In situ sensing of HABs for shellfish management

Michael Brosnahan
Woods Hole Oceanographic Institution
NESSA Meeting
Plymouth, MA
10 April 2019

McLANE RESEARCH LABORATORIES, INC.

SeaTrac

VIMS | WILLIAM & MARY
VIRGINIA INSTITUTE OF MARINE SCIENCE

Woods Hole Center for
OCEANS & HUMAN HEALTH

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

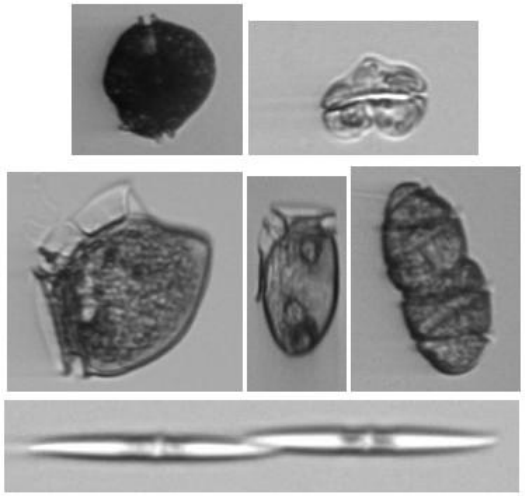
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

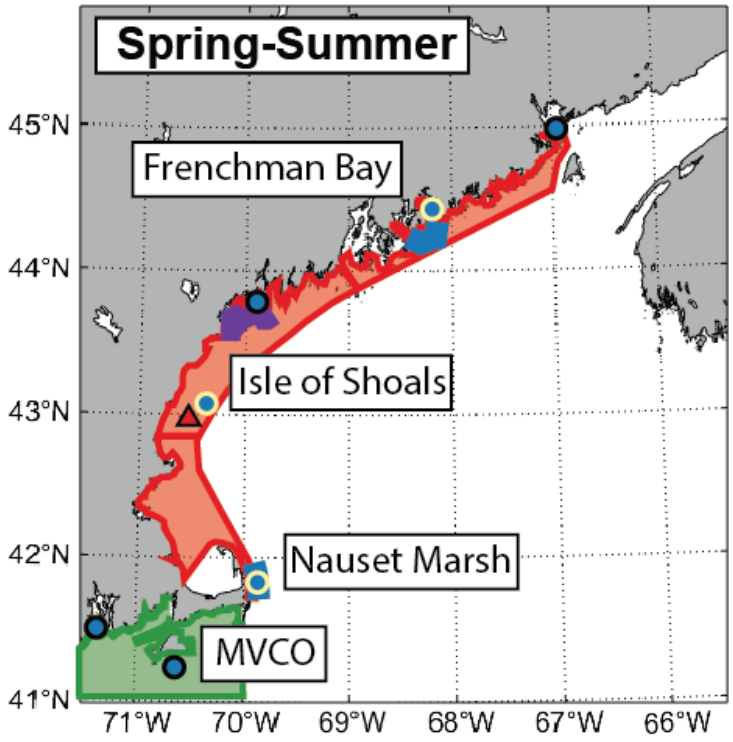
Bowdoin

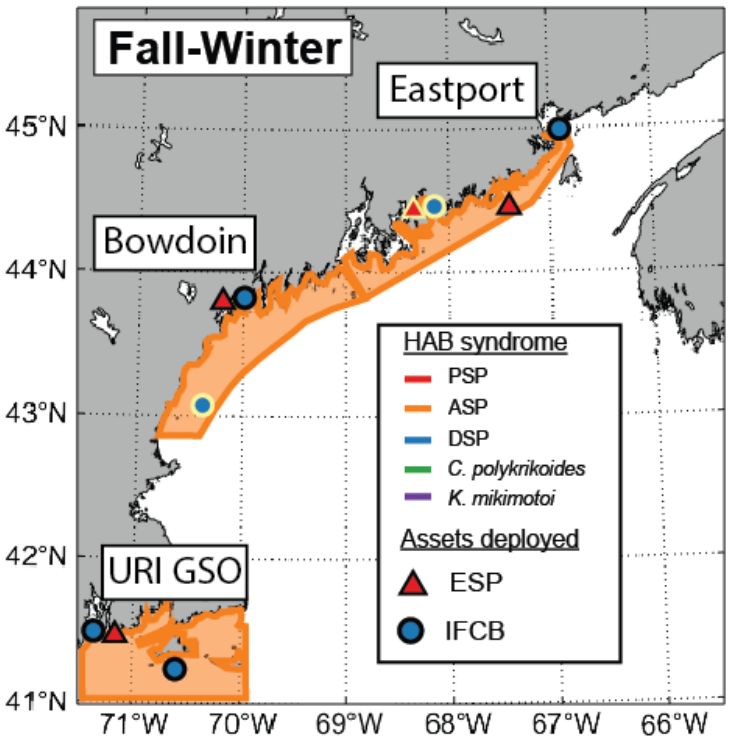
M B A R I

NERACOOS

New England HAB occurrence

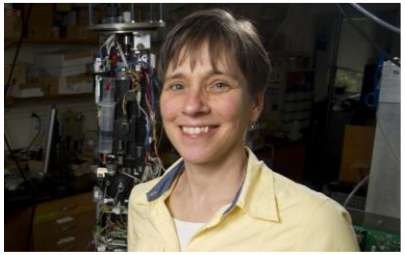






In situ phytoplankton monitoring technologies

Imaging FlowCytobot (IFCB)



WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

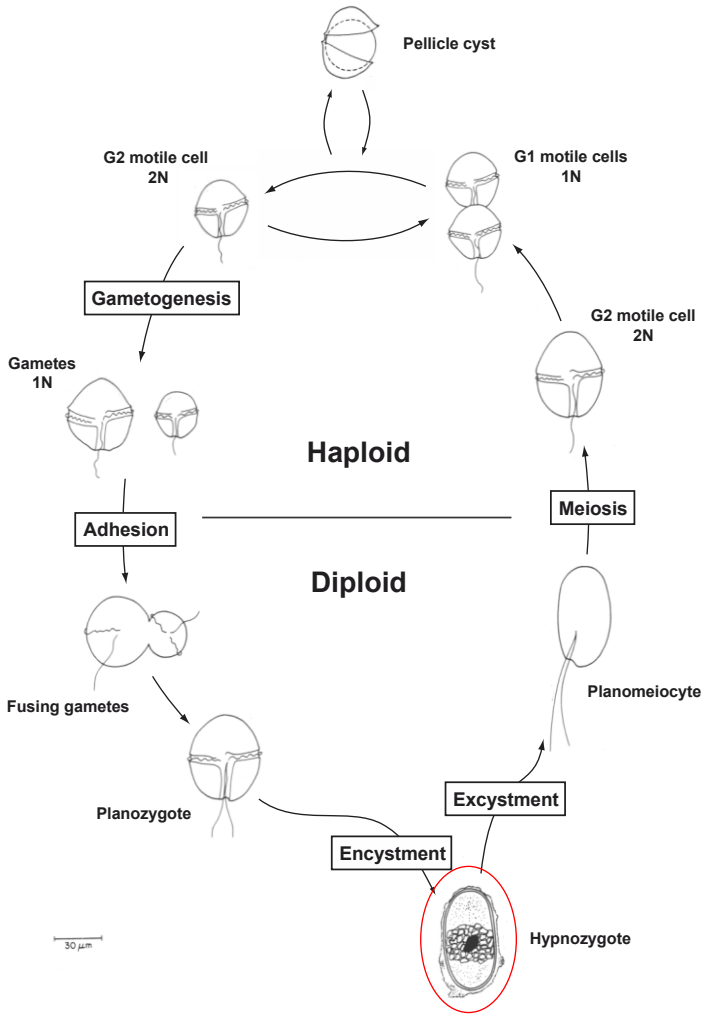
Environmental Sample Processor (ESP)

