ANNIVERSARY RETROSPECTIVE

Swimming in sewage

Warm spots in the ocean usually mean pee, but did you know that cold spots can mean poop? Swim anywhere in the world with warm seawater and you are likely to swim through patches of cold water or to feel an icy chill when you dig your feet down into the sand. These sensations are the experience of submarine groundwater discharge. This is a natural process in which relatively fresh water leaks out of the ground and buoyantly floats to the ocean's surface. It occurs along most coastlines in the world and, in warm regions with lots of rainfall, it feels cold because of the temperature contrast between warm, tropical seawater and cool, fresh aquifer water.

Growing up on the island of Kaua'i (Hawai'i), with more than 10 m of precipitation annually and seawater temperatures of about 22 °C, experiencing cold spots is commonplace. It was not until my undergraduate studies, however, that I put a name to this phenomenon. From a paper published by Meghan Dailer and colleagues (*Mar. Pollut. Bull.* **60**, 655–671; 2010), I learned that these cold spots were areas of submarine groundwater discharge, and that this discharge has a propensity for pollution. Deploying cages of algae along Maui's coastline, Dailer and colleagues found that seaweeds, in regions of submarine groundwater discharge downstream of developed land, acquired a heavier nitrogen isotope signature, indicative of receiving nitrogen from sewage. Because the work hypothesized that this sewage was from cesspools and local wastewater treatment injection, this study and subsequent follow-ups prompted litigation between the Environmental Protection Agency and Maui County for violations of the Clean Water Act.

Concerned about the potential for faecal contamination in a bay on O'ahu, Kahana, I learned how to locate submarine groundwater discharge using

Credit: Jenny Lynn Bernier

a naturally occurring geochemical tracer (^{222}Rn). Aboard an instrument-laden kayak designed to sniff out areas of elevated ^{222}Rn concentration, I paddled around the bay with the help of several colleagues. Thankfully, Kahana appeared to be relatively pristine, with only slightly elevated nitrogen concentrations in the groundwater discharge. Interestingly, the largest submarine groundwater plume, which contributed most of the bay's nitrogen, was perfectly encompassed by Huilua Fishpond — a 600-year-old Hawaiian aquaculture system delineated by a 500-metre-long wall of piled lava rock. This semi-permeable wall permits juvenile fish to enter the fishpond and feed on the consistent supply of algae fed by the nitrogen-rich groundwater discharge.

Native Hawaiians have clearly recognized the importance of nutrient-rich submarine groundwater discharge for centuries: numerous fishponds across the island chain also co-locate with these groundwater plumes, such as Kanewai on O'ahu and Kaloko on Hawai'i. When maintained, this network of fishponds can provide Hawai'i with over 1 million kilograms of sustainable seafood annually. □

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