2015 Annual Report

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Project title: Cytometer technology for autonomous platforms
Project leads: Tom O'Reilly, Denis Klimov
Project manager: Tom O'Reilly
Project team: Denis Klimov, Tom O'Reilly, Francisco Chavez
Collaborators: Heidi Sosik and Rob Johnson (WHOI), Peter Lopez (NYU), Heike Schmitz and Roger Dellor and Kurt Kiesow (Jupiter Research Foundation), Jarred Swalwell (UW), John Samson and Stephen Jones (4Deep Inwater Imaging), Steve Steinberg (SCCWRP)

Project summary

Shipboard cytometers already provide critical information about marine microbial communities and how they respond to environmental change. This project is investigating cytometer integration with autonomous vehicles such as LRAUV and Wave Glider, using existing as well as emerging technologies. A mobile autonomous cytometer could enable long-duration microbial surveys without the need for an expensive crewed vessel, and in the AUV case could investigate under-ice ecosystems in climate-sensitive polar regions.

Dr Peter Lopez of NYU Langone Medical Center, O'Reilly, and Klimov co-authored an invited peer-reviewed 'perspective' paper entitled 'Cytometers set sail with seagoing mobile robots' for the MTS Journal; the paper reviewed marine cytometer state-of-the-art, applications, and potential integration with autonomous marine vehicles.

Klimov continued development of a bench-top flow-through imaging fluorescent microscope prototype and a concept of a submersible instrument. The bench-top prototype is intended to evaluate hardware, fluidic, electrical, optical and software designs that might be adapted for an AUV-compatible instrument. Klimov explored some key architectural features. The instrument is based on an Android phone as the control and processing platform, uses a standard microscope objective, and has two illumination sources; a white LED and a blue LED to stimulate chlorophyll fluorescence. He explored mechanisms to control flashing of the LEDs through either the phone's USB or audio port and investigated a flow cell design that utilizes a pressure-compensated self-cleaning gear pump. Submersible instrument is intended to be used in shallow water and be equipped with low pressure housing to reduce cost.

The team hosted a visit by John Samson of 4Deep (formerly Resolution Optics). 4Deep manufactures a submersible "holographic microscope" with size and power characteristics that may be compatible with LRAUV. John described the latest version of this instrument, which utilizes a pulsed laser source to reduce exposure time and therefore enable faster vehicle speed while maintaining full optical resolution. John stated that an even smaller, lower-power instrument will be available soon. He also demonstrated new versions of the instrument's "Octopus" and "Swordfish" software applications that improve processing speed and fix bugs found in previous versions. Klimov is now using the new software to reprocess data acquired with an older version of the instrument during the pumped CTD rosette tests aboard the *Rachel Carson* cytometer comparison cruise in 2014.

O'Reilly and Klimov hosted discussions between Scholin and Chavez labs and Jupiter Research Foundation engineers, in regard to design and application of JRF's Wave Glider microscope.

O'Reilly hosted seminar speaker Steve Steinberg of the Southern California Coastal Water Research Project, who described aquatic applications of Cell Scope, a low-cost portable field microscope based on mobile phone technology.

The team began planning a mobile cytometer/microscope workshop to be held at MBARI in 2016.

The team continues to analyze and compare data from several 'off the shelf' instruments borrowed over the past two years, including SeaFlow and Submersible Microscope.

The team will complete this analysis and publish internally in 2016.

Figures:
Fig 1: Flow-scope concept
Table1: Key characteristics of mobile platforms (from MTS Journal paper)

Addenda
This should include the accomplishments of all members of your group who are MBARI employees. Please follow the format of the addenda in the 2013 Annual Report.

Invited publication:
Lopez, Peter, Thomas C. O'Reilly, and Denis Klimov. "Cytometers Set Sail With Sea-Going Mobile Robots." *Marine Technology Society Journal* 49, no. 3 (2015): 17-26.