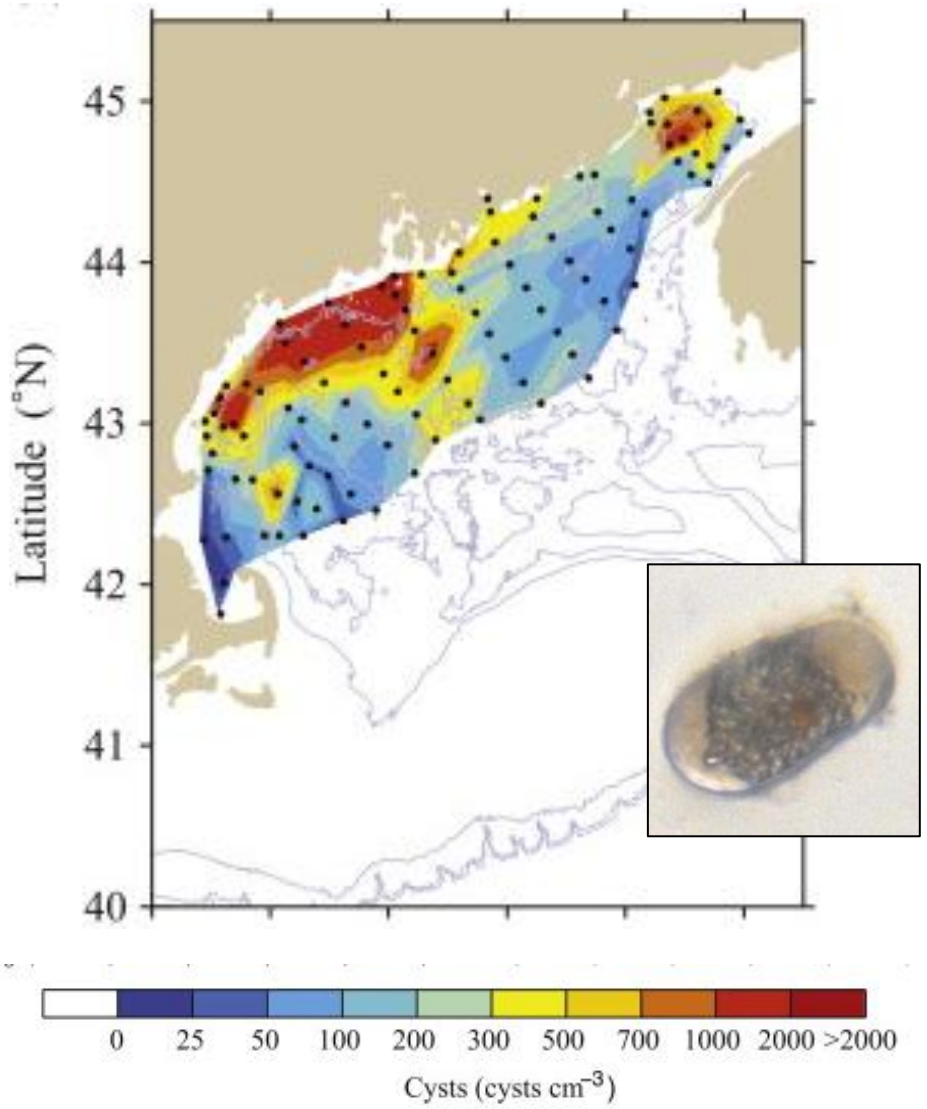
M B A R I

McLANE®
RESEARCH LABORATORIES, INC.

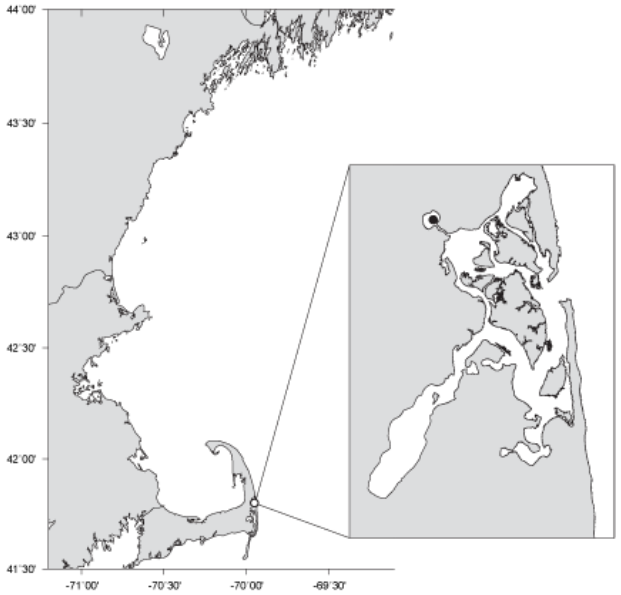
The Imaging FlowCytobot (IFCB) is an automated, submersible microscope

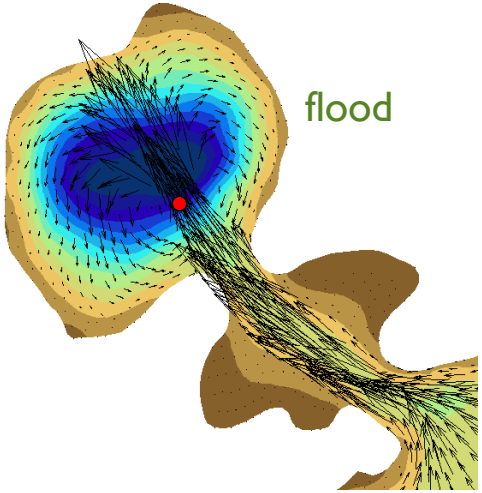
Alexandrium causes PSP, cyst stage drives bloom ecology

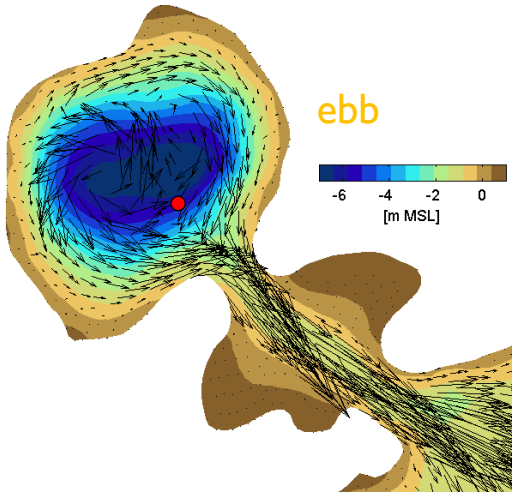


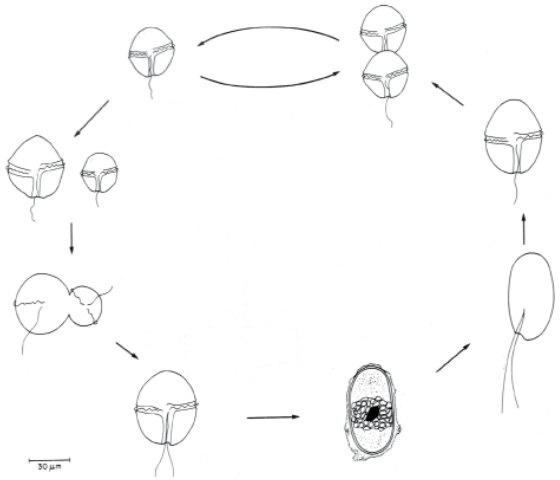


Inshore blooms of *A. catenella* in the Nauset Marsh are localized within small kettle ponds



