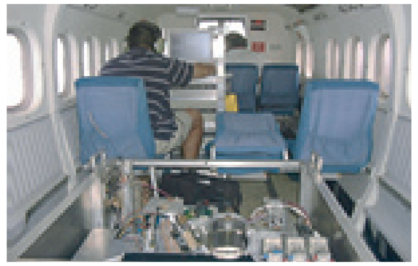
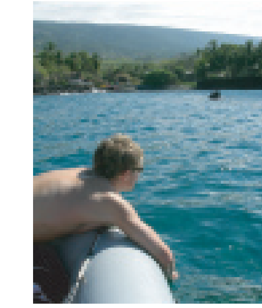


Thermal Infrared Surveys and Nutrients Reveal Substantial Submarine Groundwater Discharge Systems Emanating from the Kona Coast of Hawaii

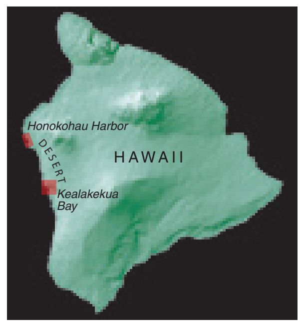
Abstract #: OS15B-06

Adam Johnson, Craig Glenn, Paul Lucey (University of Hawaii, Honolulu, HI 96822, *adamgj@hawaii.edu* and *glenn@soest.hawaii.edu*)
William Burnett, Ricky Peterson, Henrieta Dulaiova (Florida State University, Tallahassee, FL 32306)
Eric Grossman (U.S. Geological Survey, 400 Natural Bridges Dr., Santa Cruz, CA 95060)



Introduction:

Local accounts of cold water spots and previous qualitative infrared (IR) imagery have indicated several locations where groundwater is discharging from coastal embayments of west Hawaii. We conducted high-resolution aerial IR surveys, using a spectrometer having 0.1°C sensitivity, to map surface water temperatures and identify spatial extents of numerous groundwater plumes emanating from coastlines surrounding Kealakekua and Honokohau-Kaloko areas. **We combined our IR imagery with ground-based measurements of nutrients, salinity, and Ra and Rn isotopes to assess the submarine groundwater discharge (SGD) in the area.**

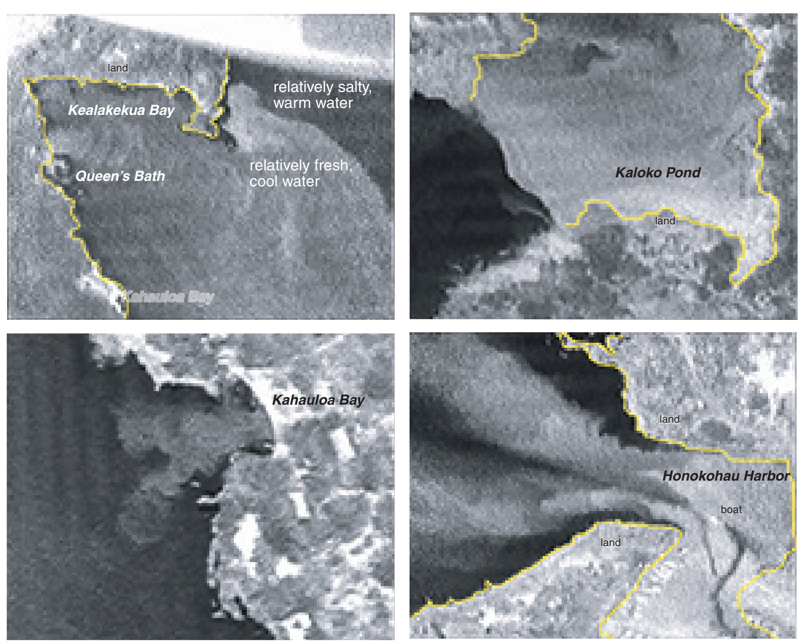


1. Study Areas:

Kealakekua Bay and embayments in Kaloko-Honokohau National Historical Park area were our first study sites. These occur on the arid, desert-like leeward coast of the Big Island where fluvial inputs are virtually nonexistent. Submarine groundwater exiting at the coastal zone thus controls practically all freshwater delivery to this wide region.

2. Previous Studies:

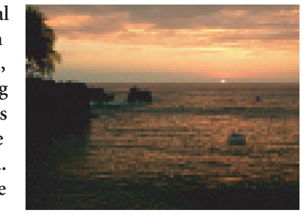
Past aerial infrared images taken in 1992 (George Wilkins) along west coast of Hawaii using handheld camera. Although resolution is poor, the images show plumes of cool freshwater (white) emanating out across the surface of relatively warmer marine (dark) waters.



