A PHOENIX Rises

A Caltech-led team installs new air-quality sensors throughout Altadena to monitor airborne dust after the fires.

By Kimm Fesenmaier

In the wake of the Eaton fire, Caltech researchers quickly deployed a network of particulate air-quality sensors on rooftops in and around the burned areas of Altadena. The network of 29 sensors is dubbed PHOENIX (Post-fire airborne Hazard Observation Environmental Network for Integrated Xposure-monitoring) and aims to monitor airborne dust as debris removal and rebuilding continue.

"We wanted to give the community a source of independent air-quality measurements," says Haroula Baliaka (MS '23), a graduate student in environmental science and engineering at Caltech who helped install the PHOENIX sensors. The data, which is updated every five minutes, can be used by agencies such as FEMA, the EPA, and the Army Corps of Engineers to gauge how well dust-mitigation efforts are working, she adds.

Above: **Nikos Kanakaris, Coleen Roehl,** and **Paul Wennberg** install a sensor on a fence.

Baliaka, along with Coleen Roehl, an associate research scientist at Caltech; and Nikos Kanakaris, a machine learning researcher at USC; reached out to the community to identify possible installation sites and then quickly went out to set up the sensors, which run on solar power and use cellular networks, whereas many other sensors require access to Wi-Fi.

Each of the air-quality devices measures particulate matter in three size categories: particulates measuring less than 1 micrometer in diameter (PM1.0), particulates less than 2.5 micrometers in diameter (PM2.5), and particulates up to 10 micrometers in diameter (PM10).

Paul Wennberg, Caltech's R. Stanton Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering, who initiated the PHOENIX project, says the PM10 particles settle to the ground relatively fast compared to the smaller PM2.5 particles, which tend to stay aloft for days. "These larger particles are much more indicative of local dust events," Wennberg says. "Since one of our goals was to be able to isolate from the general aerosol pollution of Los Angeles things that were more related to the fire debris, we needed sensors capable of good PM10 measurements."

Although the PM10 particles settle quickly, Wennberg says the air mixes them around and can carry them roughly a kilometer away. "If you have a dust source during the day, and if it's made out of the ash and the dust from these houses, it will get transported some distance. We're trying to place our sensors roughly a kilometer apart in every direction to be able to isolate and figure out where the dust is coming from."

While the PHOENIX website currently shows only raw sensor data, the team plans to continue incorporating additional features to the site that will illustrate general air quality across Altadena and identify dust events.

The researchers also plan to make the data as accessible as possible and use machine learning and predictive models to gain additional insights.

View the PHOENIX data

Inside Look

Victoria Orphan

The deep blue sea beckons in the office of this geobiologist . . .

By Omar Shamout

. . . Victoria Orphan was 16,000 feet below the surface of the Pacific Ocean when the power went out.

Orphan, along with a member of her research team and a pilot, were riding in a tiny spherical submersible, known as Alvin, measuring about 7 feet in diameter. They had ventured to Alaska to explore methane seep sites in an area near the Aleutian Islands and investigate the interactions between microorganisms in this extreme environment where the gas is released from the ocean floor.

"Suddenly, the monitors blacked out and the red emergency lights came on," recalls Orphan, the James Irvine Professor of Environmental Science and Geobiology, and the director and Allen V. C. Davis and Lenabelle Davis Leadership Chair of Caltech's Center for Environmental Microbial Interactions (CEMI). "It didn't last very long, but it was enough to make you realize you were very far from the ship above."

Orphan's scientific travels have also taken her to the Baja Peninsula in Mexico and Chile's Easter Island. Technical challenges—though perhaps not as scary as an undersea power outage—are common on these complex research expeditions. However, the benefits of the trips far outweigh the risks, she says. The adventures offer an extraordinary opportunity to form intense bonds with other researchers while conducting field work that could help elucidate the fundamental biology that allows certain deepwater microbes to consume—and thereby sequester—methane before the powerful greenhouse gas is released into the atmosphere.

"Through an anaerobic process, these microbes consume up to 80 percent of the methane directly in the sediments before it can get in the atmosphere," Orphan says. "I am very interested in understanding the details of how this symbiosis operates because it sits near the limits of our understanding of microbial energetics."

When she is not at sea, Orphan connects with students and colleagues in her office in the Seeley W. Mudd Laboratory of the Geological Sciences. Guests are welcomed into the space by the room's warm wood furniture, including leather-bound chairs, and a round, pullout meeting table that notches into her desk. In one corner, an inviting Swedish ergonomic lounge chair occupies Orphan's favorite reading nook.

Trinkets, fossils, artwork, and an array of artifacts dot the office. Some were collected during Orphan's travels, while others were gifted to her by former students. Everything comes with a story.

