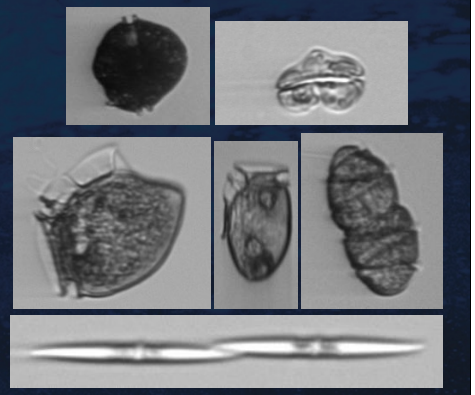
Introduction to the Imaging FlowCytobot phytoplankton sensor

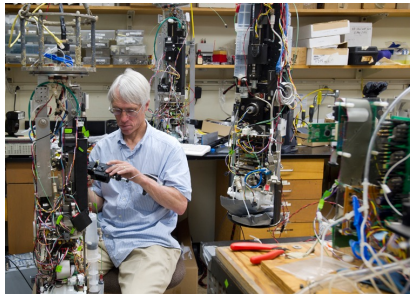
Mike Brosnahan

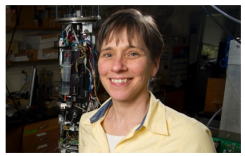
GlobalHAB symposium on automated in situ observations of phytoplankton

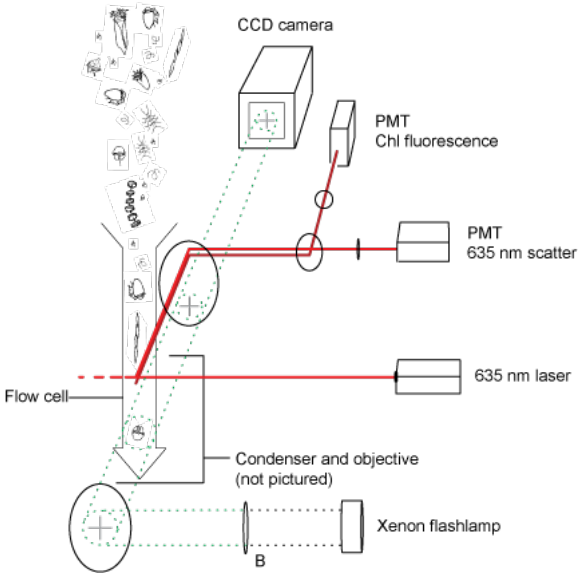
23 August, 2022

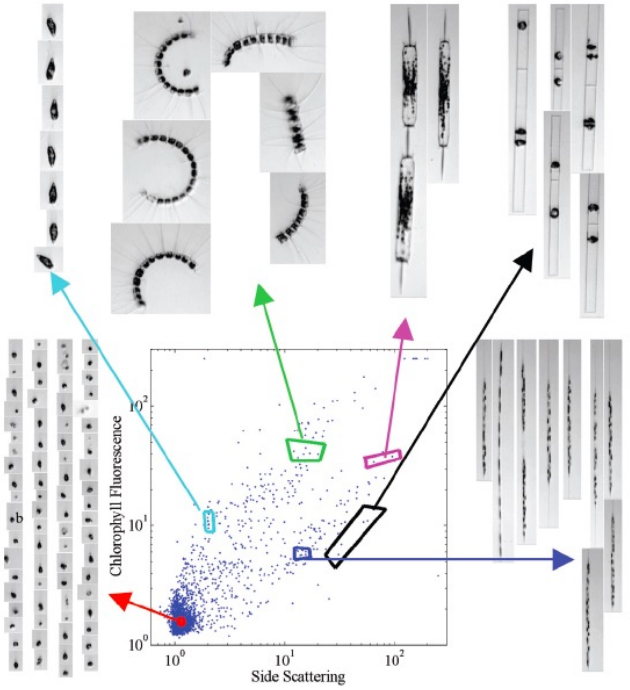


IFCB acts as an automated, submersible microscope









WOODS HOLE OCEANOGRAPHIC INSTITUTION

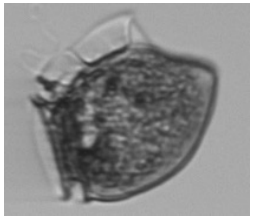
Sosik and Olson, 2007

IFCB specifications and capabilities

Designed for continuous, in situ operation at depths of up to 50 m, deployment durations of several months

Captures submicron resolution images of particles between 5 and 150 µm long at rates of up to 12 sec^{-1}

Recirculating sheath flow provides:
- biofouling protection
- hydrodynamic focusing for consistent, sharp imaging