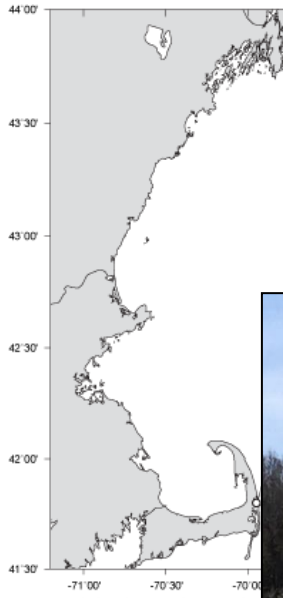


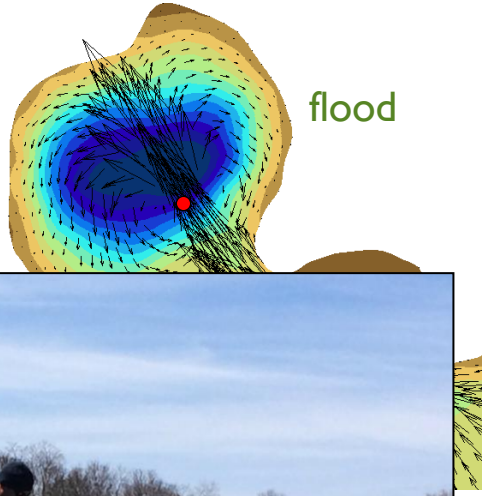


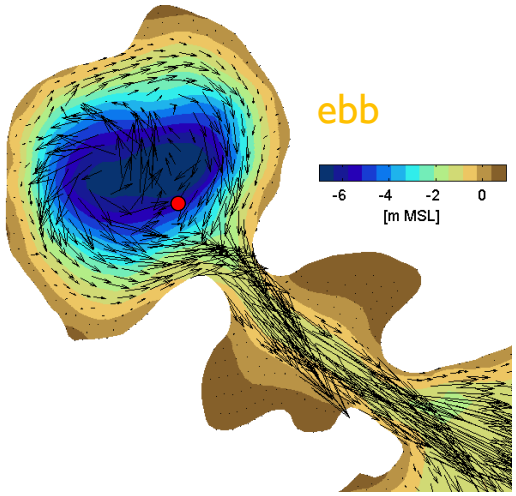


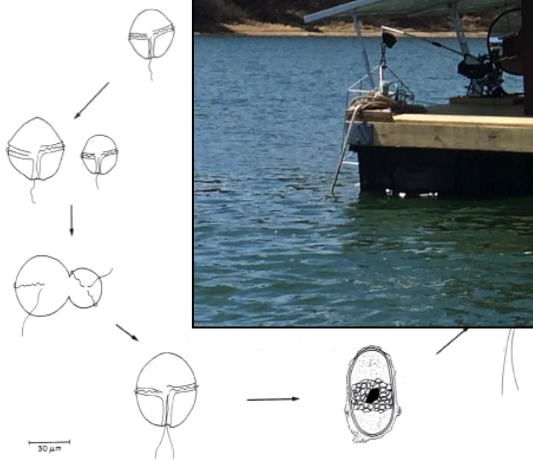
Enables study of a single population through its complete bloom cycle

Inshore blooms of *A. catenella* in the Nauset Marsh are localized within small kettle ponds



