AUV Speeds up Sampling of Ocean's Biogeochemistry and Health

The world's first underwater vehicle designed specifically to collect both biological and chemical samples from the ocean water column successfully completed sea trials off the coast of New England, USA, on 9 July 2017. The new autonomous underwater vessel (AUV), named '*Clio*', will help scientists better understand the inner workings of the ocean while also improving sampling efficiency and reducing the time and cost of broad biogeochemical surveys.

Developed in an engineering collaboration between Woods Hole Oceanographic Institution (WHOI) and the University of Texas Rio Grande Valley (UTRGV) and in scientific collaboration with the University of Michigan at Ann Arbor, *Clio* will improve sampling efficiency and also reduce the time and cost of broad biogeochemical surveys, which are necessary to understand patterns and cycles of the marine food web and the role that the ocean plays in shaping Earth's climate.

Cutting the Cord

Currently, researchers gather samples by using battery-operated pumps, lowered down to various ocean depths on a wire. The pumps suck seawater through a filter that also captures particles. When the pumps are back on deck, the heads containing the filters are removed and brought to a lab for analysis. This had disadvantages, for example: the wire.

Almost a decade before the development of Clio, Breier, then a scientist and engineer at WHOI, designed a SUPR (SUspended Particulate Rosette) sampler—a chemical and biological sampler shaped like a hockey puck that could be used with remotely operated vehicles to collect samples from hydrothermal vents on the ocean floor. For this project, Breier adapted the sampler to fit inside an AUV to enable it to sample at various depths in the water column.

The design of the system needed to be versatile enough to meet the scientific needs of a wide community, simple enough to operate rapidly and with little training, and compact enough to fit in the AUV.

Once lowered off a ship, the vertical-diving Clio propels itself to the bottom of the seafloor using a pair of thrusters and then stops at a series of pre-programmed depths during its ascent to filter water and collect samples.

AUV Design Aspects

The AUV, which is roughly the size of a large refrigerator, can dive to a maximum depth of 6,000 metres (3.7 miles) and operate underwater for 12 to 14 hours at a time. Clio then returns to the surface with stacks of filters representing 100s of litres of seawater that oceanographers can use to measure the genetic and functional diversity of marine microorganisms, as well as nutrients that control their diversity.

Clio has been designed to be as compressible as it is practical, so that, as the water density around it increases with depth, its buoyancy changes relatively little. That saves battery energy that would otherwise be expended fighting buoyancy and avoids the need for complex active variable ballast systems.

Clio's shape is low drag to minimise the battery energy expended while travelling in the water column, and it also enables ready access to the samplers once on deck. Clio also needs to avoid affecting the biological and chemical samples it collects, especially by leaching iron into the water column, so the vehicle uses almost no iron-containing materials in its construction.

Sampling During the Sea Trials

On major expeditions that survey across entire ocean basins, Clio can be in the water performing a survey, while other researchers can concurrently take separate sets of samples using the wire system. To demonstrate this capability during sea trials earlier this month aboard the R/V *Neil Armstrong*, the cruise science party deployed a standard wire-mounted oceanographic instrument known as a CTD rosette, which measures conductivity, temperature, and depth, while Clio simultaneously filtered samples at depth a few 100 metres away.

During the expedition, Clio completed five dives, including two dives to 2,000 metres (1.2 miles) and filtered more than 1,000 litres (264

gallons) of seawater from nine different depths for microbiological and biochemical analysis.

By analysing the biomass Clio collects, scientists can tell what’s living in the water and the nutrients they are using to perform biological functions, and also learn more about the ocean microbiome—the microbial system that helps drive life processes and elemental cycling on Earth.

Science Testing

Next up, Clio will undergo a year of science testing in Bermuda beginning in April 2018. Funding for the design and development of Clio was provided by the National Science Foundation's Ocean Technology and Interdisciplinary Coordination Program and the Gordon and Betty Moore Foundation.
