Flowing Towards the Future of Plankton Monitoring with FlowCam

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Introduction

- Plankton are a group of primary producers that form the basis of all aquatic food webs and provide invaluable ecosystem services[1]
- Plankton respond quickly to environmental changes and can threaten environmental and public health in the form of harmful blooms[2]
- Monitoring Plankton community composition is essential tool for coastal management
- Historically long-term plankton monitoring has been made difficult by limitations of traditional microscopy
- In recent years new tools have been developed to lower the amount of time and expertise required to enumerate plankton

Flow-Imaging-Microscopy

Flow-imaging microscopy methods involve the imaging, identification, and analysis of subvisible particles suspended in a liquid medium[1]

Advantages

- Rapid analysis of sample composition
- Automated generation of individual particle properties
- Images are preserved for future analysis
- Semi-automated particle classification capabilities

Disadvantages

- Inability to speciate most cell types
- Swapping hardware is required for capturing whole size spectra
- Particulate may obscure target particles
- Lack of standardized methodologies

Anatomy of a FlowCam

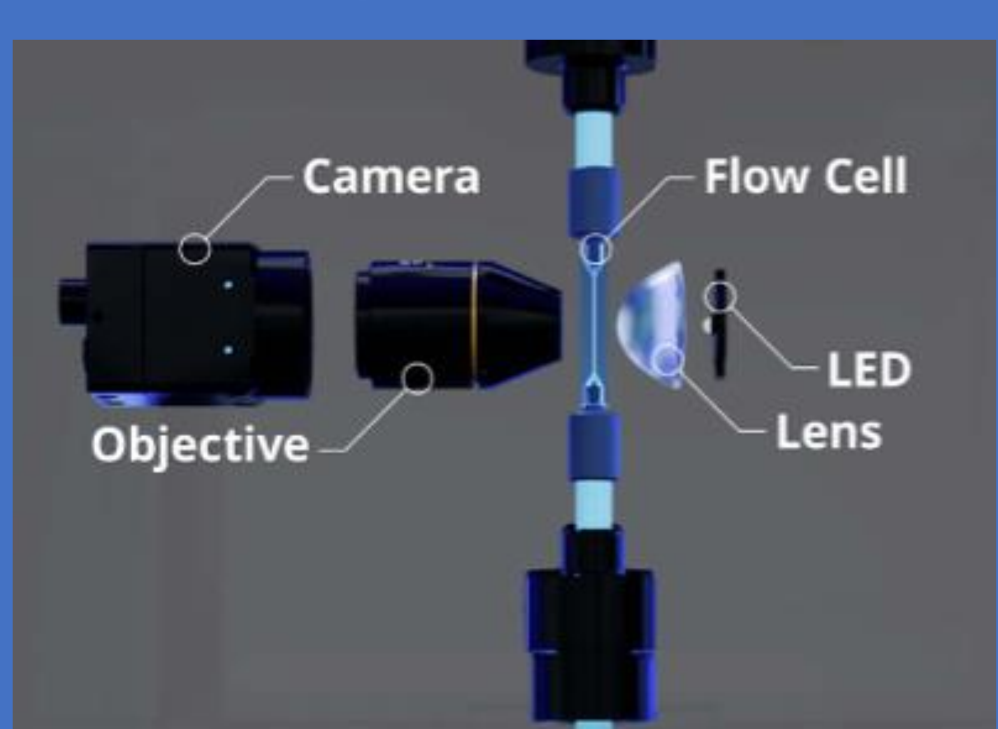
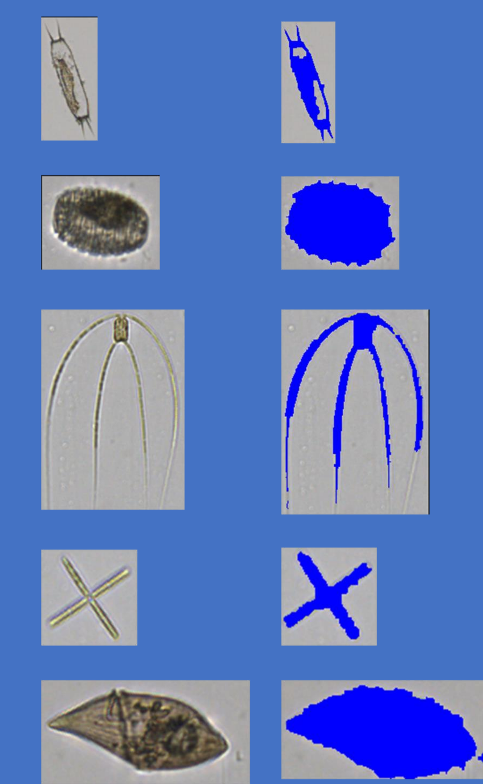


