An Analysis of Water Quality in Maunalua Bay

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Introduction

Water quality is one of the main drivers of ecosystem health in Maunalua Bay, affecting ecosystem services like fish stocks, recreational activities, aesthetic values, and transportation of sediments. However, in 2002, the Hawaii State Department of Health (DOH) declared Maunalua Bay an impaired water body, indicating pollution levels do not meet state standards for public safety (Department of Health 2006, Mālama Maunalua 2009). Causes of declining water quality in the bay include increased urban development, the use of fertilizers and pesticides for landscaping, and alterations of natural streams (Wolanski et al. 2009).

These human-induced changes have resulted in increased levels of nutrients, chlorophyll, and turbidity, which negatively impact native seagrass and coral health in the bay. Additionally, high levels of total suspended solids (TSS) cause concern in Maunalua Bay by not only absorbing heat from sunlight but also preventing sunlight from reaching bottom-dwelling flora (Mitchell and Stapp 1992). As a result, surface temperature increases and photosynthesis is inhibited. Warmer surface water also results in lower levels of dissolved oxygen, which is exacerbated by fungi and bacteria decomposing plant materials in the water (Mitchell and Stapp 1992).

Additionally, excess nutrients can be toxic to aquatic organisms, as well as causing other cascading effects on ecosystems. Nitrates in estuarine and marine ecosystems can be moved by municipal wastewater injection wells, subsurface groundwater discharge (Amato et al. 2016), and directly from surface runoff (Filippino et al. 2017). Increases in chlorophyll-a levels are linked to eutrophication, or “dead zones” where algal blooms consume oxygen, and are important indicators for linkages between terrestrial and aquatic ecology (Marcionilio et al. 2016). Vegetation, land-based nutrient contamination, and local landscape ecology can all influence chlorophyll-a levels (Marcionilio et al. 2016).

Despite knowledge of these issues, few efforts have been successful in limiting human impacts on water quality. In this project we: (1) develop a database of past water quality research in Maunalua Bay; (2) explore patterns and composition of pollution in the bay; and (3) develop recommendations for constructing a Quality Assurance Project Plan (QAPP) that would enable community groups to conduct consistent water quality monitoring in Maunalua Bay.

Methodology

As part of our effort to understand water quality in Maunalua Bay, we first conducted an extensive literature search identifying past scientific studies in both the Waiʻalae Nui and Kuliʻouʻou watersheds. Our objective was to make these studies easily accessible to both researchers and the general public, which entailed creating a bibliography categorizing prior research by topic (nutrients, turbidity, etc.) and alphabetically by author. In some cases, it was necessary to obtain raw data by directly contacting the authors. We compiled these sources into a spreadsheet to organize authors, topics, and data. For each study, we summarized and extracted relevant results that would be helpful for our project, as well as for future work on water quality in Maunalua Bay.

We then conducted our own study to identify issues affecting the bay today. We collected water samples at 250 meter increments beginning from the stream mouth extending out into the bay at both the Kuliʻouʻou and Waiʻalae Nui watersheds, as well as at key flow points within the highly industrialized Kuapā Pond. These watersheds had all been examined in previous studies. Samples were collected at low tide to reduce the influence of marine high-tide influx. Samples were collected in Whirl-Paks (eNasco Inc.) and stored briefly in a dark refrigeration unit between collection and analysis.

In partnership with the School of Ocean and Earth Science Technology (SOEST) Biogeochemistry Lab at the University of Hawaii at Mānoa, we analyzed each sample for both organic and inorganic nutrient loads, chlorophyll-a, total suspended solids (TSS), and turbidity (Nephelometric Turbidity Units; NTU). A nutrient flow analyzer was used to determine nutrient concentrations of the water samples, which was calibrated against United States Geologic Survey (USGS) standards. Nitrates, nitrites, ammonium, phosphates, and silicates were included in the analyses performed. Chlorophyll-a was measured as biomass using a fluorometer after filtration and extraction. TSS was calculated by obtaining the weight differential before and after filtering water across pre-weighed 0.7 micron filters. NTU was acquired using a nephelometer. Distance from shore was calculated using sample location GPS points in ArcGIS (Esri Inc.).

