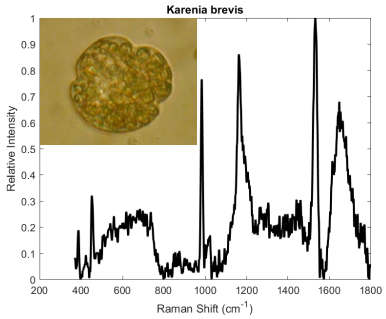
HABStats.22

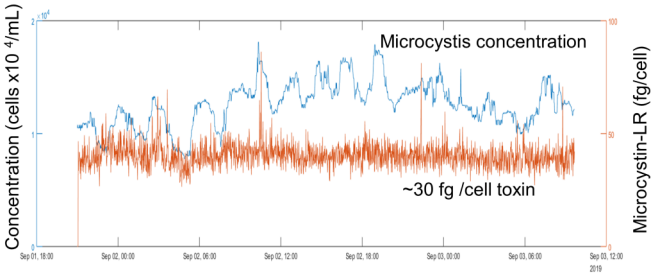
Raman Imaging Flow Cytometer

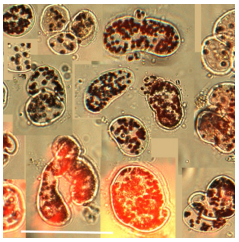
For detection and quantification of HABs, toxins & and microplastics



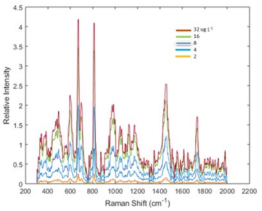
Real-time Data from Santuit Pond since September 2019

Concentration of microcystin-LR in *Microcystis wesenbergii* cells in Santuit Pond water





Left: Microcystis colonies. Right: Raman spectra for Microcystin



Overview: HABStats is a Raman Imaging Flow Cytometer. Like a conventional Flow Cytometer, it has a flow cell where cells and particles between 1 and 500 µm flow past an interrogation window where a laser (532 nm) is triggered to expose the target for a few milliseconds while the fluorescence signal is captured by photomultipliers. HABStats also has a white light imaging system that captures a color image of the target at the same time the laser excites it. In addition to fluorescence information, the Raman shift of light reflected by vibrating molecules is captured by a series of dichroic filters and a sensitive spectrometer. The Raman spectrum from a single target represents a molecular fingerprint of a given compound. Single species of algal cells or microplastic particles emit a specific spectra that is related to its chemical composition and can be species-specific or polymer-specific. Some Harmful Algal Bloom (HAB) toxins such as microcystin-LR, Domoic Acid and Saxitoxin, may be discriminated, classified and quantified by HABStats

Target Features: Features of each target are extracted such as color, shape, texture and morphology (size, minimum/maximum axes, area, volume, perimeter, equivalent spherical diameter and fractal index) and stored in a database along with timestamp.

Dataset Management: Data produced by HABStats include images of targets (algal cells or colonies and microplastics) and their Raman and fluorescence spectra. The combination of the Raman and fluorescence information is digitized into a barcode and stamped on the image of that target. The combination of the image and its barcode is sent to a Convolutional Deep Learning Neural Network (CDLNN) that has been trained to identify the target. New targets may be trained by adding their data to a new class and building a new CDLNN model. A HAB and plastic library of spectra are also used to identify unknown particles.

Manually Classify: This option allows users to view images and their spectra by time or size and classify them to a particular class. There are options to hide already classified images, create new classes and set reference images for each class.

View Results: Select specific runs from training set configurations and show the training results, validation results, wild results, along with the ability to display the training, test, validation, and wild images. Time series plots and plots of specific variables against each other provide an immediate understanding of the particle field. Data are telemetered to a central location.

Specifications:

Computation	
Computer	Embedded NVIDIA® Jetson™ TX2
GPU	1 TFLOP/s 256-core with NVIDIA® Pascal™ or Maxwell™ Architecture
CPU	64-bit ARM® A57 CPUs or HMP Dual Denver 2/2MB L2 + Quad ARM® A57/2MB L2 (Up to 2 GHz)
Imaging	
FLIR Grasshopper 3 machine vision camera	12 MegPixels
Field of View	780 x 690 µm
Detection limits	
Microcystin-LR	0.84 µg L^{-1} ~5 fg/cell
Domoic Acid	1 fg/cell
Saxitoxin	0.2 to 20 ppb
Power	
Voltage / Current	+12 VDC 2A or 120vac
Physical	
W x H x D	32” long by 8” diameter aluminum housing
Weight	48 lb in air; +12 lbs in seawater
Depth Rating	10 m
Raman Spectrometer	
Laser	2W 532 nm
Spectrometer	Wasatch 532, 50 µm slit

Product specifications subject to change without notice.

