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Clio: Toward routine operations for a fast vertical profiling vehicle designed for global ocean biogeochemical mapping

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Abstract

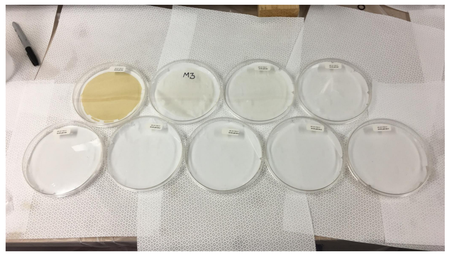
We report the design and results from a series of recent cruises using a fast vertical profiling autonomous underwater vehicle called Clio. Clio has been designed specifically to complement conventional wire-based sampling techniques—to improve ship-time utilization by operating simultaneously and independently of conventional techniques, and thereby to cost-effectively improve the understanding of marine microorganism ecosystem dynamics on a global scale. Life processes and ocean chemistry are linked: ocean chemistry places constraints on marine metabolic processes, and life processes alter the speciation, chemical associations, and water-column residence time of seawater constituents. Advances in sequencing technology and in situ preservation have made it possible to study the genomics (DNA), transcriptomics (RNA), proteomics (proteins and enzymes), metabolomics (lipids and other metabolites), and metallomics (metals), associated with marine microorganisms; however, at present these techniques require sample collection. For this purpose, Clio's primary payload consists of two Suspended-Particle Rosette (SUPR) multi-samplers capable of returning up to 20 sets of filtered samples and filtrate per dive, and filtering up to 280 L of water per sample. Clio hosts additional profiling sensors consisting presently of a Seabird Electronics CTD, WET Labs combined chlorophyll and backscatter fluorimeter, and C-Star transmissometer. Since sea trials in 2017 Clio has participated in 5 cruises including most recently a section cruise between Bermuda and Woods Hole in June of 2019. On that cruise Clio executed a total of 9 nightly dives 12-16 hours in length and filtered a total of 20,878 L of seawater. The vehicle holds depth to a precision of better than 5 cm, is rated to 6000 m (4100 m maximum depth to date) and transits the water column at 45 m/min. Clio has demonstrated consistent reliable performance in its intended role; however, opportunities exist to further exploit its capabilities. Clio's last two dives included autonomous data-driven selection of sample depths to better capture the deep chlorophyll maximum. Clio's large payload capacity (10s W, 10s kg) could host novel samplers as well as in situ sample processors and other profiling instruments.

Clio: A fast vertical-profiling vehicle designed for global ocean biogeochemical mapping

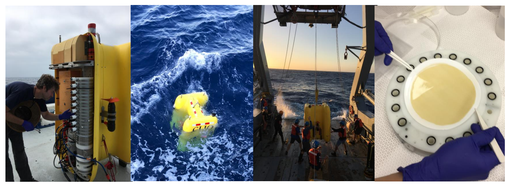
Toward routine operations

PRESENTER:
Mike Jakuba

MOTIVATION: Studying the "–omics" associated with marine microorganisms typically requires filtering large volumes of seawater in situ. Clio's primary payload consists of two Suspended-Particle Rosette (SUPR) multi-samplers capable of returning up to 20 sets of filtered samples and filtrate per dive, and filtering up to 280 L of water per sample, making it ideal for current and future large scale microbial biogeochemistry efforts (e.g. Geotraces and Biogeoscapes)