FIG 1: Flow-scope concept

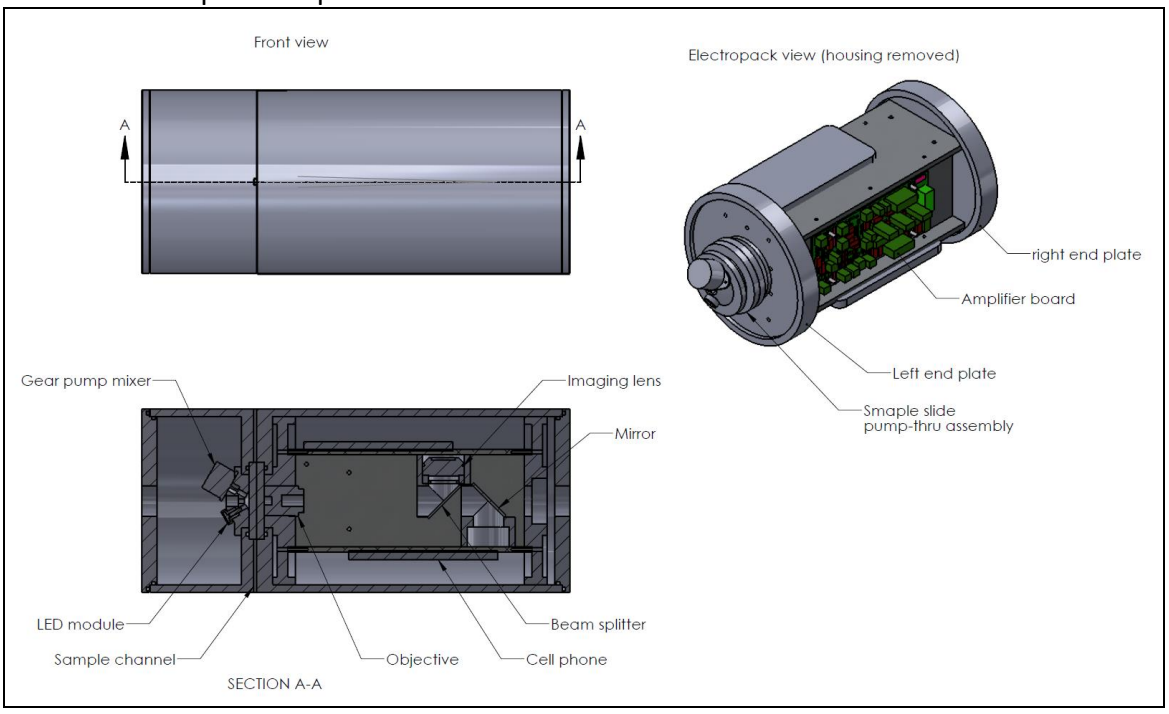

TABLE 1

Some key characteristics of the Liquid Robotics *Wave Glider SV3*, Scripps' *Spray* glider, and MBARI's *Long Range AUV.* Actual endurance will depend on energy needs of integrated instruments, including a cytometer.

	Wave Glider SV3	*Spray* glider	*Long Range AUV*
Type	wave-propelled autonomous surface vehicle	buoyancy-driven glider	propeller-buoyancy hybrid
Approximate payload dimensions (cm)	2 x deck boxes: 380x380x127 1 x deck box10x37x17 towed body: 15 dia x 100 len	11 dia x 15 len	30 dia x 33 len
Max payload weight (kg)	45	3.5	10
Hotel load (watts)	5 - 20	1	50+
Payload energy	150W solar panels, 16 MJ storage batteries	13 MJ (Li primaries)	18 MJ (Li secondaries) 40 MJ (Li primaries)
Typical endurance	months	88 days, 354 profiles	11 days, 400 km 27 days, 1000 km
Reference	liquidr.com, 2015; Brian Kieft (MBARI), personal communication	ucsd.edu, 2015; Brent Jones (MBARI), personal communication	Brian Kieft (MBARI), personal communication