Additional onboard reagents for cleaning, remote QC assessments

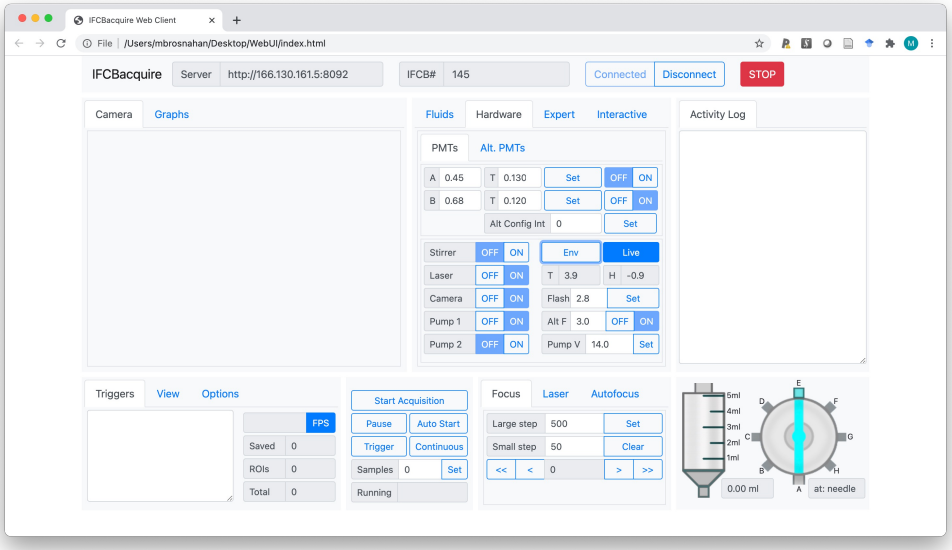
IFCB specifications and capabilities

Power and network connectivity delivered through an underwater cable

Onboard x86_64 computer runs either Windows 10/11 or Debian Linux

LINUX version API

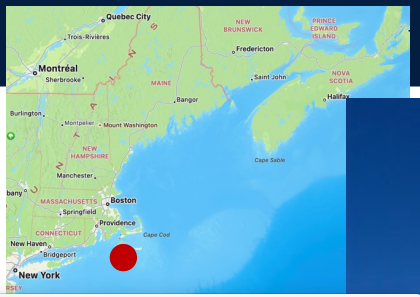
Custom fluidics routines, low-bandwidth command/ control and monitoring

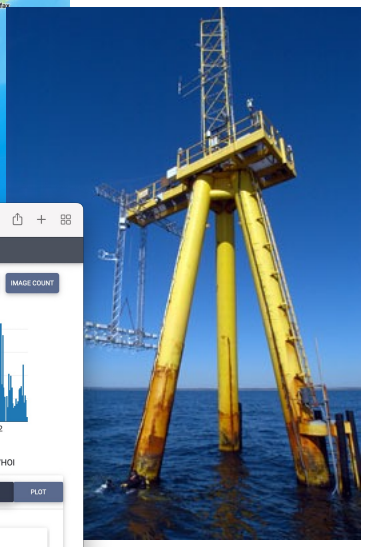


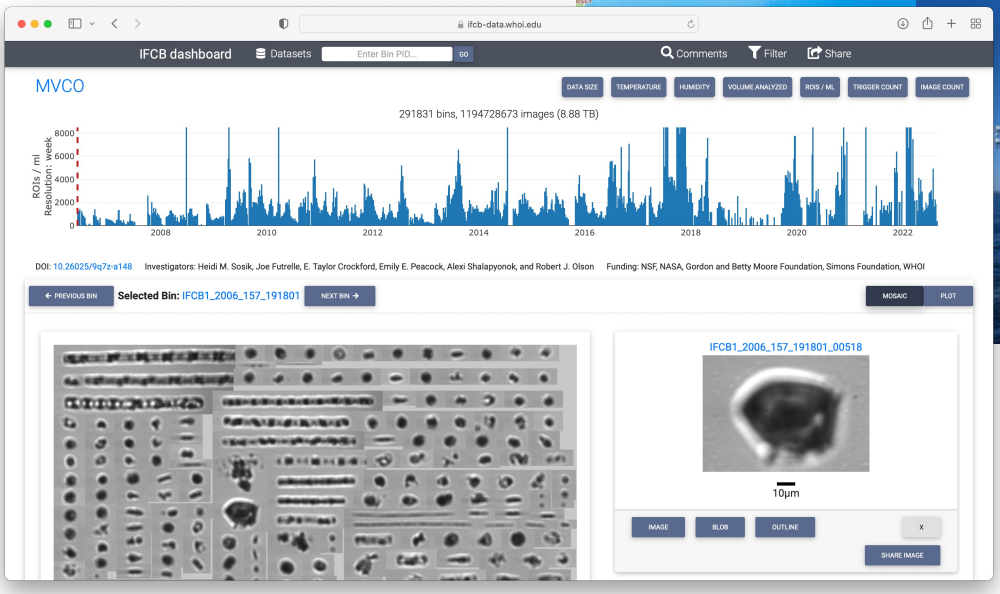
MVCO time series

16+ year time series begun by Rob Olson and Heidi Sosik in 2006

1.2 billion images (9 TB) and growing!