Fig. 1: Image illustrating the major components of a FlowCam flow-imaging microscope. (Credit: Yokogawa Fluid Imaging Technologies Inc.) [3]

Raw Images

Images taken of the inside of the flow cell while sample is flowing through



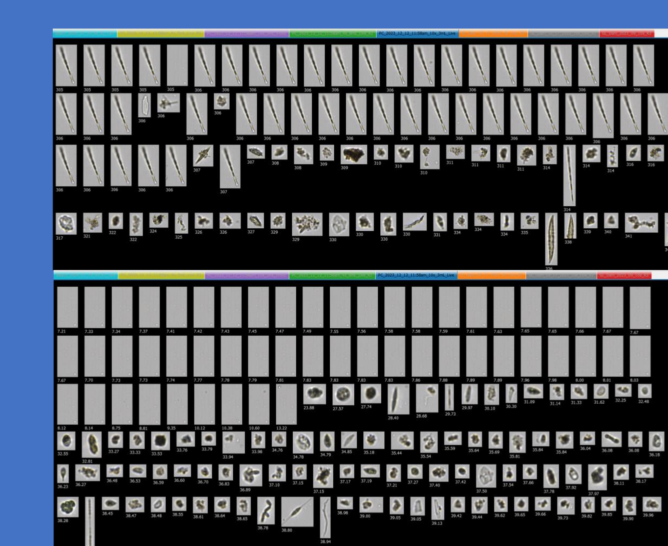
Particles

Particles are identified and separated from the raw images and a binary image is created

Name	Value
Area (ABD)	317.89
Aspect Ratio	0.40
Biovolume (Cylinder)	3430.66
Biovolume (P. ...	3060.92
Biovolume (Sphere)	4263.58
Diameter (ABD)	20.12
Intensity	133.22
Roughness	1.21
Sigma Intensity	42.75

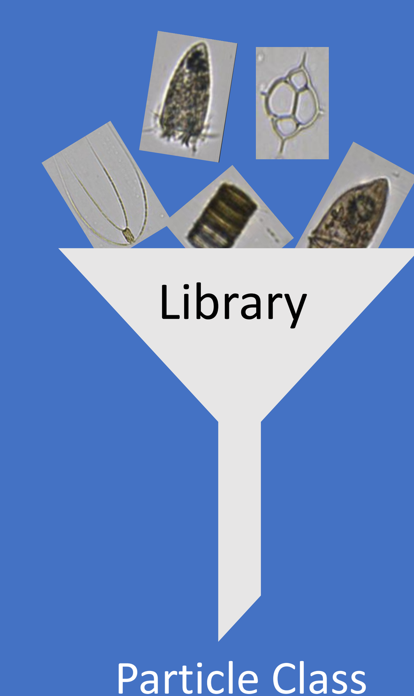
Property Statistics

Values quantifying all aspects of each particle are generated from the binary, grayscale, and color images



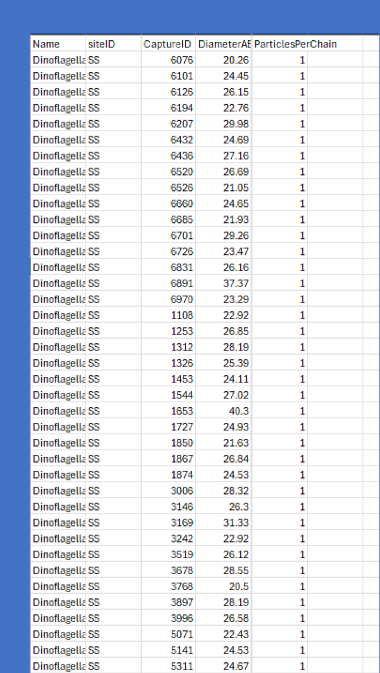
Cleaning the Run

Removal of any repeat images, empty frames, or beads from the run collage



Particle Classification

Particles are sorted through filters generated from libraries of like particles



Tidying Data

Deleting extraneous properties, correcting cell counts for chains, and adding necessary columns

Data Products

Examples from samples taken as part of our continuous water quality monitoring program during their February 2023 nutrient run

