Wastewater and Nutrient Source Tracking - A Reconnaissance Mapping Approach for Beach and Watershed Monitoring

Project Chief: Charles D. Hunt, Jr.
Project Period: August 2006 through September 2009
Cooperator: Hawaii Department of Health
Location: Islands of Oahu, Hawaii, and Maui

Problem

The State of Hawaii Department of Health Clean Water Branch administers several monitoring programs in nearshore coastal waters and stream watersheds. These include the federal Clean Water Act, enacted to ensure that waters are "fishable and swimmable") and the Beaches Environmental Assessment and Coastal Health Act (BEACH Act), enacted to ensure public health during recreational exposure. The Hawaii Department of Health applies a tiered water-quality monitoring approach, analyzing for fecal indicator bacteria, suspended sediment, nutrients and other chemistry, and supporting water-quality parameters. A vexing problem is identification of nutrient and pathogen sources. High bacterial counts are observed at sites, but without means for discrimination, their origin remains ambiguous and cannot be demonstrated to the satisfaction of stakeholders and regulators. For example, pathogens and nutrients that are present in municipal and domestic wastewater have also been linked to widespread nonpoint pollution from watershed soils and surfaces. A contributing problem is that bacterial sampling typically is done at a few scattered sites and there is insufficient detail to make a convincing case for a particular cause or source by inference from spatial patterns.

Objectives

Initial objectives of this series of studies were to (1) enhance Hawaii Department of Health monitoring abilities by developing an in-house methodology for rapid wastewater reconnaissance; (2) assemble an instrument package and water-quality mapping strategy that will help identify wastewater and nutrient sources; (3) conduct two proof-of-concept field case studies at Kualoa Beach Park and Kahana Bay on Oahu; (4) evaluate method success and identify needed refinements. Following a successful prove-out of the methodology, subsequent field surveys have sought to: (5) determine nutrient concentrations at Kealakehe, Hawaii, and whether ground water discharging at Honokohau Harbor contains a wastewater fraction; (6) attempt detection of major municipal wastewater injection plumes at Kihei and Lahaina, Maui, by conducting shoreline instrumental transects and sampling for laboratory analysis of nutrients, pharmaceuticals, and organic waste indicators in marine water, as well as 15N isotopic composition in both water and benthic macroalgae; and (7) conduct a similar field survey of Kaelepulu Pond on Oahu using the wastewater source tracking approach to support Department of Health's "Watershed Sanitary Survey" program.

Relevance and Benefits

The methodology developed during this study will enhance the ability of Hawaii Department of Health to protect public health by monitoring state waters under the federal Clean Water Act and the BEACH Act. A water-quality mapping capability will expand areal coverage beyond a network of fixed sites currently being monitored and provide spatial patterns and context within which bacterial counts from fixed sites will be more interpretable. It should also help identify inflows or “hotspots” for targeted water sampling. We will use off-the-shelf technology and work collaboratively with Department of Health scientists and technicians so that the developed methodology will reside in-house with DOH at the conclusion of the project. The methodology can be shared with other stakeholders such as watershed restoration groups. The proposed study addresses effects of land use and population increases on water quality and coastal water resources, which are high priority water issues of the USGS Strategic Plan and the Science Plan of the USGS Pacific Islands Water Science Center. This effort also fulfills a long-term USGS data objective to increase collection of water-quality data that directly relate to highly visible and critical human-health and aquatic-health issues, such as hypoxia, harmful algal blooms, and nutrient enrichment.

Approach

The Wastewater and Nutrient Source Tracking methodology will be developed and applied in a collaborative effort by USGS and Department of Health scientists and technicians. The methodology incorporates two main elements: (1) transecting of nearshore waters using water-quality instruments to map spatial patterns and identify "hotspots" for targeted water sampling; and (2) water sampling for multiple geochemical tracers that are diagnostic of wastewater and nutrient sources. It is intended as a rapid reconnaissance for first-order wastewater and nutrient source detection, and will be a tiered approach, progressing from least expensive reconnaissance mapping with field meters to more expensive (but more diagnostic) laboratory water analyses. Mapping surveys will use a portable instrument package with recording GPS (Global Positioning System) capability. Two case-study surveys will serve as “proof-of-concept” evaluations while the four other sites studied will put the methodology into practice.