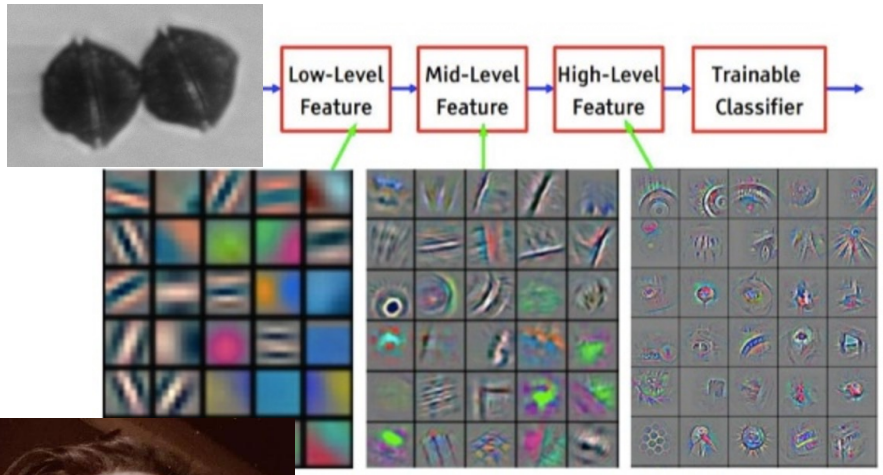




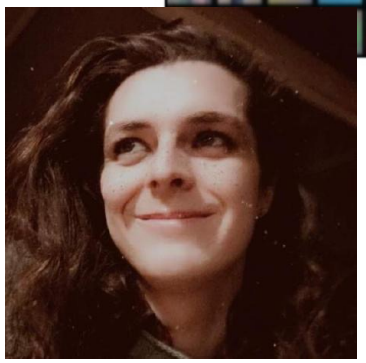


WOODS HOLE **OCEANOGRAPHIC** INSTITUTION

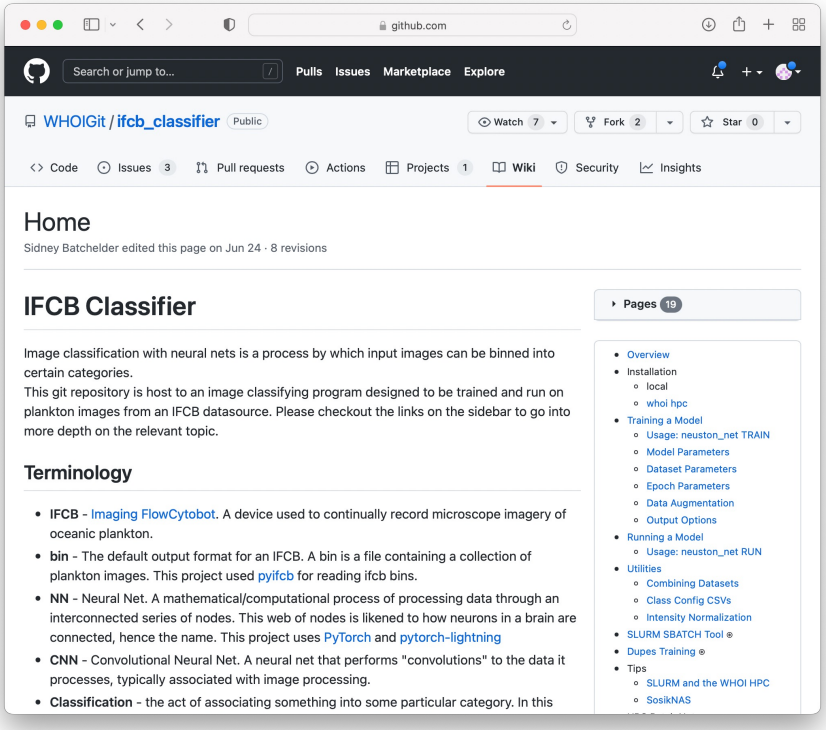
ML models translate images to spp. counts



Alexandrium_catenella_TAG_doublet



Sidney Batchelder
WHOI IS Application Development



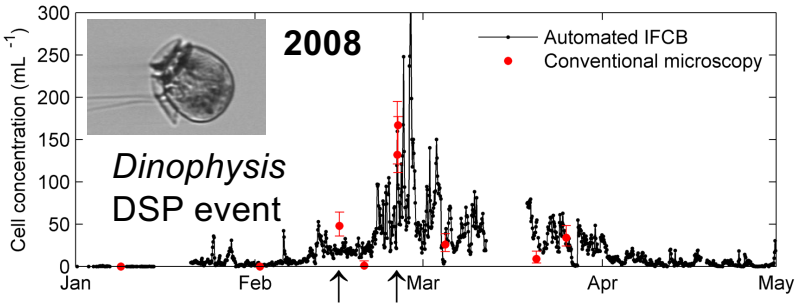
WOODS HOLE OCEANOGRAPHIC INSTITUTION

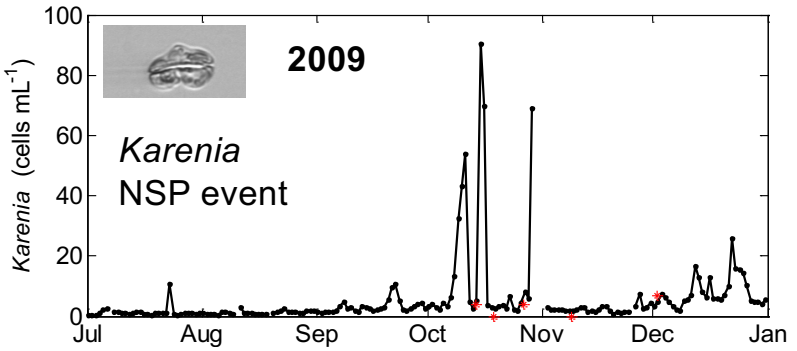
Application to HAB surveillance and monitoring