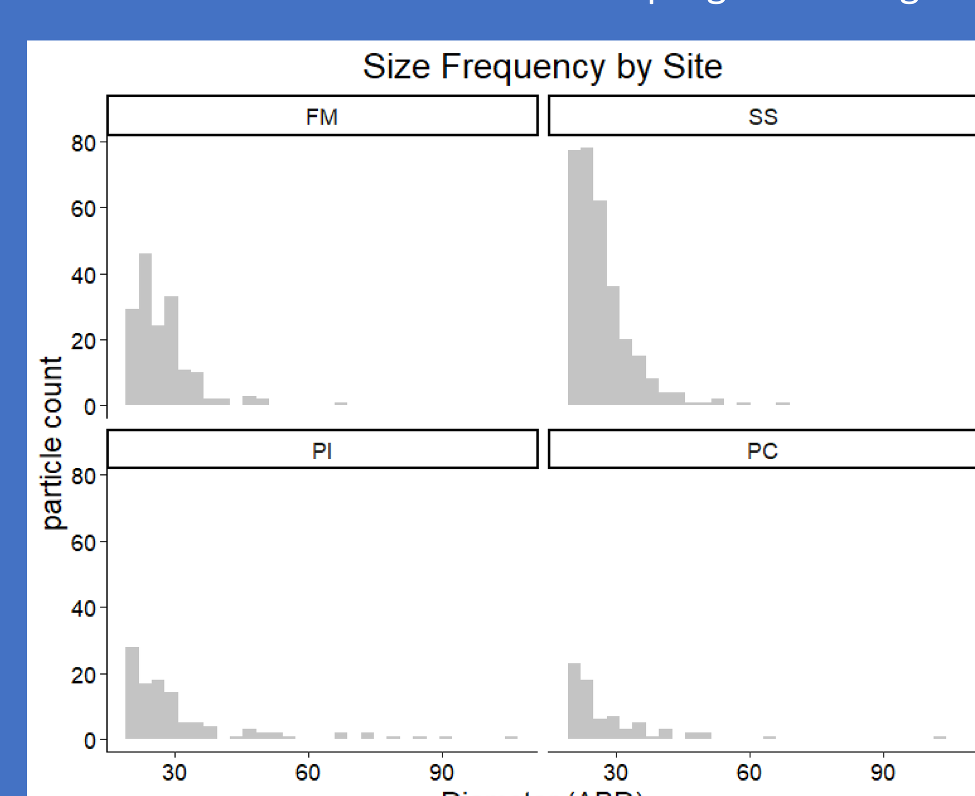


Fig. 2: Histograms illustrating the size spectrum of plankton cells captured at each SWMP site in Diameter (ABD). Due to hardware limitations only cells 20μm-100μm were counted

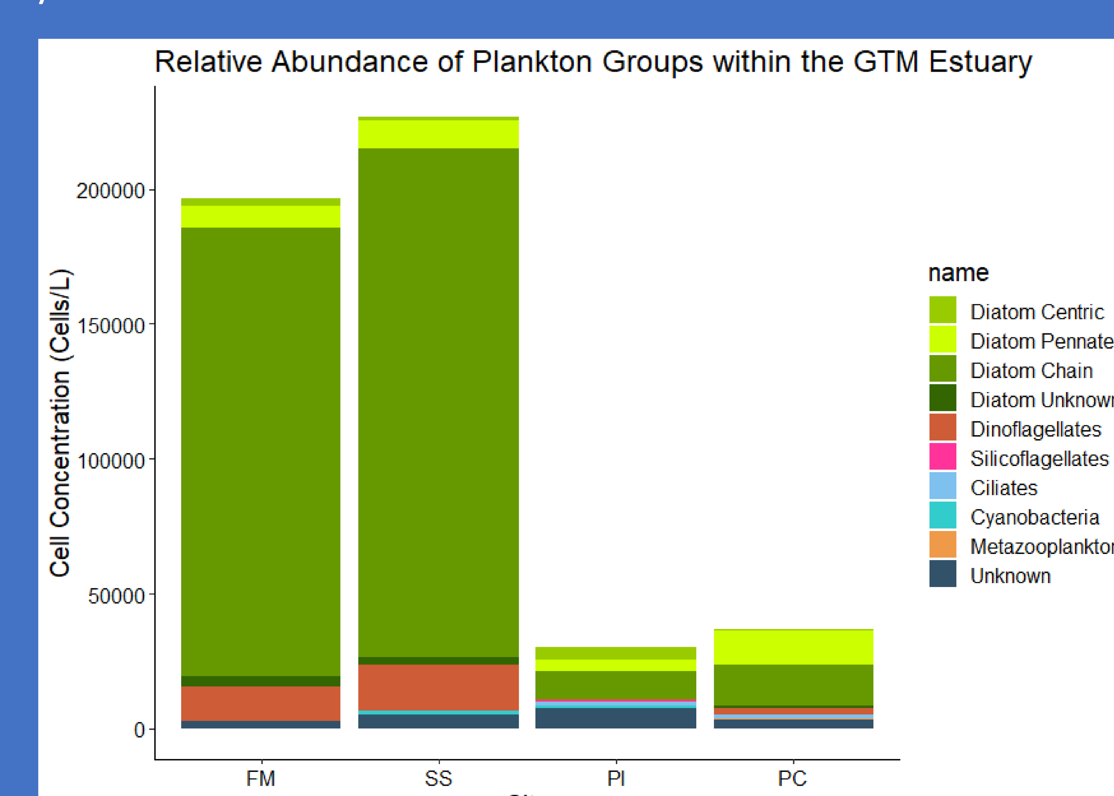


Fig. 3: Relative abundances (cells/L) were calculated at each site for a set of plankton functional types (PFTs). This set of PFTs are groups that exhibit distinct morphological and physiological traits.