Progress

The first phase of this project ran from August 1, 2006 through November 30, 2007, and was devoted to method development and "proof-of-concept" field case studies at Kualoa Beach Park and Kahana Bay on Oahu. After these proved successful, the second phase of the project began in October 1, 2007, with the main objective being to attempt detection of two municipal wastewater injection plumes on Maui, one centered at Kalama Park in the south Kihei area, and the other at Kahekili-Honokowai in the Lahaina area. On the Big Island of Hawaii, monitor wells and springs at Kealakehe (near Kailua-Kona) were sampled to determine nutrient concentrations and whether ground water discharge to Honokohau Harbor contained a wastewater fraction; sampling was successfully completed in December 2007. The Kaelepulu Pond surveys on Oahu will be completed in July 2008.

Products and Significant Findings

One formal report has been published: U.S. Geological Survey Scientific Investigations Report 2009-5253 "A Multitracer Approach to Detecting Wastewater Plumes from Municipal Injection Wells in Nearshore Marine Waters at Kihei and Lahaina, Maui, Hawaii." Wading and kayak surveys produced strong multitracer evidence for wastewater detection in the marine water column at both locales, most notably by detection of pharmaceuticals carbamazepine and sulfamethoxazole and by heavy nitrogen-isotope compositions in water and benthic algae that are consistent with a wastewater source that has undergone partial denitrification. Surveys indicated that each wastewater plume spans about a mile (1.6 km) of shoreline, agreeing well with prior numerical modeling at Kihei (Hunt 2006).

Data compilations and briefing presentations were produced by earlier surveys during method development and refinement. Results of proof-of-concept surveys at Kualoa and Kahana, Oahu, were presented to the Hawaii Department of Health on February 27, 2007. You can download a copy of the slide presentation (4.1 Mb PDF). Results of sampling at Kealakehe, Hawaii, were presented to the Hawaii Department of Health on March 13, 2008; a slide presentation(5.7 Mb PDF) may be downloaded. Results from the Kaelepulu Pond surveys are available in maps and data tables.

Wastewater and Nutrient Source Tracking, Kaelepulu Pond, Oahu, Hawaii

Wastewater and nutrient source tracking surveys were made in Kaelepulu Pond, Kaelepulu Canal to its outlet at Kailua Beach, and Hamakua Canal to its head at Kawainui Marsh levee in cooperation with the State of Hawaii Department of Health on July 22-24 and 28-30, 2008.

The surveys were made during “fair-weather” conditions via kayak and included: (1) trolling with a multiparameter water-quality sonde, and (2) water-column sampling at about 10 centimeters beneath the water surface.
Download location map (2.6 Mb PDF).

Water samples were analyzed for nutrients, pharmaceuticals, and waste-indicator compounds and are the most diagnostic for wastewater presence and nutrient-source inference because of low detection levels of the laboratory analyses. Nutrient concentrations and speciation are highly subject to biotic processes and time of day. Forty samples were analyzed for nutrients and stable isotopes, 20 for pharmaceuticals, and 10 for waste-indicator compounds. A sample of tap water (sample 41) was also analyzed for stable isotopes to define the municipal-supply end-member.
Download data for water samples (0.2 Mb PDF).

Specific conductance and fluorescence measurements were made on all 40 water samples. These measurements allow only modest inference by documenting fresher-water inflows and the possible presence of laundry fabric brighteners (although the fluorometer also responds to dissolved organic matter likely to be present at significant concentrations in the pond and canals).

Download specific conductance and fluorescence data (0.3 Mb Excel file).

Measurements made with the multiparameter water-quality sonde are possibly the least diagnostic for wastewater and nutrient inference, but they add the supporting value of denser and more continuous spatial patterns and document the status of near-surface water quality on the dates surveyed.

Download data collected with the water-quality sonde (0.3 Mb Excel file).