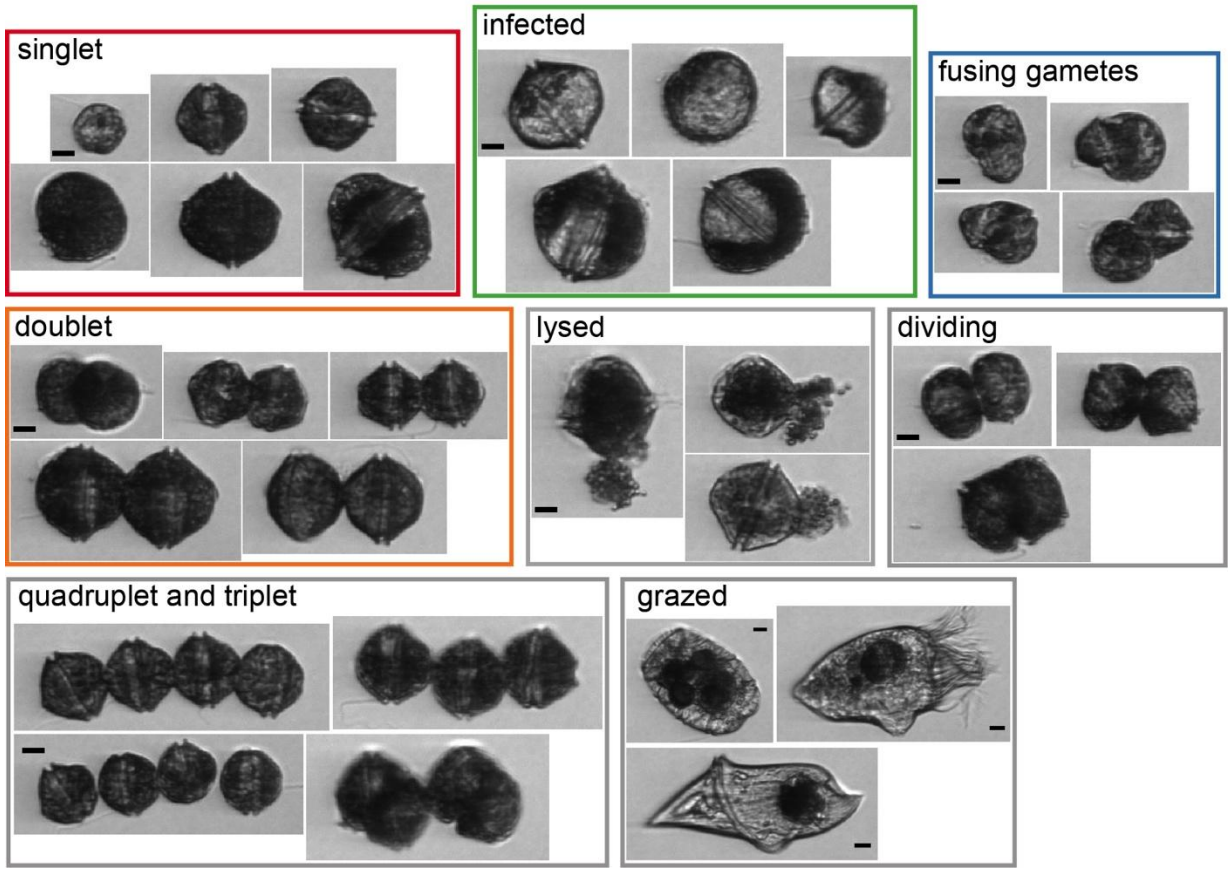




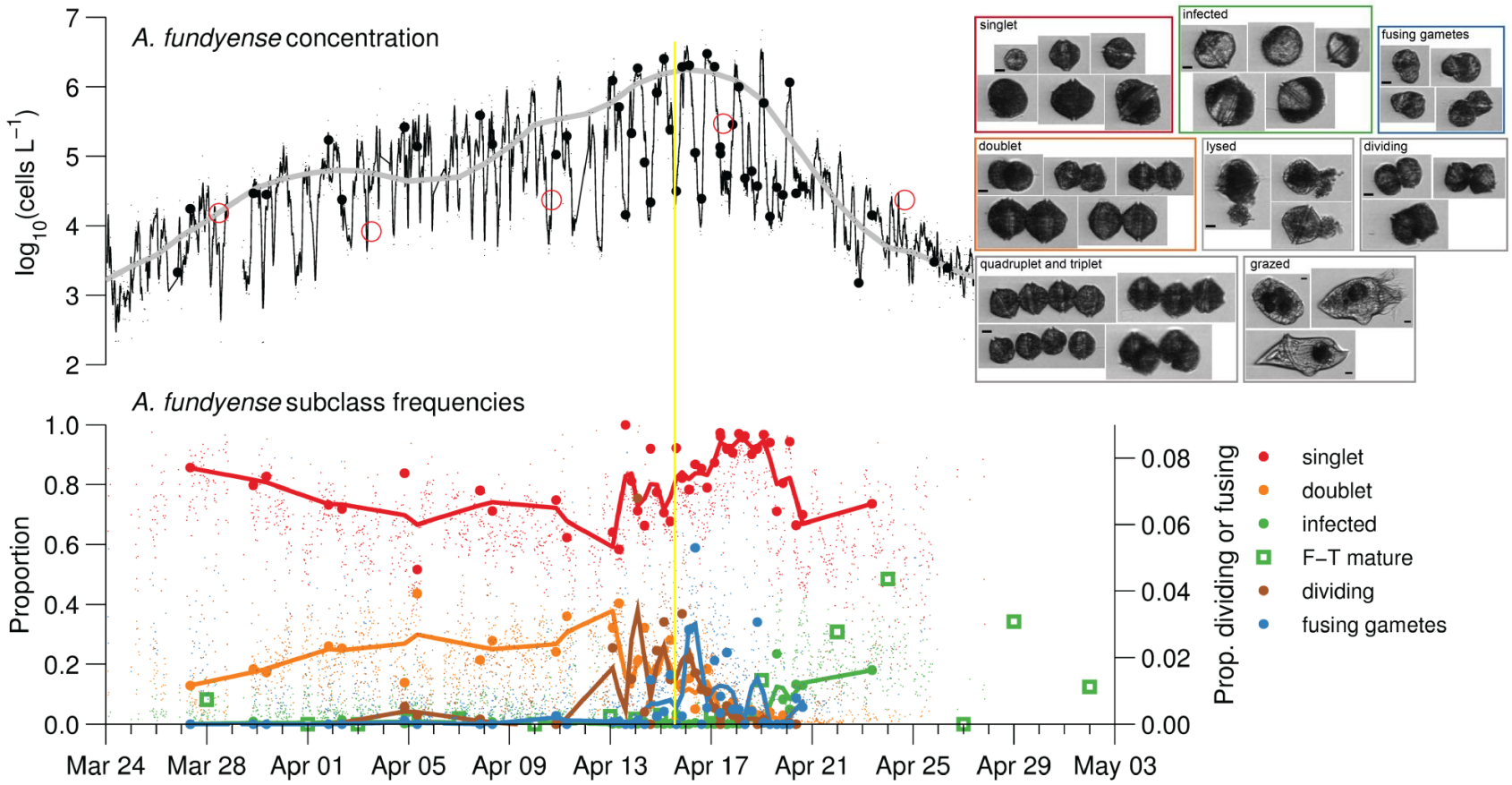


dy of a single
through its
complete bloom cycle

A. catenella cell types recorded by Imaging FlowCytobot (IFCB)



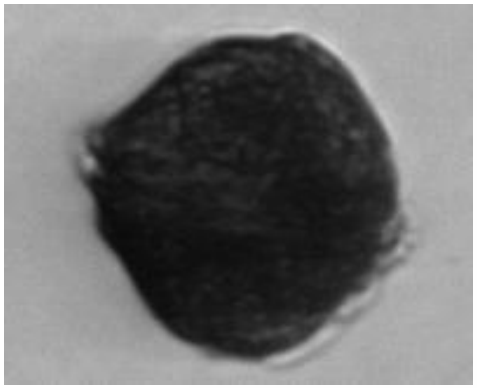
Life cycle stage associated bloom phases

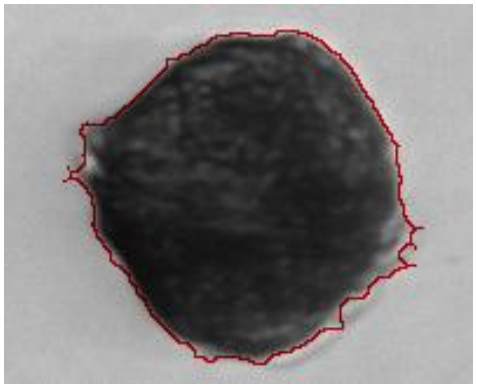


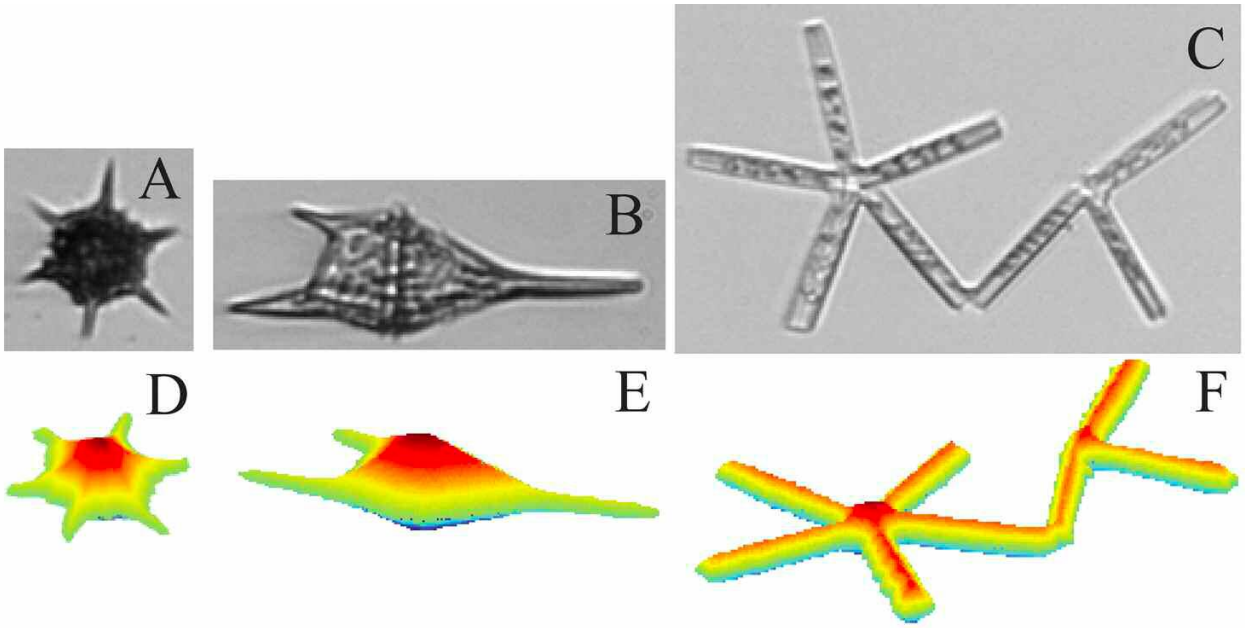
Onset of bloom declines are marked by spikes in the frequency of fusing gametes