A Work in Progress

- Drafting a formal standard operating procedure detailing maintenance and workflows for the FlowCam
- Creating an efficient data pipeline and management plan
- Improving the effectiveness of library generated filters and classification templates
- Exploring the collaborative and educational potential of the FlowCam with volunteers and visiting investigators

Monitoring Goals

- Generate cell counts and size frequencies to characterize plankton community composition within the GTM Estuary
- Develop plankton community characteristics as indicators of changes in water quality and food web dynamics
- Collect actionable and real-time data on the presence of HAB species within the GTM Estuary
- Provide a valuable resource for stakeholders, visiting investigators, and the community

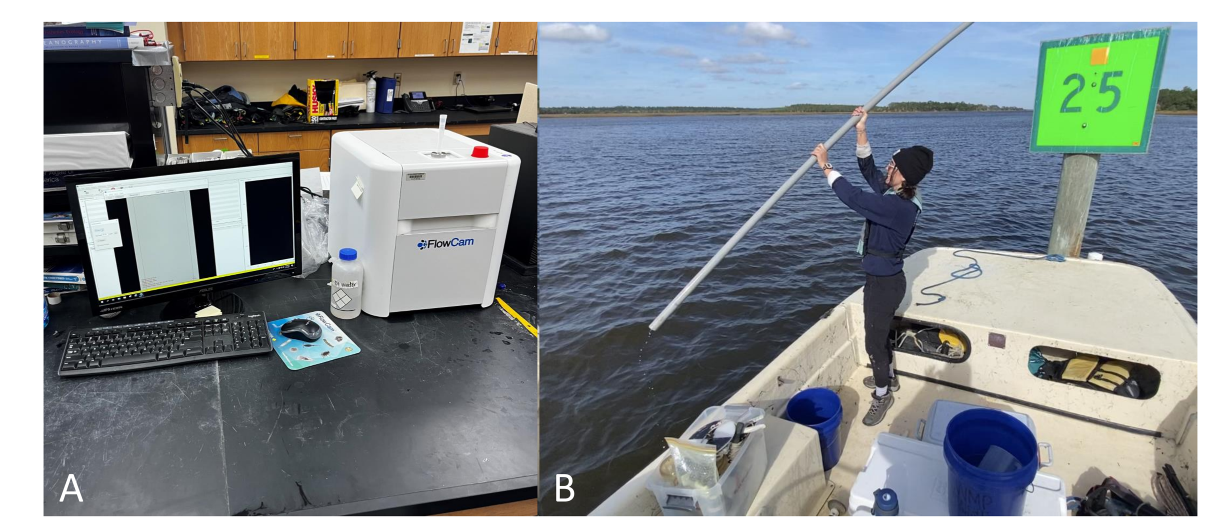


Fig. 4: (A) The GTMNERR's FlowCam 8100 is a stand-alone unit that can easily fit on a desktop or workbench. (B) Technician Megan Howkins collecting water samples during a water quality nutrient sampling run (credit: Silas Tanner)

Significance

- Drastically reduced turnaround times for quantitative plankton data
- Synthesis of plankton and water quality data to identify factors driving shifts in community composition and ecosystem function
- Ability to contribute to global plankton diversity projects with images from the GTM
- FlowCam can be used by visiting investigators to help answer a wide variety of questions.

References

1. Naselli-Flores, L., & Padisák, J. (2023). Ecosystem services provided by marine and freshwater phytoplankton. *Hydrobiologia*, *850*(12), 2691–2706. https://doi.org/10.1007/s10750-022-04795-y

2. Chandel, P., Mahajan, D., Thakur, K., Kumar, R., Kumar, S., Brar, B., Sharma, D., & Sharma, A. K. (2023). A review on plankton as a bioindicator: A promising tool for monitoring water quality. *World Water Policy*, 1–20. https://doi.org/10.1002/wwp2.12137

3. Yokogawa Fluid Imaging Technologies Inc. Scarborough, ME. The Ultimate Guide to Flow Imaging Microscopy for Aquatic Life Sciences. https://info.fluidimaging.com/the-ultimate-guide-to-flow-imaging-microscopy-for-aquatic-life-sciences. Accessed 2024.