Growing up in the small beach community of Leucadia in Encinitas, California, Orphan has always felt drawn to the ocean. She knew as early as kindergarten that a career in marine science lay in her future. After receiving her bachelor's degree from UC Santa Barbara (UCSB), Orphan did some of her graduate work at the Monterey Bay Aquarium Research Institute before earning her PhD, also from UCSB.

Through the years, one sea creature from the briny deep has always held an almost mystical charm over her, as evidenced by the numerous pieces of eight-legged artwork that surround Orphan's workspace.

"I feel very connected to octopuses in a way that's hard to explain," she says. "I find their way of experiencing the world kind of inspiring in that each arm has its own basic sensory brain and can feed back into the whole organism. It's a good reminder of trying to take on different perspectives in thinking about the world."

Looking around the room, Orphan reflects on why she keeps so many pieces of art on display. "I really am very sentimental," she says. "I love having visual reminders of all the rich experiences and interactions I've had with students over the years."

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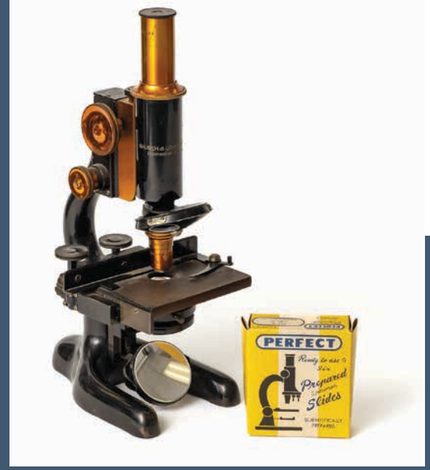


Bausch & Lomb microscope

One of Orphan's most prized possessions is this microscope. Manufactured in 1915, it was given to her, along with some insect and bacteria specimen slides, by her family's next-door neighbors when she was a child. Orphan recalls spending hours poring over the slides and looking at the organisms' physical features. "Our yards shared a little gate, and I would often go and visit the neighbors. They would give me Goldfish crackers," she says. "They knew I was excited about nature, so right before the husband died, he gave this microscope to my mom to help me explore the natural world. I'm still doing it today."

Calcite hydrothermal chimney flange

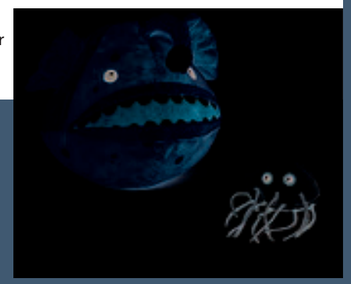
Orphan collected this mineral specimen in the Pescadero Basin off the coast of La Paz, one of the deepest hydrothermal vent sites in the Gulf of California. "Instead of producing the black smoke, which are really metal sulfide particles, released from many hydrothermal vents, this system produces super critically heated fluids, which lack metal sulfides. So, instead of making chimneys built of fool's gold, these hydrothermal structures are made of bright white calcite, producing beautiful crystal spires and flanges. It's a magical place."

Styrofoam artwork

Orphan and her team members come up with all kinds of ways to pass the long hours during ocean voyages. A popular pastime involves decorating pieces of Styrofoam that then shrink due to the water pressure under the ocean. The shrunken mannequin head was crafted on Orphan's 2024 trip to the Aleutian Islands and features a drawing of the Alvin submersible. The octopuses are made from cups and came from a research trip to Monterey. "Any deep-sea–faring person will probably have at least a shrunken cup," Orphan says. "It's definitely a tell."

Plushie toys

Even bacteria can be cute. Orphan gives out these soft and squishy *E. coli* toys (lower right) to students in her microbial ecology course and also to award winners at the annual CEMI symposium and gala. The anglerfish plushie came from a recent alumnus and former student of Orphan's who bought it at the Monterey Bay Aquarium gift shop and gave it to her as a present.



Handmade Kiliwa doll

In 2021, Orphan and her team traveled to Baja California to study the microbes living in a newly discovered hydrothermal vent system in the Gulf of California. A colleague from the Autonomous University of Baja, California, who participated in the expedition suggested these newly discovered vents be given Indigenous Kiliwa names to keep the language alive and honor the people of the Baja Peninsula. He acquired this doll from an elderly Kiliwa artist and gifted it to Orphan. The dress is made from palm material and the hair from yarn. "The artist has since passed away, so there's a limited number of them. I love it. It's very special and reminds me of the trip and my wonderful colleagues," she says.

Octopus artwork

The octopus art on display in Orphan's office includes a detailed pencil drawing given to her as a gift, a colorful ceramic piece she bought in Spain, and a glass sculpture gifted to her by a former graduate student. "My students know about my deep fascination and appreciation for the intelligence of octopuses," she says.