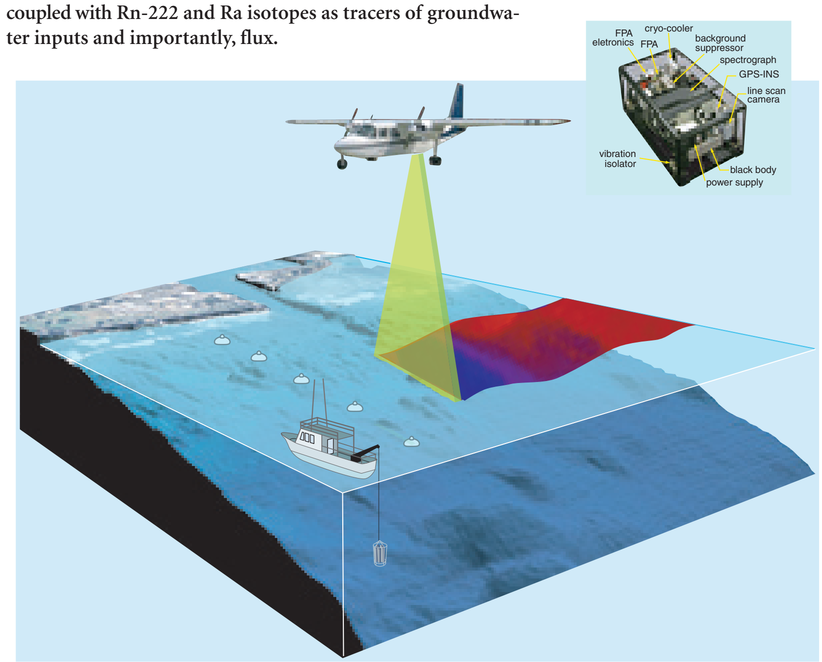
3. Methods:

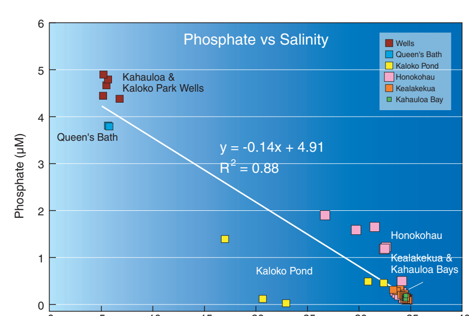
Our aerial surveys are conducted using the University of Hawaii's Airborne Hyperspectral Imager (AHI) Infrared system. The AHI sensor collects 256-pixel-wide swath images containing long-wave infrared (LWIR) data, so multiple overlapping flights are required to survey each area. Each pass is flown unidirectionally so that the plane's orientation remains consistent from pass to pass. The sensor is internally calibrated to a blackbody before and after every individual pass of data acquisition.

Post-processing LWIR data involves averaging over the spectral range of 8-12 microns and converting to temperature. Each flight swath is geo-corrected based on the plane's altitude, speed, pitch, yaw, and roll. Further georeferencing by correlating specific pixels in the IR images to their corresponding pixels on base maps is also required. Individual flight swaths are combined to produce a near complete IR image of each area. Results are cross-checked with high accuracy against multiple simultaneous ground-based observations

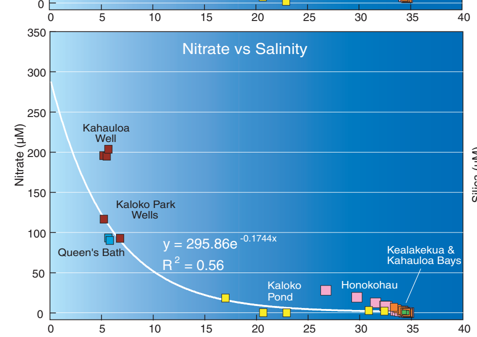


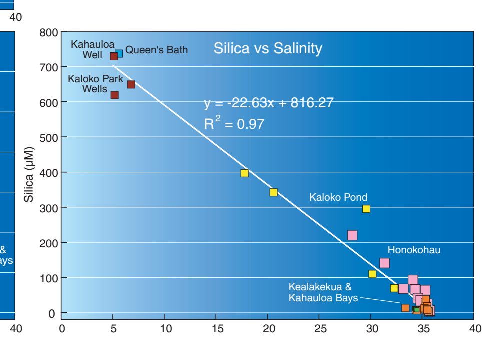
Salinity, temperature, nitrogen, phosphorus and silica concentrations were simultaneously determined from surface waters, onshore brackish wells, and tidal ponds. These are coupled with Rn-222 and Ra isotopes as tracers of groundwater inputs and importantly, flux.