UT-MSI pier, Port Aransas, TX

The Imaging FlowCytobot is a powerful monitoring tool

Continuous operation enables detection of patchy blooms

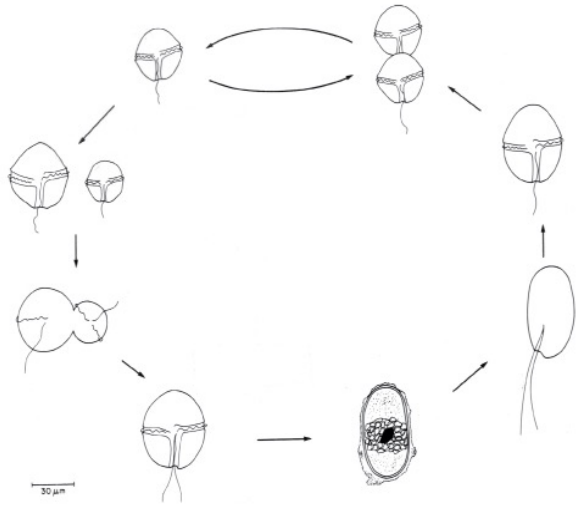




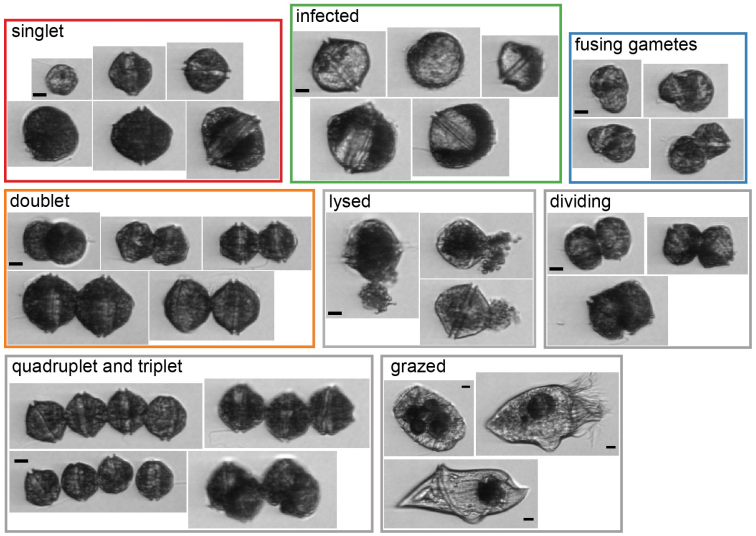
Campbell et al., 2010

Understanding HAB life cycles, bloom dynamics

BrosnahanLAB
harmful algal bloom ecology



A. catenella cell types



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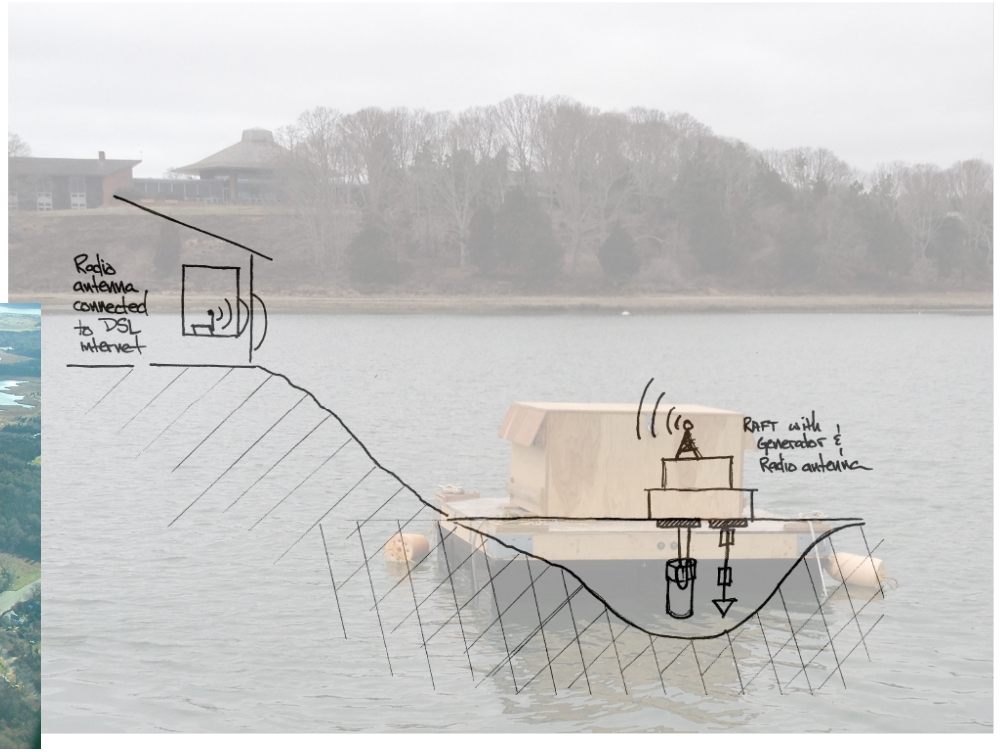
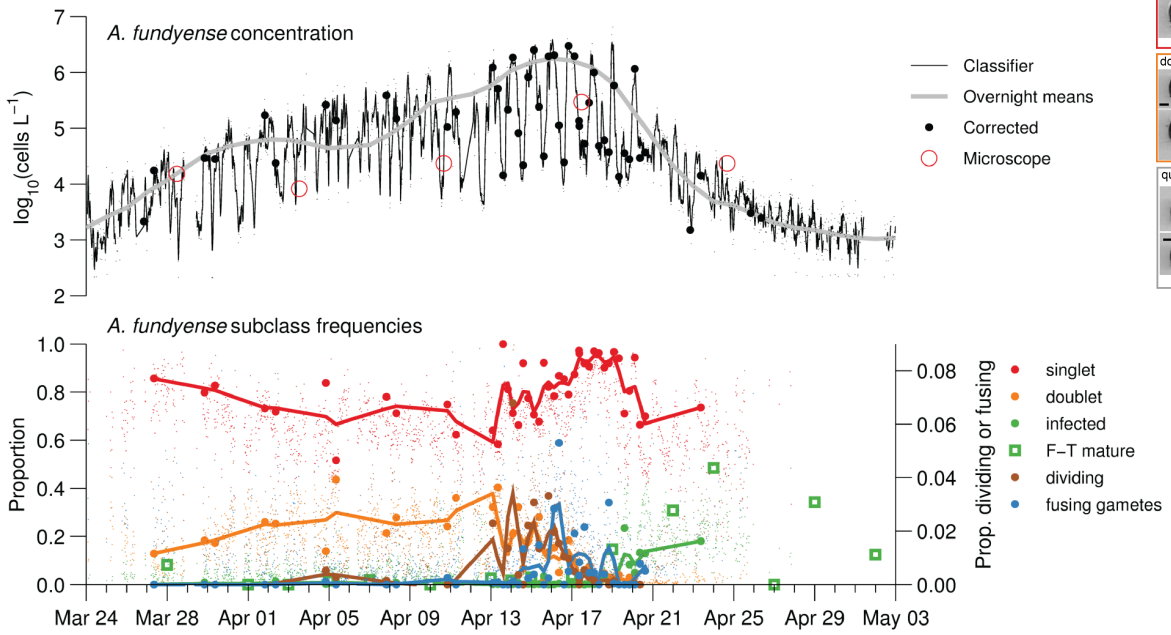
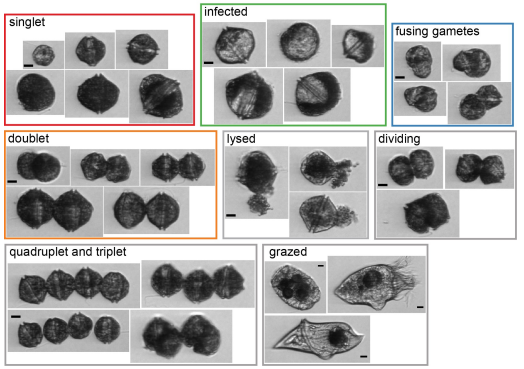
Understanding HAB life cycles, bloom dynamics