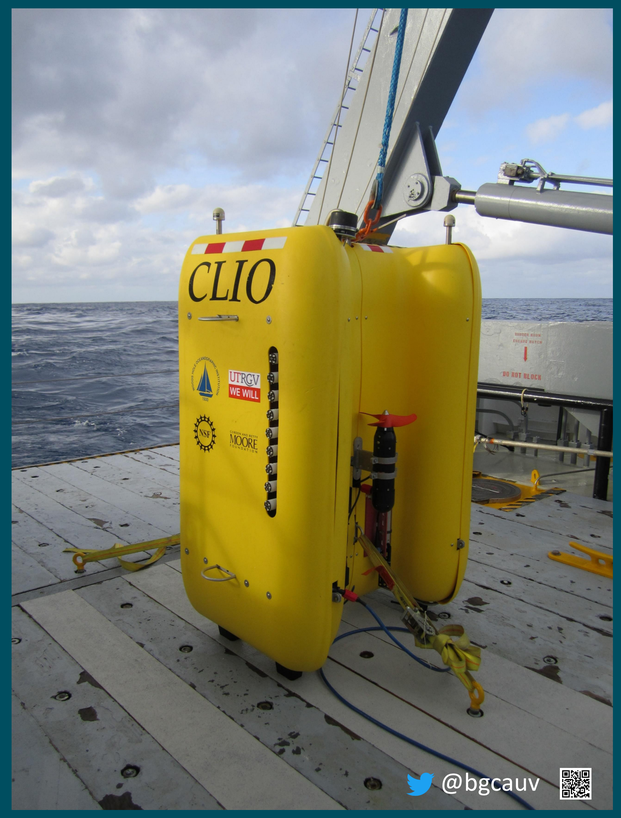


OPERATIONAL STATUS: Since sea trials in 2017 Clio has participated in 5 cruises including most recently a June 2019 section cruise between Bermuda and Woods Hole. On that cruise Clio executed a total of 9 nightly dives 12-16 hours in length and filtered a total of 20,878 L of seawater. The vehicle holds depth to a precision of better than 5 cm, is rated to 6000 m (4100 m maximum depth to date) and transits the water column at 45 m/min.



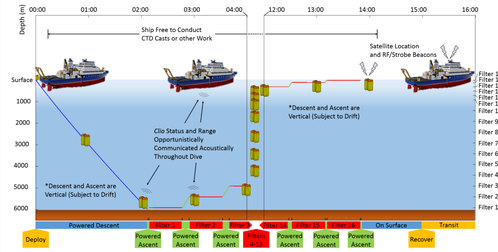
ADAPTIVE SAMPLING: Clio's last three dives included autonomous data-driven selection of sample depths to better capture the deep chlorophyll maximum. Clio's large payload capacity (10s W, 10s kg) could host novel samplers as well as in situ sample processors and other profiling instruments.

The **Clio AUV** autonomously collects **filter samples for "–omics" studies**, filtering **1000s of liters of seawater** per dive.

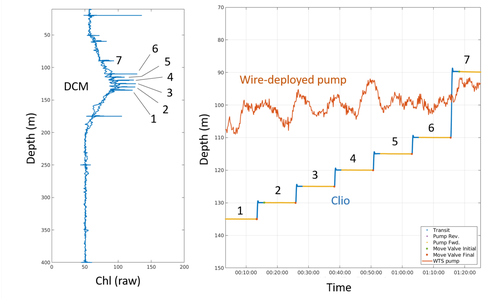


Take a picture for a list of abstracts with **scientific results** using **Clio samples**

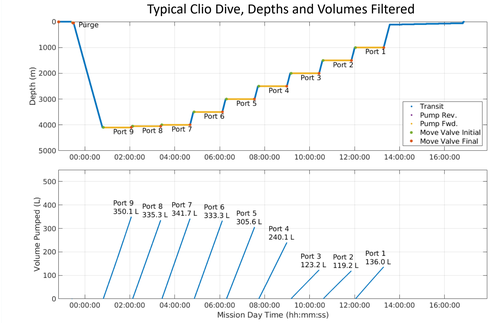
Concept of Operations



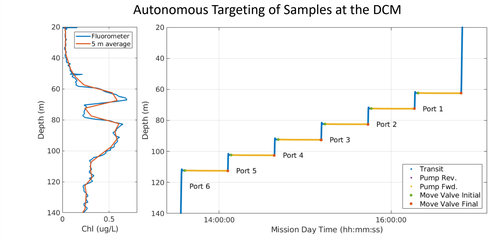
Clio Holds Depth Precisely

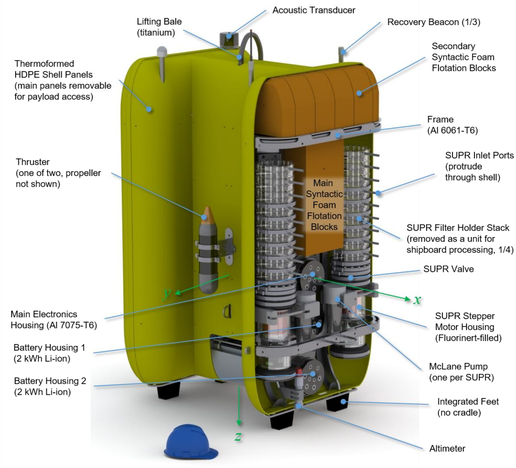


Typical Clio Dive, Depths and Volumes Filtered



Autonomous Targeting of Samples at the DCM





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