Brosnahan et al. L&O 2015

Cell volume estimates from distance maps



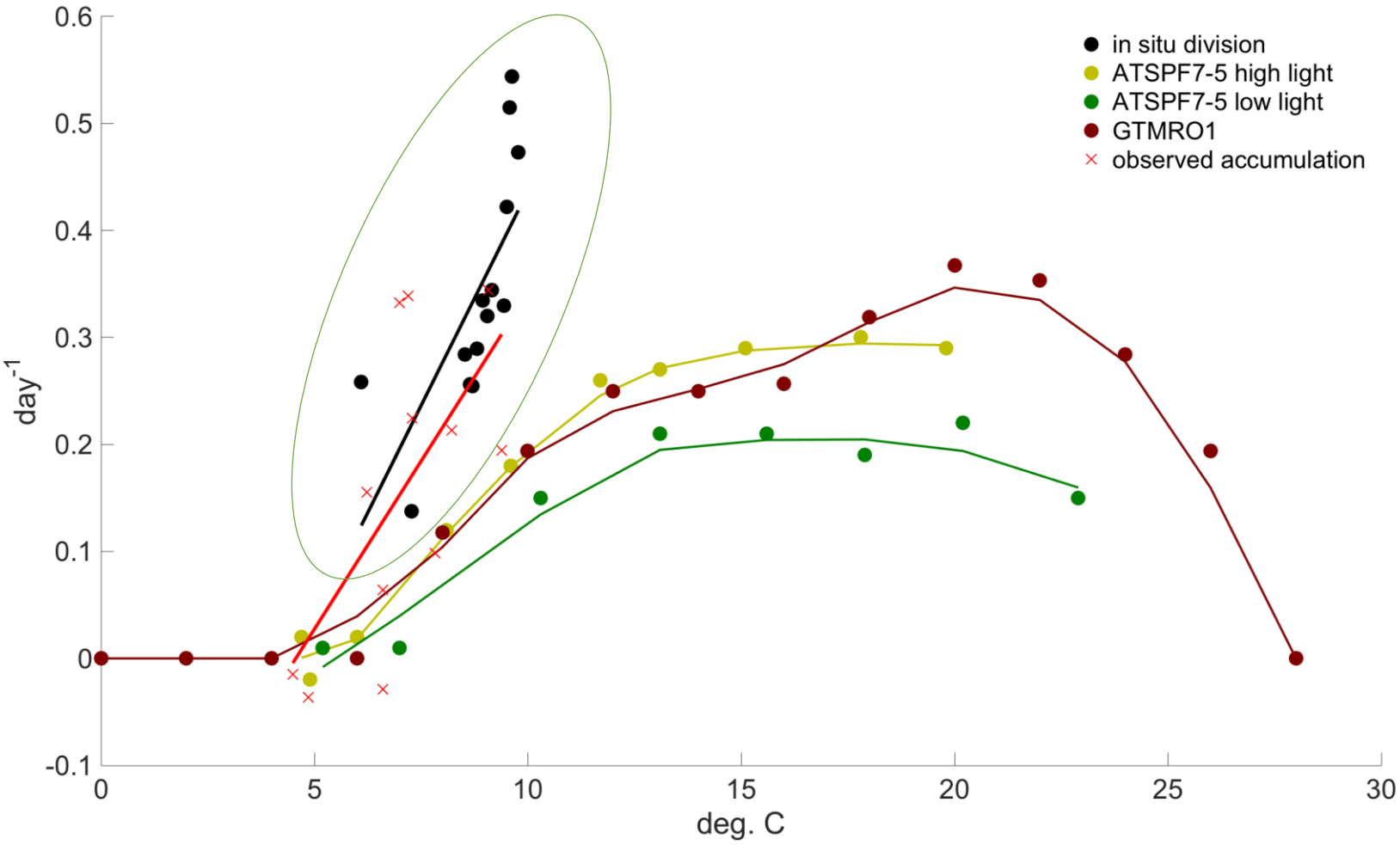




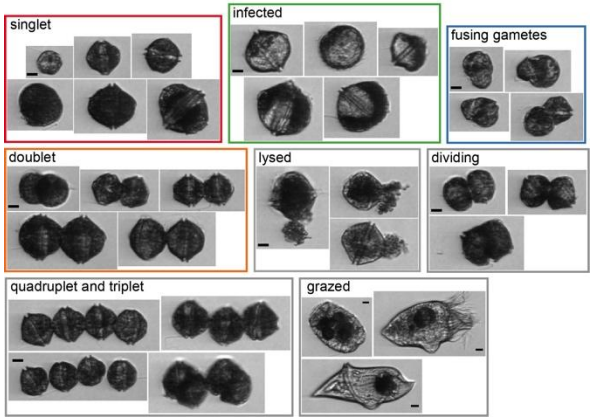
Moberg and Sosik, 2012

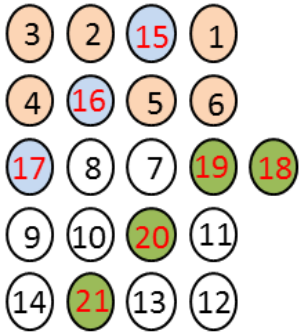
Volume estimation is integrated into the image processing pipeline

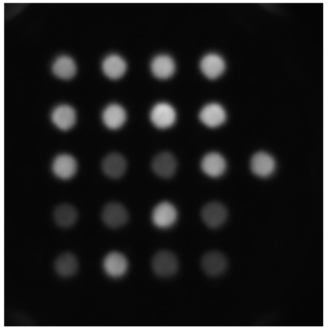
Cells divide much faster in Nauset than in culture

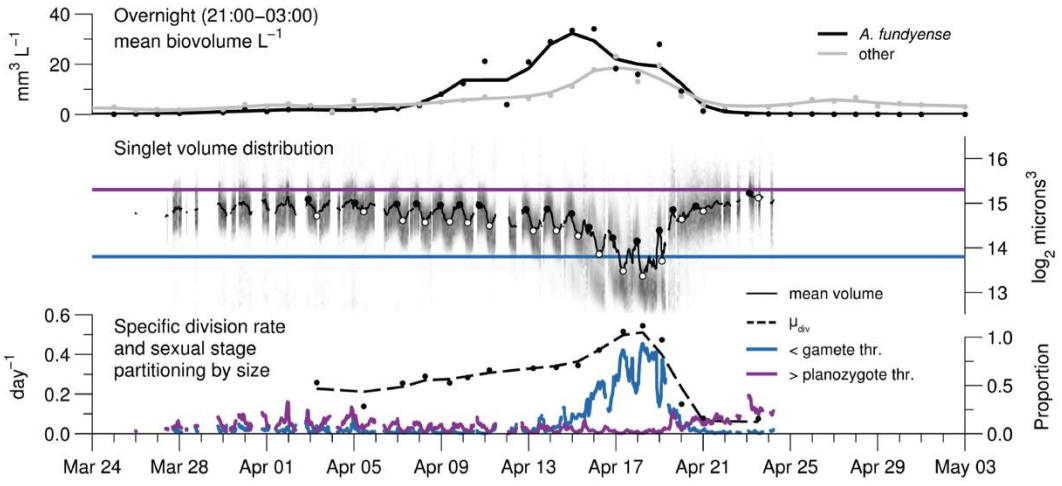


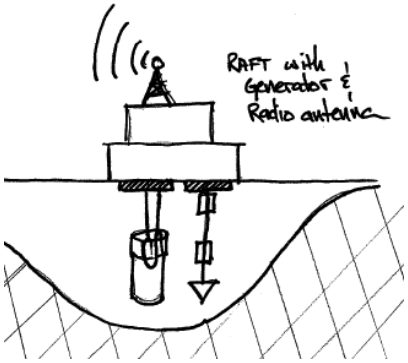
Adaptive ESP sampling based on real-time analysis of IFCB images