Understanding HAB life cycles, bloom dynamics



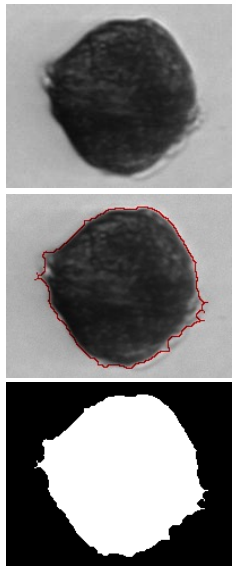


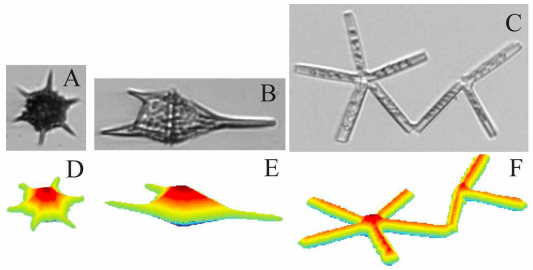
Onset of bloom declines marked by sexual induction and new cyst production

Brosnahan et al. 2015

WOODS HOLE **OCEANOGRAPHIC** INSTITUTION

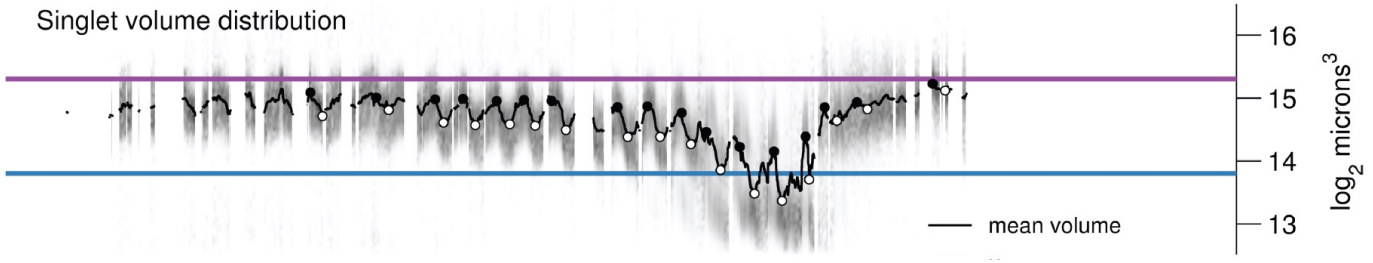
Cell size dynamics to understand in situ physiology