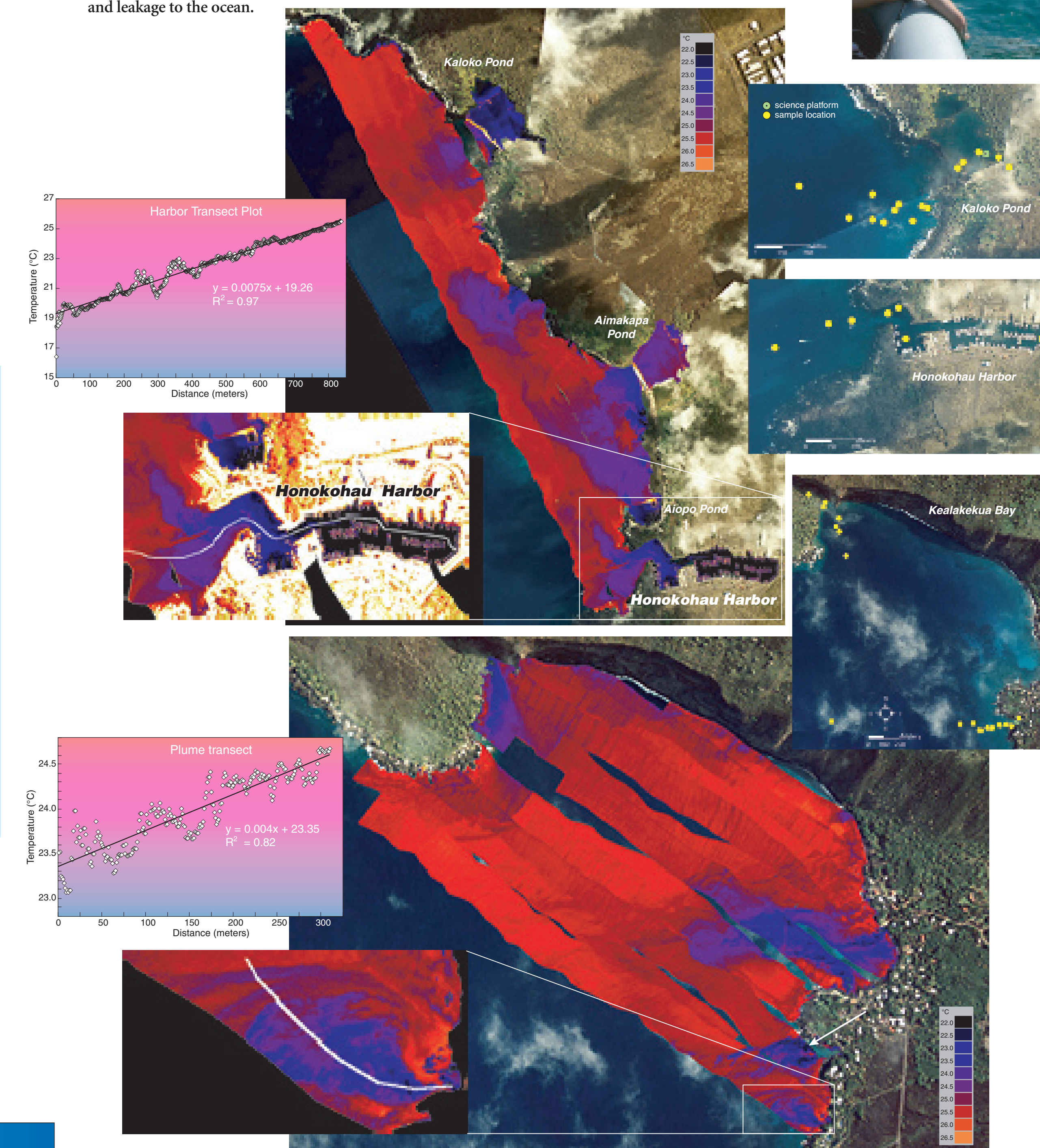
Both silica and phosphate follow near-perfect linear dilution trends from nearshore fresh-brackish ponds through coastal waters into marine waters. Nitrate concentrations, however, decrease exponentially from offshore, presumably due to selective uptake and preferred utilization.





4. Results:

Submarine groundwater discharge is clearly delineated by aerial LWIR imagery. Color-enhanced infrared images show plumes of fresh water (dark blue color ~22.5 - 24.5°C) emanating out across the surface of marine waters (red color ~25 - 27°C). Due to substantial freshwater inputs, much of the surface water funneling out **Honokohau Harbor** is less than 22°C (black). **Kaloko** (north) and **Aimakapa** (south) **Ponds** in Koloko National Park also show substantial groundwater buildup and leakage to the ocean.



Five discrete point sources of freshwater input are defined and quantified by LWIR imagery within the Kealakekua Bay area. Collectively, these five plumes cover at least 25% of the area's surface water. To date, Ra and continuous Rn measurements from one small plume alone (arrow) indicate water fluxes of ~3000 to 6000 m³ per day.

5. Conclusions:

Aerial infrared imaging is a novel method for collecting precise, high-resolution surface temperature data and quantitatively identifying freshwater plumes over extensive areas. As demonstrated here, combining this with ground-based determinations of nutrients (and other effluents), salinity, temperature and Ra and Rn tracers produces a new integrated multi-faceted approach to quantitative assessment of the effects of SUBMARINE GROUNDWA-

GEOLOGY & GEOPHYSICS
SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
nsf