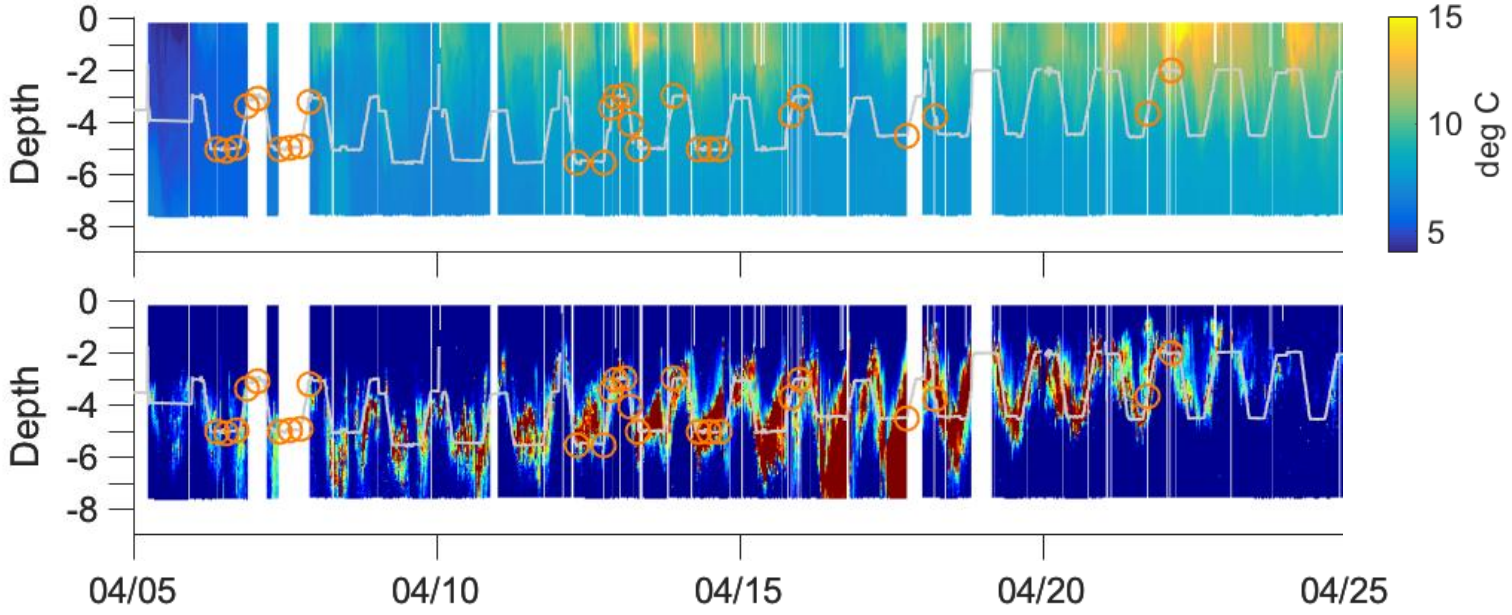




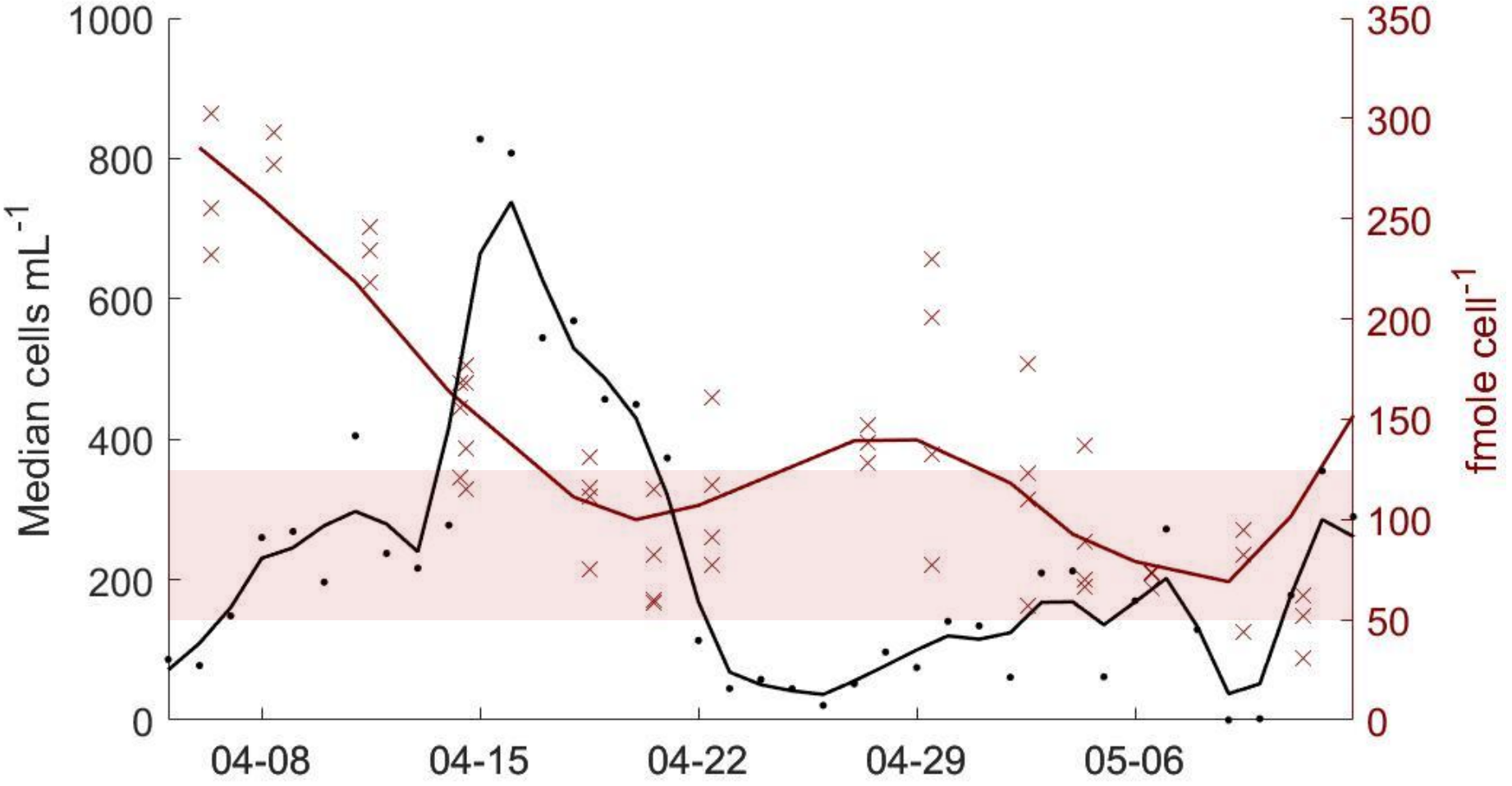




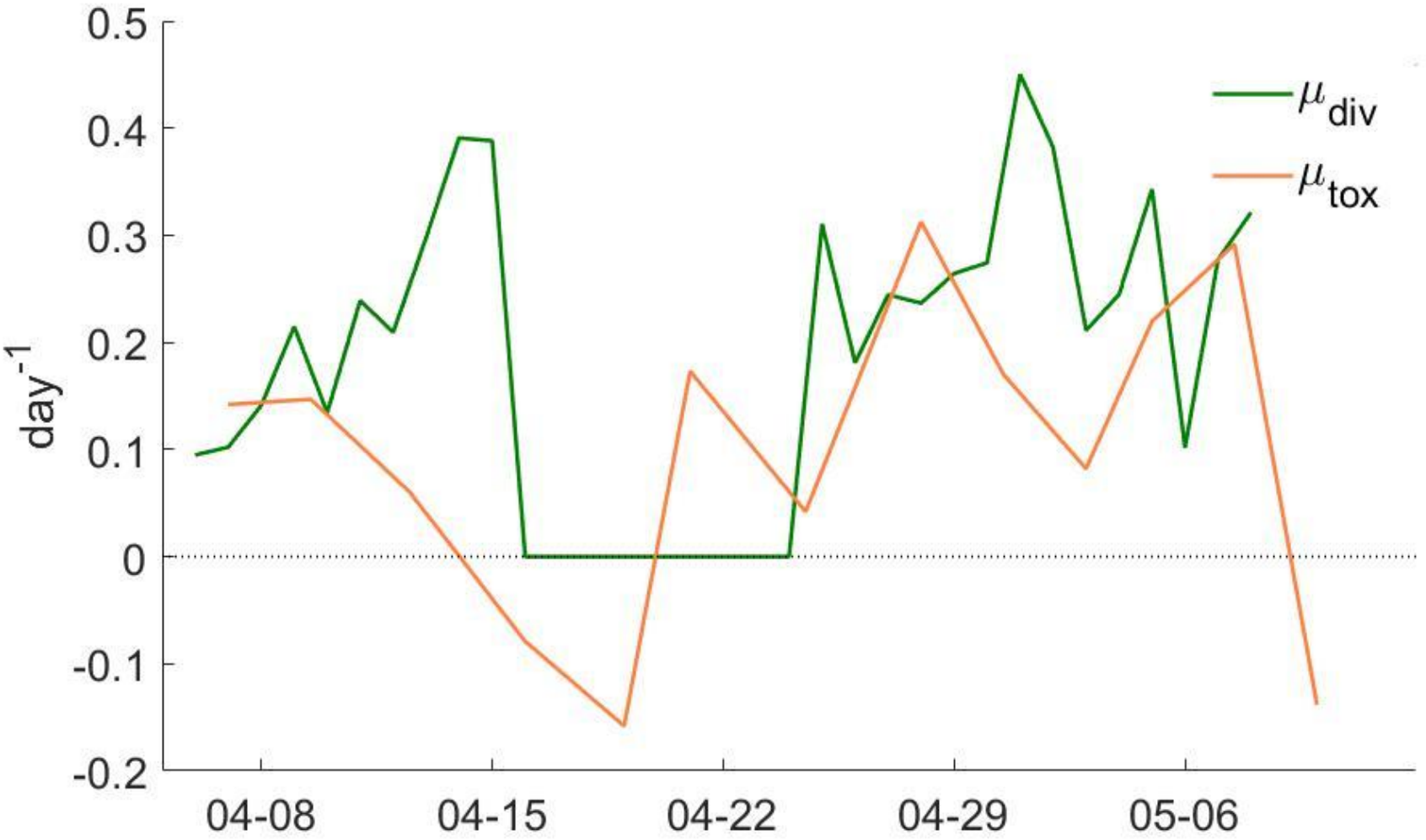
Instrument tracking of vertically migrating populations



LC MS/MS quantitation of cellular toxin quotas (*q*)