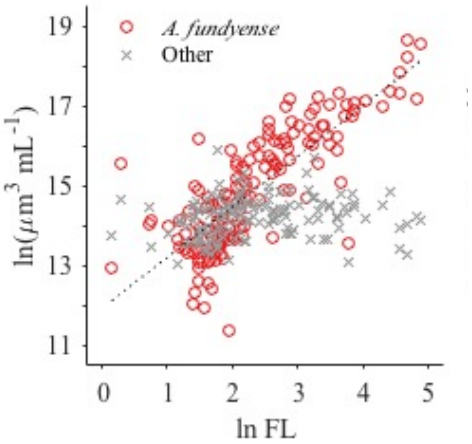


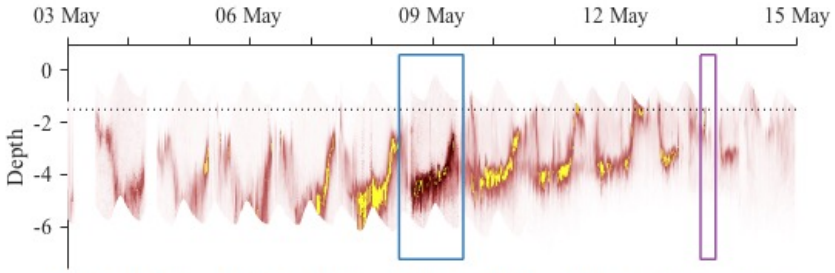
Moberg and
Sosik, 2012

A. catenella grow, produce toxin, and form gametes much faster than expected!



Coupling IFCB to a profiling sonde



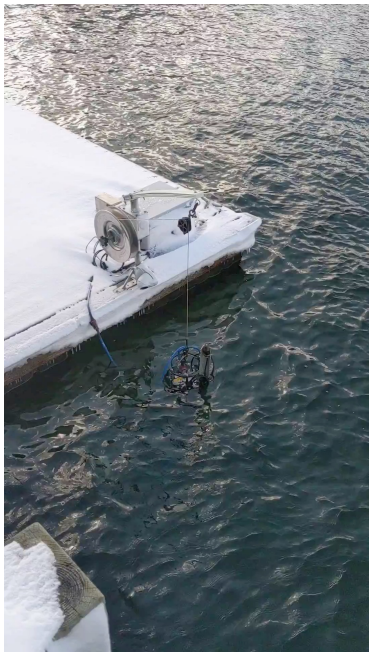


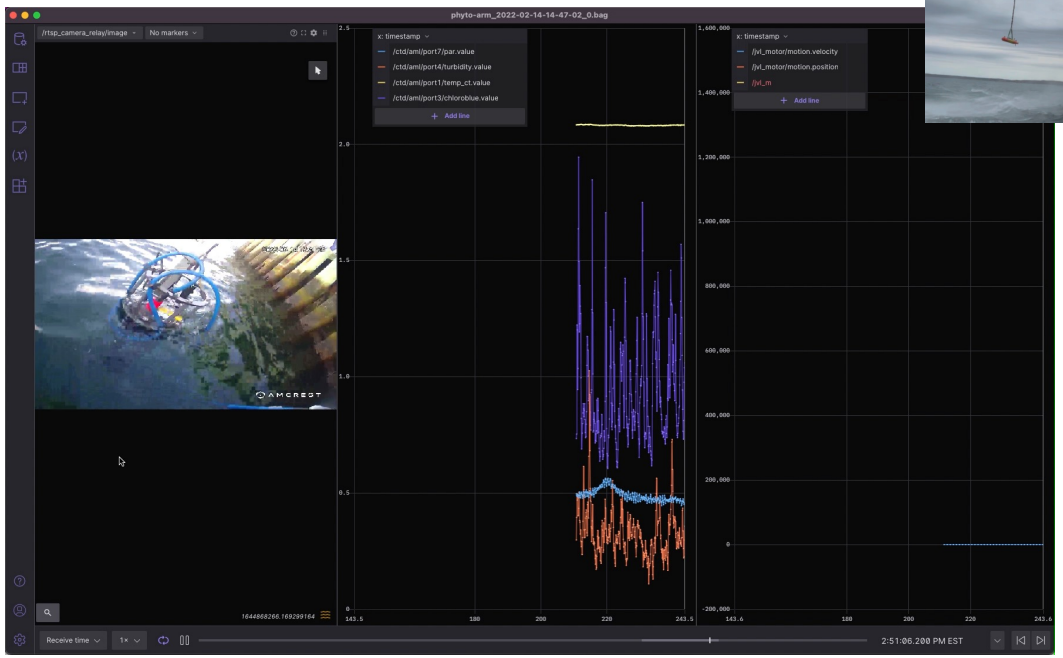
Brosnahan et al. 2017

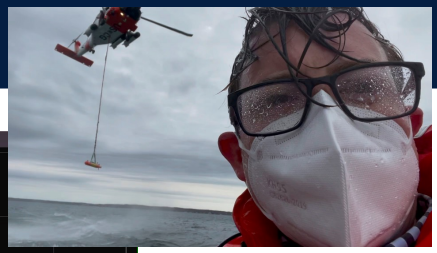
Near peak of blooms, *A. catenella* is the dominant source of chlorophyll fluorescence

Cells alter their vertical swimming behavior on sexual induction, causing red water

IFCB as a hub for sensor integration







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PHYTOarm
harmful algal blooms phytoplankton monitoring
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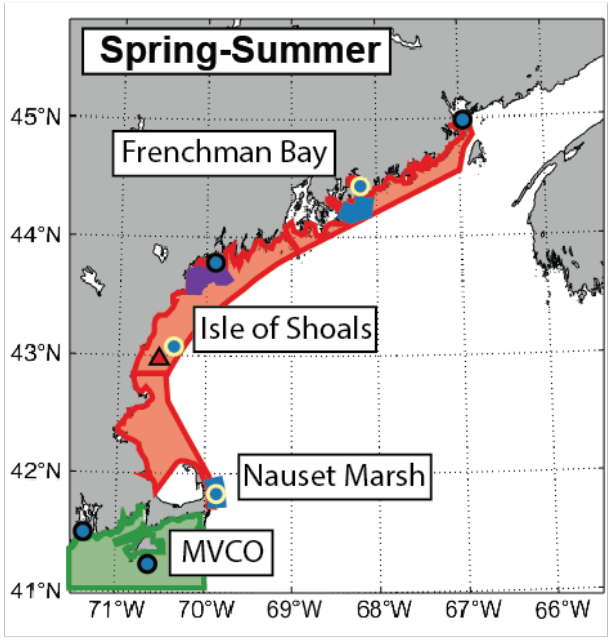
IFCB network development to address changing HABs

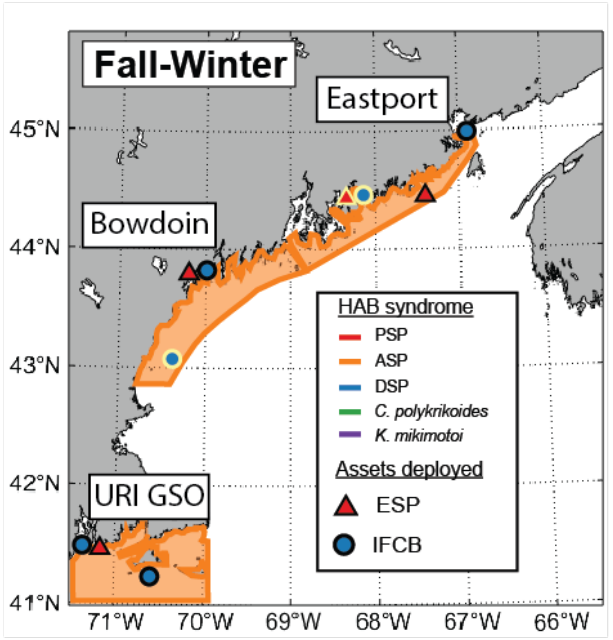
Long history of PSP

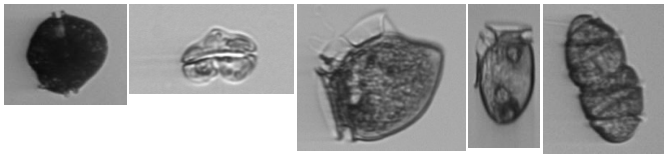
ASP and DSP are new biotoxin threats

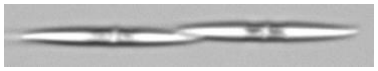
Increasing aquaculture impacts

Impacts are now year-round









NCCOS

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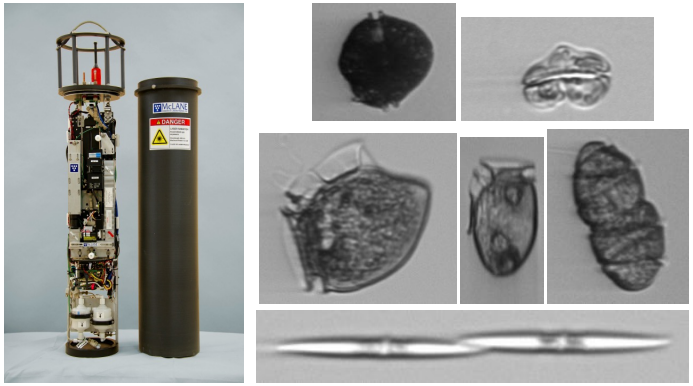
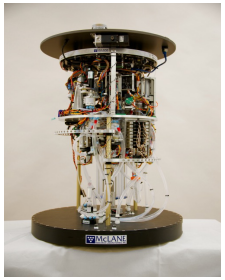
Advanced HAB sensors

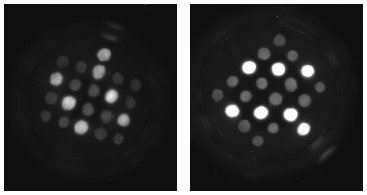
Imaging FlowCytobot (IFCB)



Automated light microscopy

2G Environmental Sample Processor (ESP)





‘Molecular lab in a can’