In order to make useful recommendations for developing a successful QAPP in Maunalua Bay, we interviewed natural resource managers and community groups in the process of developing their own QAPP, which requires adherence to both federal Environmental Protection Agency (EPA) guidelines and State DOH guidelines. Groups interviewed included: Surfrider Kauaʻi Program, the Nature Conservancy at Kiholo Bay, Hawaiʻi, and Hui o Ka Wai Ola, a community group supported by a partnership between the Nature Conservancy Marine Program, Maui Nui Marine Resource Council, West Maui Ridge to Reef Initiative, and University of Hawaiʻi Maui College. We identified logistical concerns and required steps for community groups to develop a water quality monitoring program.

Results

Our analyses indicate that turbidity values were highest in areas with ongoing development and showed decreasing trends from stream mouths outward into the ocean in both the Kuliʻouʻou and Waiʻalae Nui watersheds. Similarly, nutrient levels were highest near the mouth of both watersheds with progressively lower nutrient levels occurring in marine environments further from the stream mouths. Our results revealed direct correlations between NTU, nutrient loads, and chlorophyll. In the Kuapā Pond sites, we found consistently high values for NTU, nutrients, and chlorophyll.

At all sites across our study, NTU and nutrient loads were above DOH standards for safe water usage. Conversely, TSS levels were found to be normal across all sample sites. In comparing our own results with those found in previous studies, we did not identify any noteworthy changes in water quality since Maunalua Bay received its DOH impaired water body designation in 2002 (Department of Health 2006, Mālama Maunalua 2009). There was a slight increase in nutrient levels in Waiʻalae Nui and a slight increase in turbidity levels in Kuliʻouʻou compared to Richardson et al. (2015), but without more comprehensive historical data, it is difficult to determine if these changes are anomalous.

Conclusions

Thinking about potential actions to improve water quality in Maunalua Bay, it is critical to first consider the causes of water quality degradation. Our results indicate that, as water exits the stream mouths into the ocean, a drastic decline in both turbidity and nutrient loads can be tracked. This gradient suggests the primary source of nutrient and sediment loading in the bay comes from anthropogenic sources of runoff, such as fertilizers and pesticides commonly used in landscaping practices. This source linkage is supported by the consistently high levels of nutrients we found throughout Kuapā Pond.

A disconcerting result from our study was the lack of change in water quality that we found when analyzing previous work from the bay. Since Maunalua Bay received its impaired water body designation from the DOH in 2002 (Department of Health 2006, Mālama Maunalua 2009), water quality has not changed substantially. Static degraded water quality measures indicate efforts to improve water quality in the bay have been unsuccessful. This lack of change is likely due to continuing development throughout the area, which would offset any improvement efforts being made by the state and/or local citizens.

Looking towards the future, we urge residents to consider potential actions they can take to help improve water quality in Maunalua Bay. First, reducing the use of fertilizers and pesticides in lawn care can limit the amount of nutrients entering the bay. Bacteria feed off the chemicals found in these fertilizers and pesticides, making excess nutrients available for other organisms. Another potentially helpful solution is constructing rain gardens. These small garden plots help filter out chemicals because plants are able to use them before they enter the water, helping prevent pollution.

Finally, a consistent monitoring program is critical for understanding trends in changing water quality. Residents can work with Mālama Maunalua to develop a QAPP for Maunalua Bay. From our interviews with other community organizations, we found several levels of effort that can be employed for water quality management, and the development of a QAPP is only useful if it has adequate community support. This support rises from local citizens volunteering their efforts to support such a large-scale, influential project. Naturally, addressing awareness about water quality issues in the bay is the first step to establishing a QAPP. Then, once they are well-organized, groups can move on to the more detailed steps of organizing the collection of standard measures of water quality, specifications of storage, filtration, analytical equipment, and documentation. These steps are necessary to complete a QAPP following governmental standards for cross-comparison. Prior QAPPs have been shown as one of the most effective tools for community-based water management and are highly recommended by our group as the next step for Mālama Maunalua and the Maunalua Bay community to take in order to restore the bay's health.

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