Specific growth and toxin production rates from LC-MS/MS data…



Accumulation of cells and toxins within the pond…

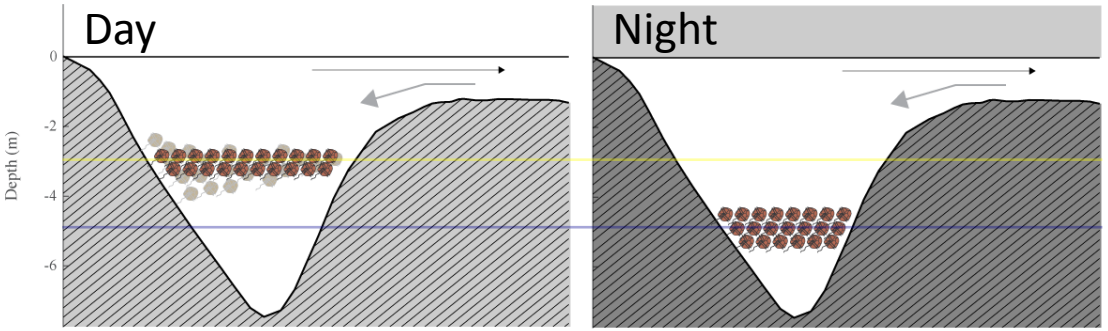
Salt Pond blooms peak consistently at total population sizes of 200-250 trillion cells

This translates to a peak standing stock of 3 m^3 of total *Alexandrium…*

>4 kg saxitoxin equivalents

~lethal dose for 10 million human adults

DEVELOPMENT



Mobile IFCB development

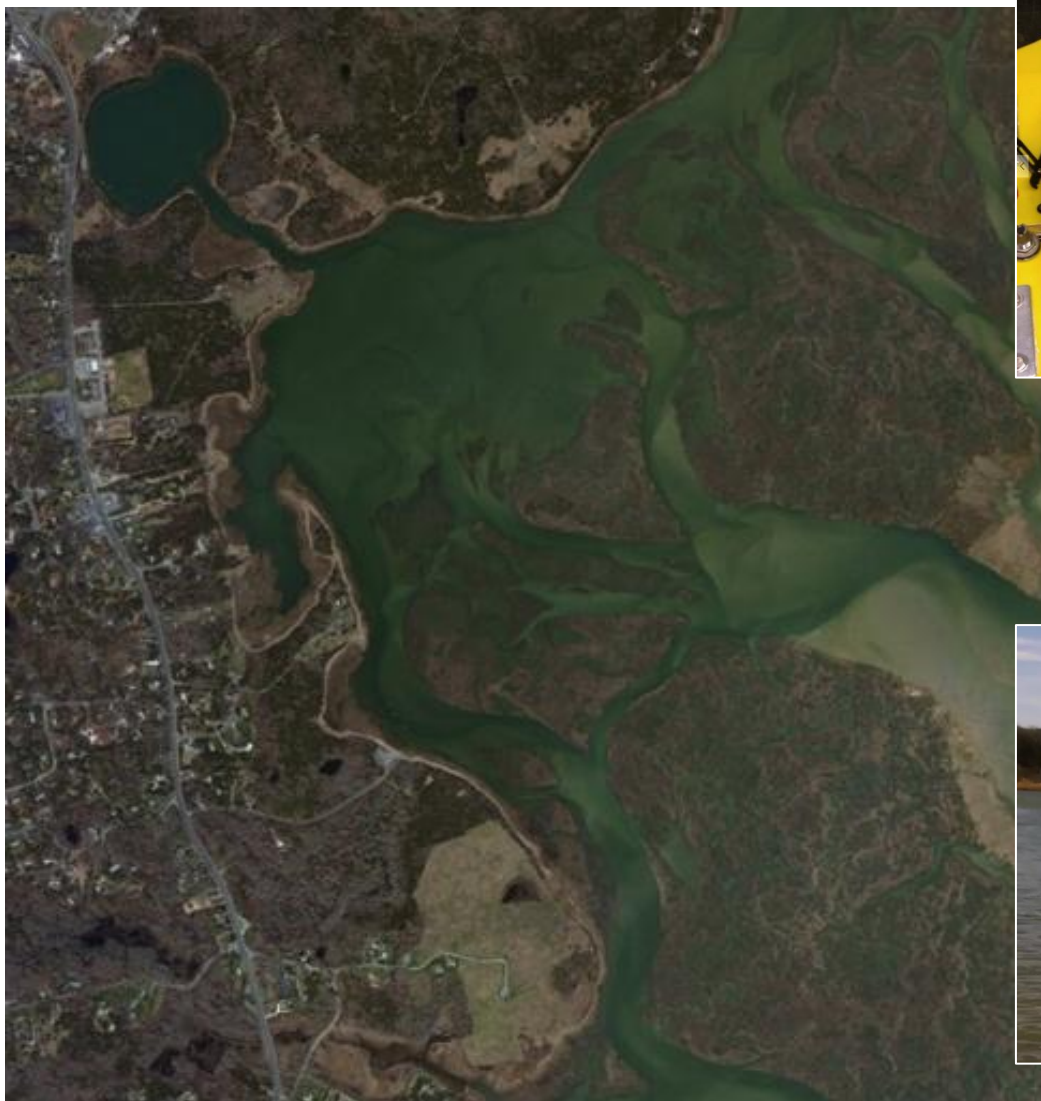
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