- Available on-instrument assays detect species-specific nucleic acid markers or toxins
- Measure particulate domoic acid (pDA) and collect archival samples **only when Pn are present**

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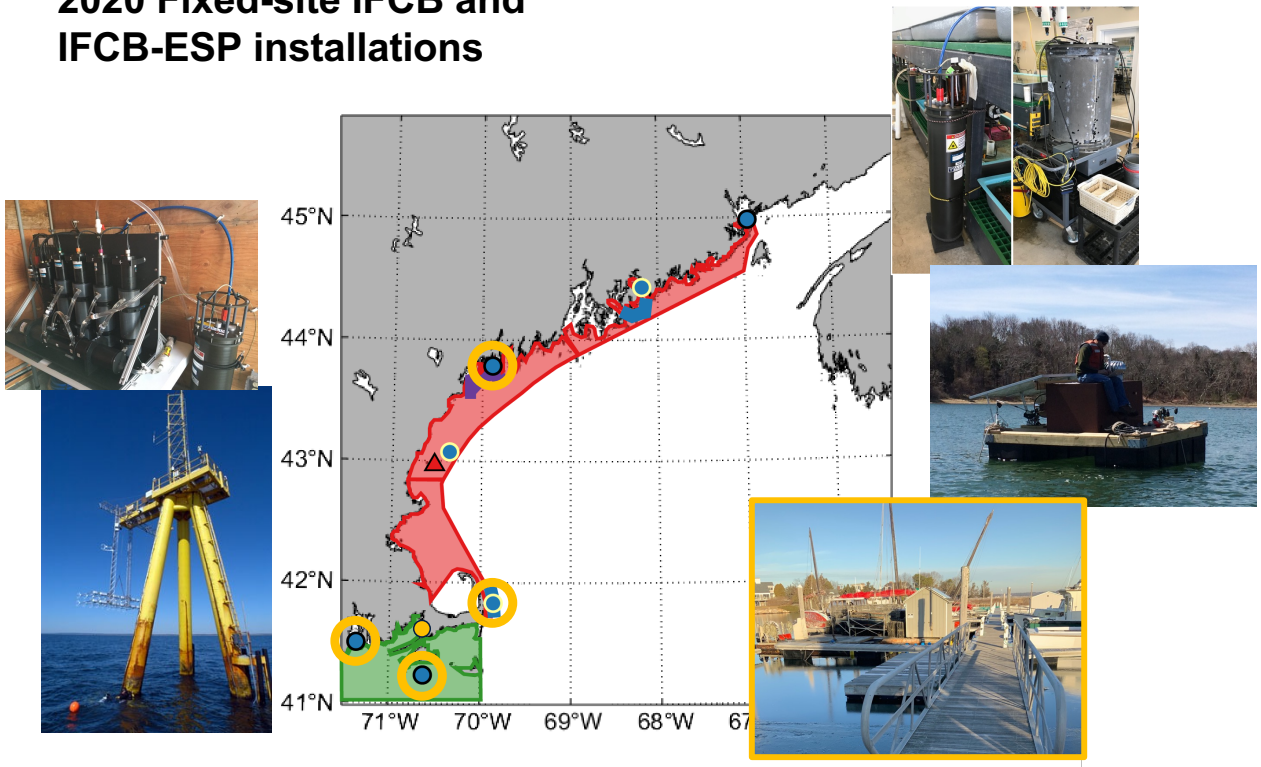
McLANE RESEARCH LABORATORIES, INC.

Fixed site installations

2020 Fixed-site IFCB and IFCB-ESP installations



Year-round

Bowdoin College

Martha's Vineyard Coastal Observatory

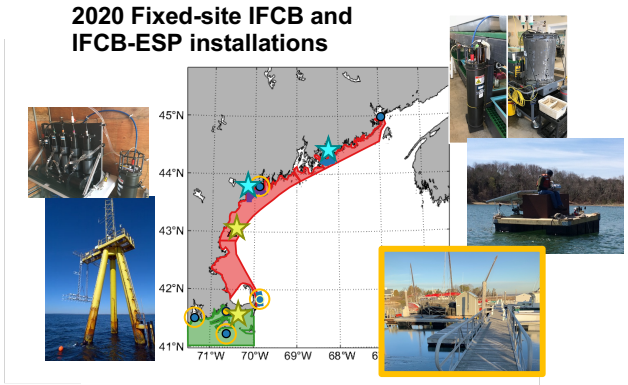
Ward Aquafarm

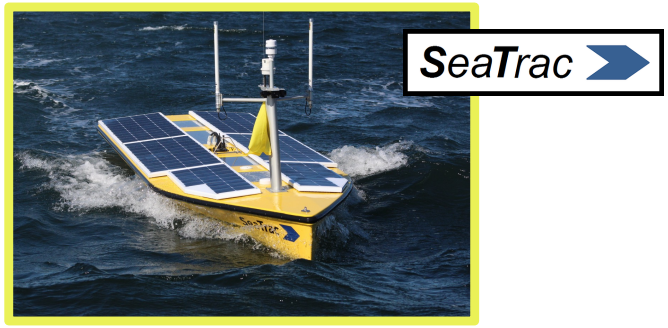
URI GSO

Seasonal

Nauset Marsh (Aug-Nov)