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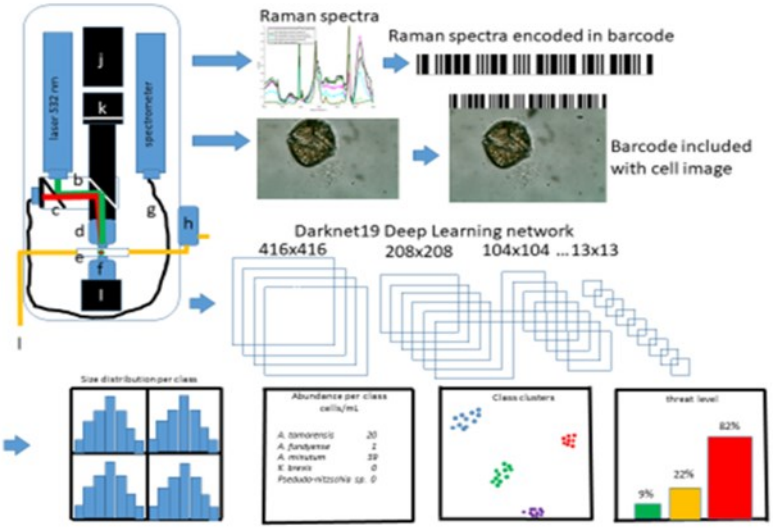
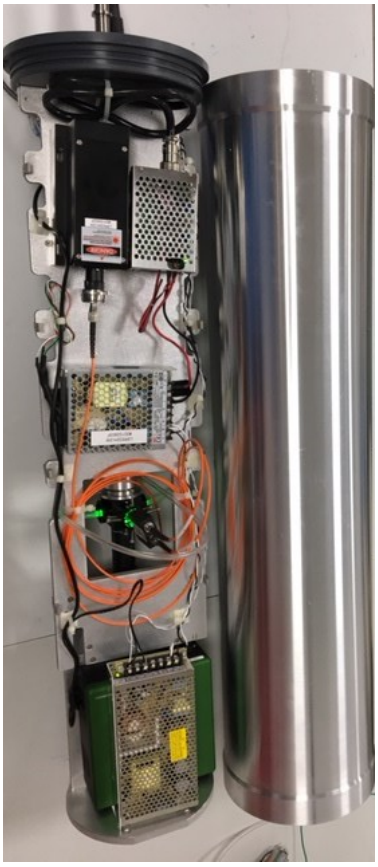
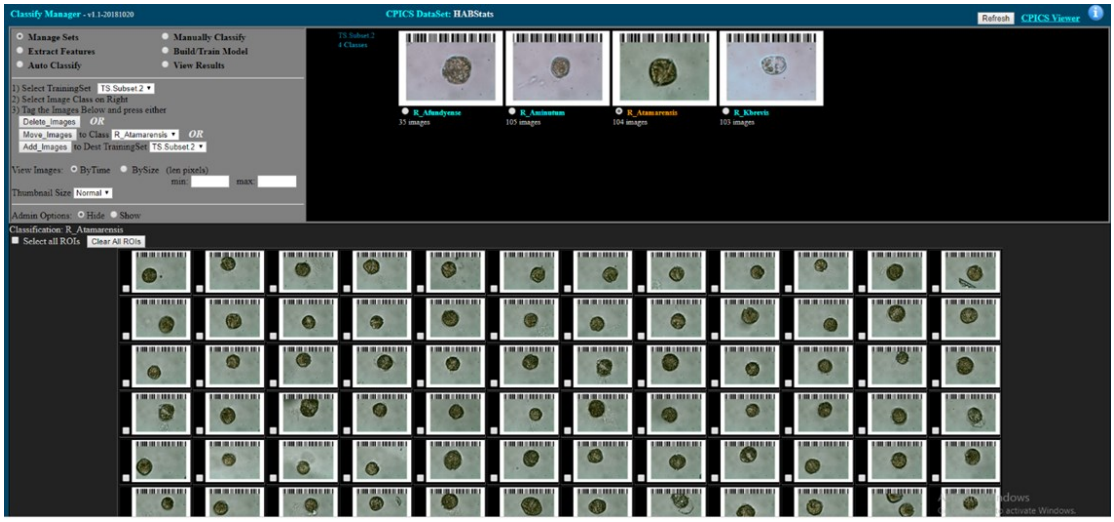
Information Management

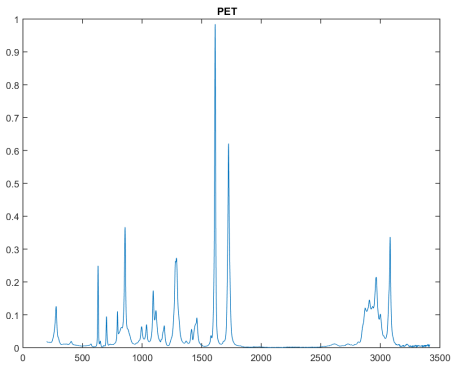




Build and train convolutional deep neural networks



Run and monitor auto classification in real-time



Left: Raman spectra of Polyethylene terethalate microplastics

Right: Confusion matrix for HABs

Species												% Accuracy
Alexandrium catenella	16	0	0	0	0	0	0	0	0	0	0	100
Alexandrium minutum	0	16	0	0	0	0	0	0	0	0	0	100
Alexandrium tamarense	0	0	15	0	0	0	0	0	0	1	0	94
Chaetoceros sp.	0	0	0	16	0	0	0	0	0	0	0	100
Chatonella marina	0	0	0	0	16	0	0	0	0	0	0	100
Chattonella subsalsa	0	0	0	0	1	13	0	0	0	2	0	81
Gambierdiscus belizeanus	0	0	0	0	0	0	14	2	0	0	0	88
Gymnodinium catenatum	0	0	0	0	0	0	1	15	0	0	0	94
Heterocapsa sp.	0	0	0	0	0	0	0	0	16	0	0	100
Karenia brevis	0	0	0	0	1	1	0	0	0	14	0	88
Isochrysis galbana T1SO	0	0	0	0	0	0	0	0	0	0	16	100