established technologies, including sonar and camera traps, but eDNA was new to them. "At the beginning we had some scepticism about its utility for our questions, but the first results were fantastic, especially because of eDNA's complementarity to the other techniques," says Mena. But at about £200 per sample, the process isn't cheap. And researchers also have to wait patiently for the results, which can take weeks to come back and even longer for more complicated analyses.

NO LAB, NO PROBLEM

Using newer tools, researchers can increasingly get immediate results in the field. For his hellbender eDNA surveys, Spear used the two3 — a smartphone-based portable qPCR machine from Biomeme in Philadelphia, Pennsylvania. Whereas a typical qPCR machine can run 96 samples at a time, the two3 can run only 3 (its successor, the Franklin range of machines, can run a maximum of 9). But instead of waiting days to receive the results from the lab, the two3 delivered them in minutes, and with comparable accuracy. "This sort of system could be really useful if you need to know if a species is there very quickly," says Spear.

But using portable instruments in the field can be a challenge. Joseph Russell, a microbial genomicist at MRI Global, a non-profit contract-research organization in Kansas City, Missouri, used a portable sequencer for monitoring viruses transmitted by arthropods such as mosquitoes and ticks in the Everglades National Park, Florida, and says it was "really logistically difficult and stressful". Not only did the wind and conditions scatter their sample tubes and reagents, but sequencing for even a few hours completely drained their laptop battery.

As a result, Russell created the suitcase-sized Mercury Lab, a portable lab that contains a workbench, cooler, centrifuge, integrated computer and enough power to comfortably run portable qPCR and sequencing experiments in remote field sites for weeks at a time. "Rather than coming back with multiple coolers full of samples, if you could just come back with a thumb drive full of data it would make a lot of things easier," says Russell.

That's a far cry from what Bohmann expected when her bat eDNA study was published in 2011. "I thought, nobody's going to be interested in this," she says. "I didn't know I had come into a brand new field." ■

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VED CHIRAYATH, NASA AMES LAB. FOR ADVANCED SENSING

A drone is used to take photographs below the surface of the water.

Drone takes to the skies to image offshore reefs

Scientists are using uncrewed aircraft to map the topography of Guam's coral reefs.

BY ANDREW SILVER

Researchers from NASA and the University of Guam have remotely mapped a large stretch of coral off the coast of the western Pacific island.

In May, the research team took less than two weeks to study two marine habitats using an uncrewed aerial vehicle (UAV), or drone, to create a centimetre-resolution digital model of the reef structure. Previously, the survey, which could help conservation efforts, would have taken divers a month. The team hopes that its efforts will help researchers to better track changes in reef structure over time.

"You'd be able to get so much coverage in a small amount of time," says one of the project's principal investigators, Romina King, an environmental geographer at the University of Guam in Mangilao, a village on the eastern shore of the island.

About one-third of corals in the shallow waters around the US territory have already died following bleaching events between 2013 and 2017, when warm temperatures caused corals to expel the important algae that give the coral their colour and provide them with essential nutrients, says King. Scientists lacked detailed measurements of reef structure, so there was no baseline to identify areas where conservation efforts were and weren't working. Now, thanks to drones, that's changing.

UAVs are popular with hobbyists, and increasingly, says King, among Earth scientists. In May, meteorologists in the United States began launching drones to study intense rotating thunderstorms called supercells across the Great Plains.

The Guam team's UAV is a US$15,000, 6-rotor carbon-fibre drone made by technology company DJI, based in Shenzhen, China. The Matrice 600 is outfitted with GPS sensors, hard drives, a memory card, a $90,000 RGB 'fluid cam' that corrects the distortion caused by the surface of the water to photograph beneath the waves, and a 7-colour ultraviolet sensor for testing NASA coral-identification technology. Including batteries, the assembly weighs about 12 kilograms.

The team sent the UAV on short hops from the shore to pre-set coordinates 30.5 metres above Guam's Tumon Bay and Tepungan Bay reefs. In total, the researchers collected about 11 terabytes of data across roughly 5 square kilometres, including image files and flight parameters such as speed, altitude and spatial orientation. NASA is using a supercomputer to process and stitch those data into 3D models of the reefs — a process that could take six months.

Ved Chirayath, director of the NASA Ames Laboratory for Advanced Sensing in Mountain View, California, developed some of the UAV's imaging technologies, and says he chose the Matrice 600 for its ruggedness: if one of the six batteries or rotors dies, it can still fly. Still, when the power levels of two batteries unexpectedly dropped mid-flight and the drone had to make an emergency landing in shallow water, the team had to ship in a backup from California to complete its work.

"Field work is hard, UAVs fail, instruments die," Chirayath says. And then there's the human element: "There's nothing that makes [you] more seasick than staring at a drone screen on boat." ■

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CORRECTION

The Toolbox article ‘Drone takes to the skies to image offshore reefs’ (*Nature* **570**, 545; 2019) gave the wrong affiliation for Ved Chirayath. He is director of the NASA Ames Laboratory for Advanced Sensing in Mountain View, California. Also, the picture caption erroneously stated that the drone was carrying a ‘fluid cam’. In fact, it is a commercial camera.