Adaptive sampling through mobile platforms





Offshore IFCB sampling

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PHYTOarm
harmful algal blooms phytoplankton monitoring
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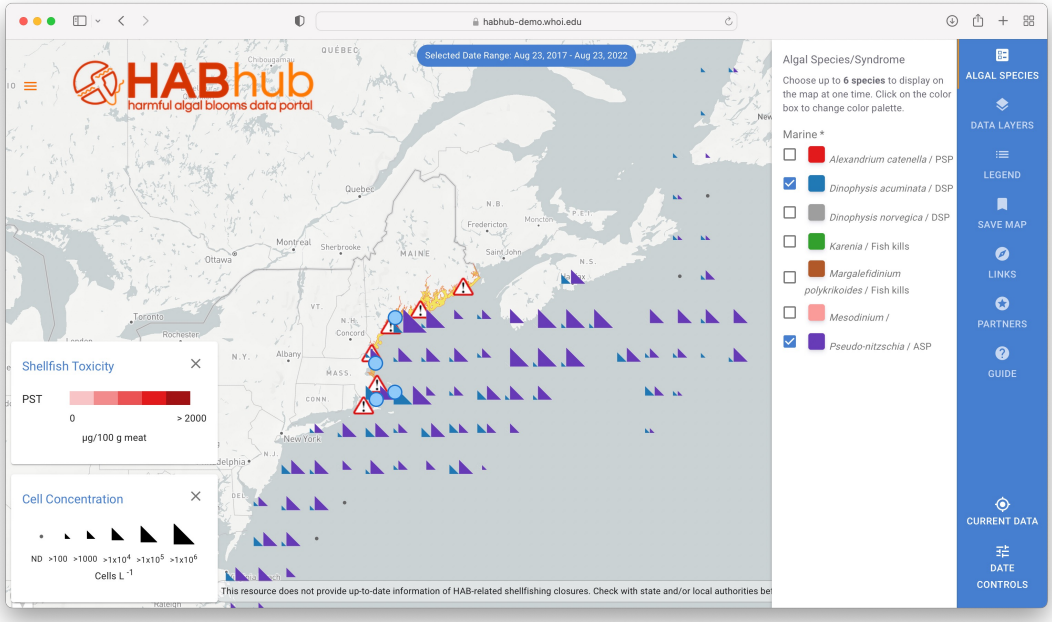
Real time observation



Aim: Make data as accessible as possible

Data classified by CNN within 1-2 h of collection

Results available immediately through an ifcb dashboard and HAB hub

NSF

NIH National Institutes of Health

Woods Hole Center for OCEANS & HUMAN HEALTH

WOODS HOLE OCEANOGRAPHIC INSTITUTION

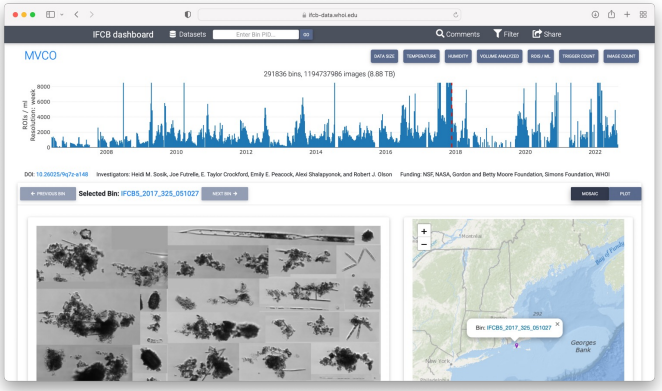
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

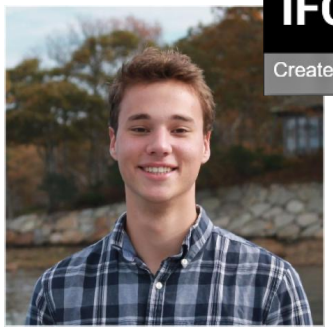
Data sharing and analysis tools!

Joe Futrelle

https://github.com/joefutrelle/pyifcb.git

https://github.com/WHOIGit/ifcbdb.git





IFCB Annotate

Created at Woods Hole Oceanographic Institution

Louis Kilfoyle

Ethan Andrews

HABhub
harmful algal blooms data portal
WOODS HOLE OCEANOGRAPHIC INSTITUTION

https://github.com/WHOIGit/whoi-hab-hub.git

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And more coming…

Axiom DATA SCIENCE

UNIVERSITY OF CALIFORNIA SANTA CRUZ

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

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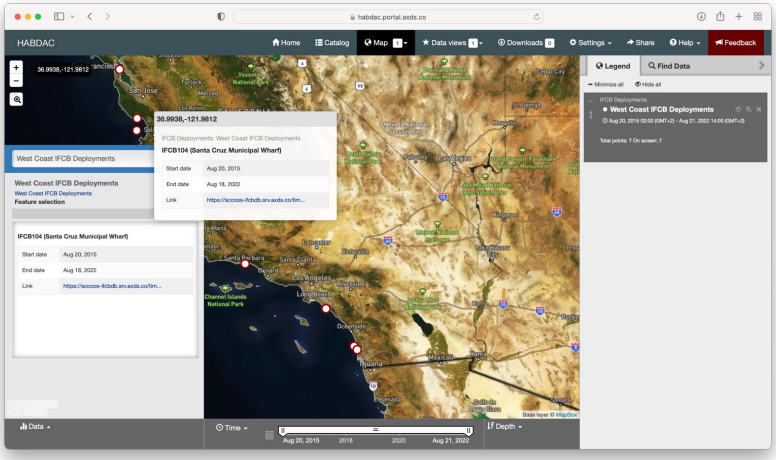

https://habdac.portal.axds.co/#

Nordic Microalgae and aquatic protozoa

http://nordicmicroalgae.org

SMHI

SBDI SWEDISH BIODIVERSITY DATA INFRASTRUCTURE

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Summary

IFCBs are well suited for detection and monitoring of many marine HAB species

Emerging as the backbone of new HAB observing systems in the northeast U.S. and elsewhere

Challenges and needs remain in areas of data standards, access/archive, image annotation, sharing of analysis products, and more!

Acknowledgements

Mrun Pathare
David Beaudoin
Verena Lucke
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Claire Anacreon
Kali Horn

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Ethan Andrews
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McLane Lab team

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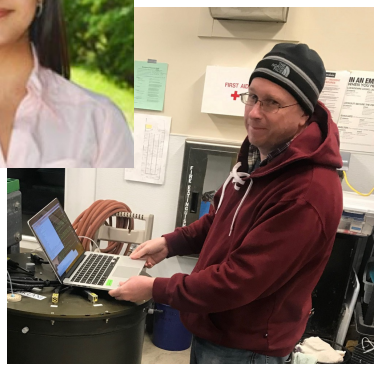
Rob Olson
Emily Peacock
Bruce Keafer
Don Anderson

Collin Roesler
Kate Hubbard
Colleen Mouw
Jake Kritzer



Dan Ward
Jane Disney
Mark Hanscome