuring tape on top of the sediment (almost hovering), to make sure you are not pushing down the mud.
2. Measure the distance from the top of the sediment pin to the surface of the sediment below.
3. Take 4 measurements at each pin (north, east, south, and west), to derive an average estimate of sediment gain or loss.
4. Take note of any damage around the sediment pin or any changes in the surrounding area that could be due to the installation of the pin.



*Figure 1: Diagram on the left depicts how to measure the sediment pin. It will be the measurement between the top of the pin and the top of the sediment. Diagram on the right depicts how to measure the north, east, south, and west measurements (circle represents the top of a sedimentation pin) to get a more holistic view of the height of the sediment around each sedimentation pin.*

# Methods - Data Entry and Analysis

1. Data that should be collected: date, observer name, sediment pin #, GPS coordinates, sediment measurements (see proposed “Sediment Pin Datasheet”)
2. Make sure to keep the sedimentation pin # and corresponding GPS coordinates consistent for each pin.
3. It is also helpful to take note of the tide (high/low).
4. Sedimentation accumulation or loss is determined by comparing measurements at sediment pins over time.

Derived from [www.tidalmarshmonitoring.org](http://www.tidalmarshmonitoring.org)

## Budget

Item	Cost (prices generated from Amazon.com)
Measuring Tape (8m)	\$10-\$16
Sedimentation Pins (2in gray, UV-resistant PVC pipe)	\$20-\$50
Paint pen	\$7-\$10
Post pounder/mallet	\$7-\$13
Hacksaw or PVC pipe cutter	\$12-\$25
<b>Total</b>	<b>\$56-\$114</b>



# References

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- [www.tidalmarshmonitoring.org](http://www.tidalmarshmonitoring.org)