



The MARS Ocean Observatory Testbed

MARS

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Deep-Sea Environmental Sample Processor

An automated DNA lab looks for life in the deep sea



The Environmental Sample Processor (left) has to have all the chemicals, containers, and computers of a full-sized laboratory. Inventing ways to pack them all into a waist-high cylinder keeps Chris Scholin (right) and his colleagues busy. Image: Kim Fulton-Bennett, MBARI.



Two divers check out the second-generation ESP in MBARI's test tank before an early 2006 deployment. The ESP works well identifying proteins and other gene products in surface waters. The design team is now working to make the system function at 90 times surface pressure, and to allow the ESP

The environmental sample processor (ESP) is a molecular biology lab packed (robotic technician and all) inside a canister the size of a kitchen garbage can. A decade in development, the present version of the robot works well in surface waters. For the MARS observatory, MBARI is developing a deep-water ESP that can do the same work in the deep ocean's cold and extreme pressure.

Underwater chemistry, done by a robot

At prearranged times or when triggered by another sensor, the ESP filters 2-L (a half-gallon) of seawater into its metal-alloy housing. The sample is washed and treated with chemicals that break down cell membranes. The freed cell contents are then washed over a wafer and passed to a series of robotic devices.

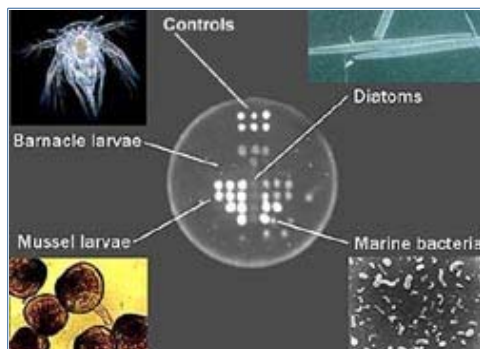
Within these devices is where the molecular chemistry happens. Standard tests detect gene products and answer specific questions: By detecting specific RNA sequences, the system can find out which organisms are present. Or, by testing for particular proteins, it can ask what those organisms are doing. (For example, an RNA test can look for a particular kind of harmful algae; a protein test can learn how much toxin it is producing.)

In surface waters, these tests are useful for monitoring algae and bacteria populations. They can also identify larger creatures such as mussel and barnacle larvae, helping biologists piece together normally hidden parts of these animals' life cycles.

The deep-sea ESP will be more of an explorer.

Cold seeps on the floor of Monterey Bay harbor strange clams that use bizarre symbiotic bacteria to adsorb food. A deep ESP connected to the MARS observatory could detect DNA from these odd creatures, as well as look for other, completely new life forms. Later, the deep

ESP could go even deeper to hydrothermal vents at twice the depth or more of MARS. Present methods for studying these vents center on using simple machines to collect and store samples until they can be hauled up and transported to a lab. A deep microbiology lab at a cabled observatory would go further, analyzing the sample as soon as it was collected and transmitting the results back home.



After the ESP has finished its work, the results literally shine through. Luminescent labels on an analysis wafer (center) are photographed. Molecules representing mussels, bacteria, other organisms, or lab controls bond to particular regions of the puck, so their location gives their identity away. Brightness indicates how much of a particular molecule was present. Image: Chris Scholin, MBARI.

The biggest obstacle to designing a deep ESP lies in doing standard labwork (normally done at around 21°C (70°F) and 1 atmosphere of pressure) on sea water that is about 4°C (40°F) and 90 atmospheres. MBARI engineers have had to construct an add-on module that collects sea water and depressurizes it before piping it into the main ESP compartment.

While engineers are redesigning the ESP's plumbing to make it deep-sea-worthy, the scientists are also expanding its analytical capabilities. Their goal is to be able to detect

rare fragments of actual DNA. The analysis is routine for technicians in roomy, well-lit biology labs. But the steps involve heating, cooling, and reheating samples to precise temperatures – difficult tasks to automate in a small, closed space with limited power availability.

Why MARS?

As the 2004 discovery of [Osedax whalebone-eating worms](#) illustrated, Monterey Bay's depths still hold plenty of secrets. A MARS-based molecular biology lab will be able to sample deep bay water more frequently and with more flexibility in timing than a pre-programmed ESP running on battery power. Scientists can use other MARS sensors to decide when the deep ESP should take samples. And with the MARS site just 32 km (19 miles) by sea from MBARI, ship visits to resupply the deep ESP are easy to schedule.

Pushing the frontiers of automated microbiology down to the deep sea is fraught with difficulties, and key to the deep ESP's development is the MARS observatory's role as a testbed. The permanent connection to shore allows engineers to solve problems from their MBARI desks, rather than making repeat visits to sea to check on progress.

The MARS testbed is also key in developing the [NEPTUNE cabled observatory](#). NEPTUNE envisions using multiple ESPs for long-term studies of the deep hydrothermal vents along the edges of the Juan de Fuca plate. Much of the hardware that will link NEPTUNE instruments and cables is under development at MARS. The deep ESP will also be part of a new microbial research center, called C-MORE (the Center for Microbial Oceanography: Research and Education) planned for the deep ocean off Hawaii. Designing and testing new instruments like the deep ESP is one of the MARS observatory's key services.

Related links



[Dr. Chris Scholin](#)
MBARI Senior Scientist



Leader of the [ESP design team](#)

- ESP project [home page](#)
- [Evolution of a Robotic Underwater Biochemical Laboratory](#) [600 kb PDF] – technical report about the second-generation ESP
- Results from ESP projects in the [Gulf of Maine](#) and [Monterey Bay](#)
- [Robotic DNA lab helps scientists](#) – MBARI homepage news story
- NASA's [Astrobiology](#) magazine covers the ESP's prospects at hydrothermal vents

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