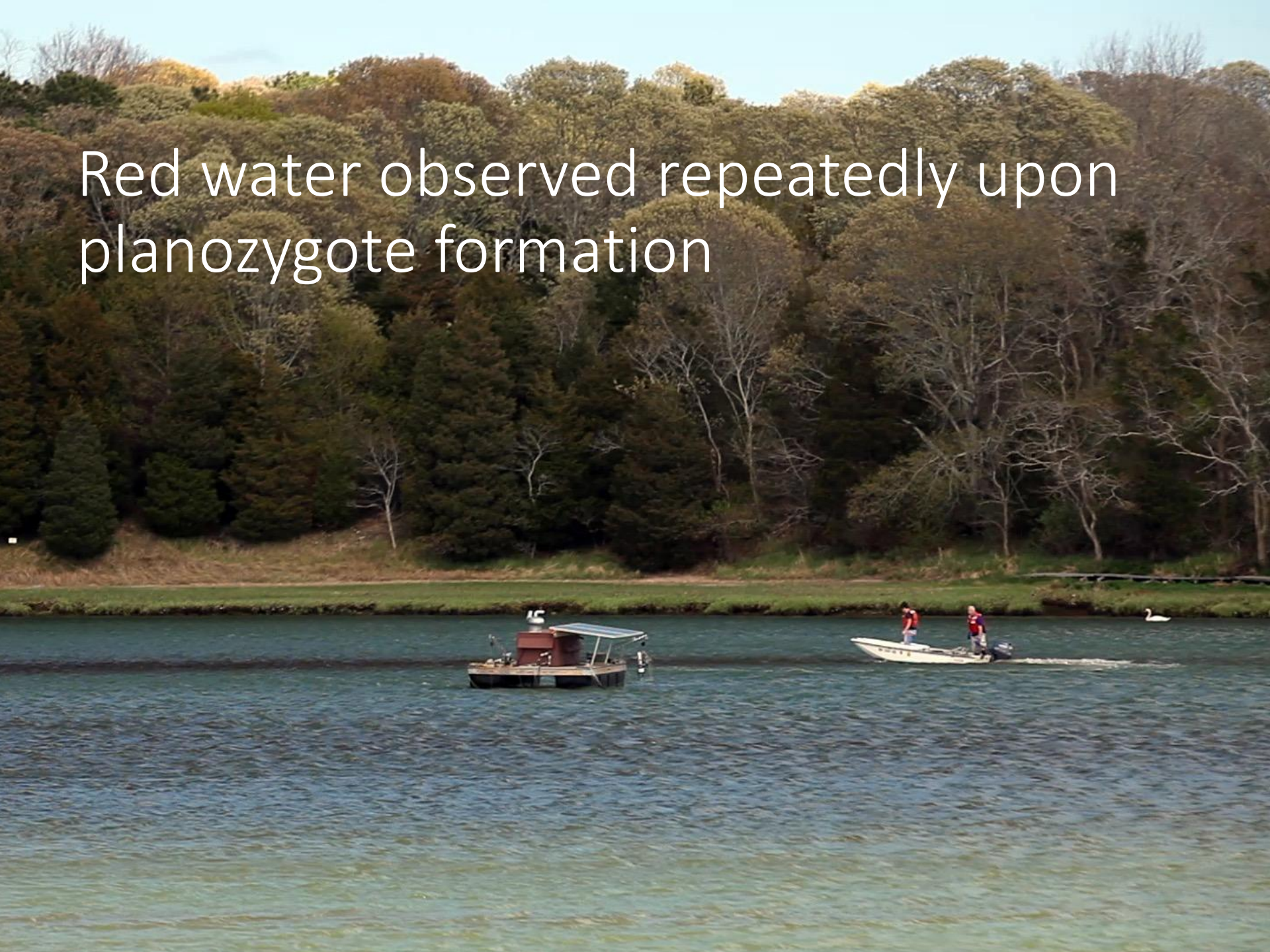
Bowdoin

SeaTrac

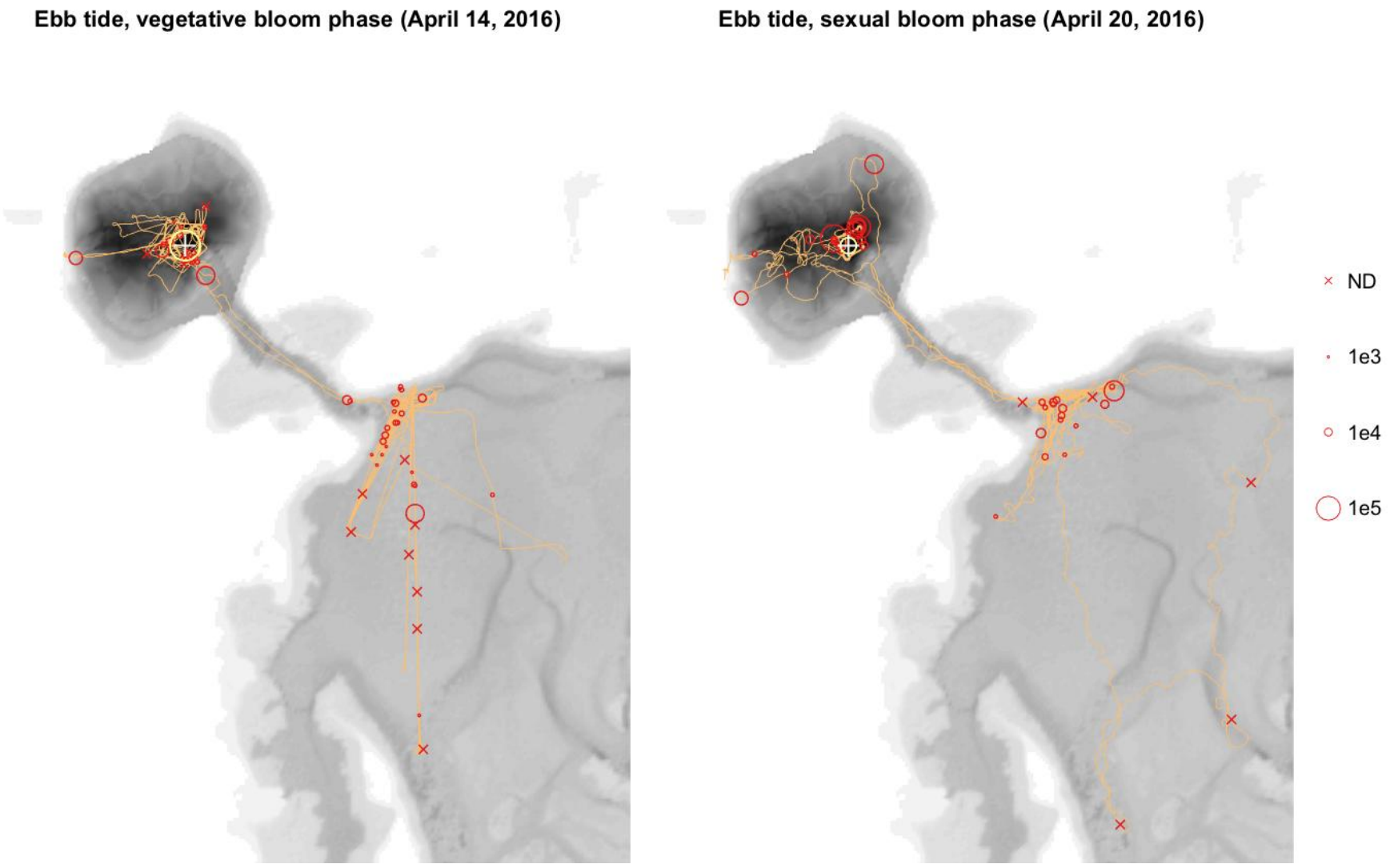
NERACOOS

Jetyak deployments to study planozygote export



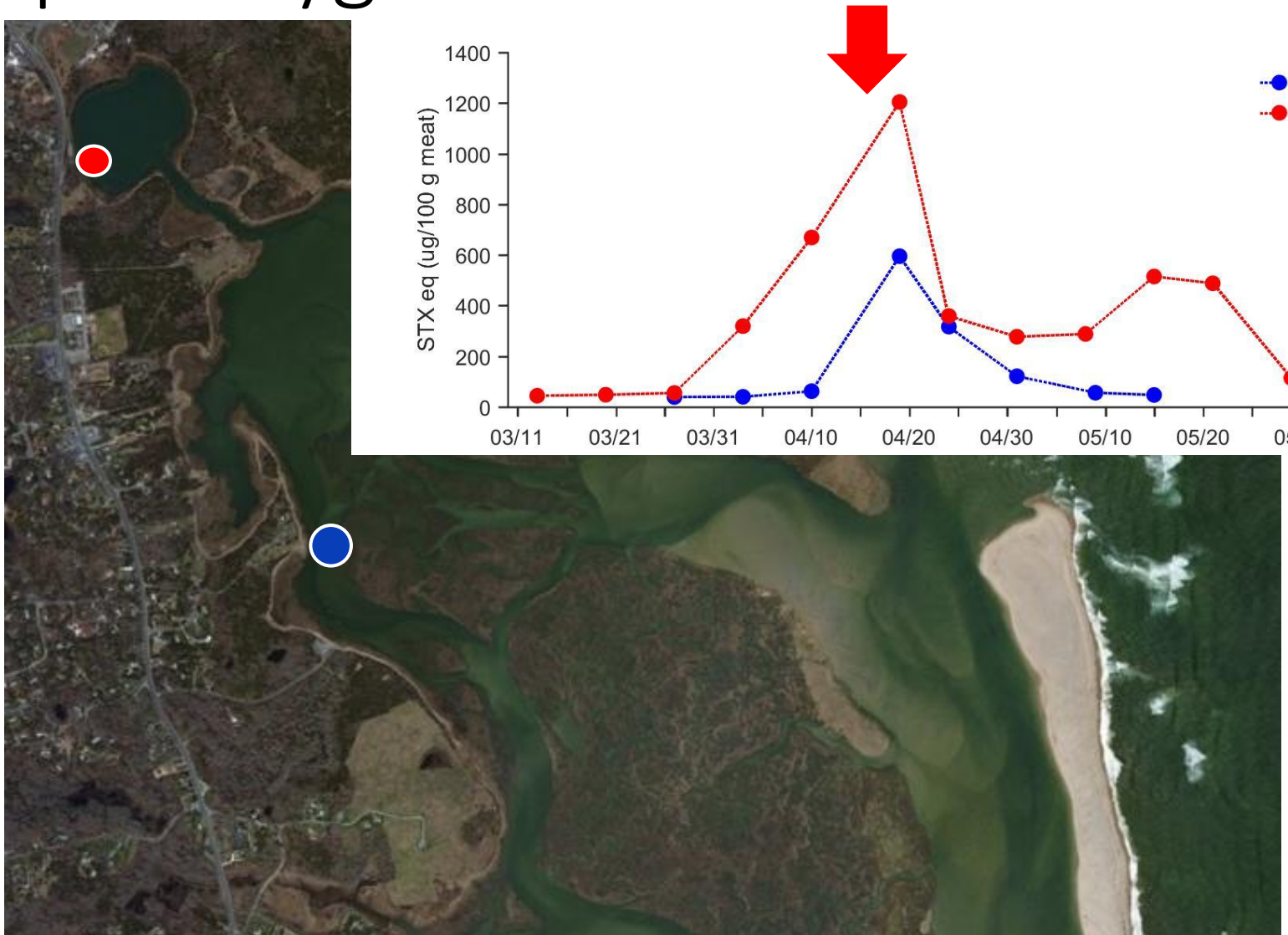

Red water observed repeatedly upon planozygote formation

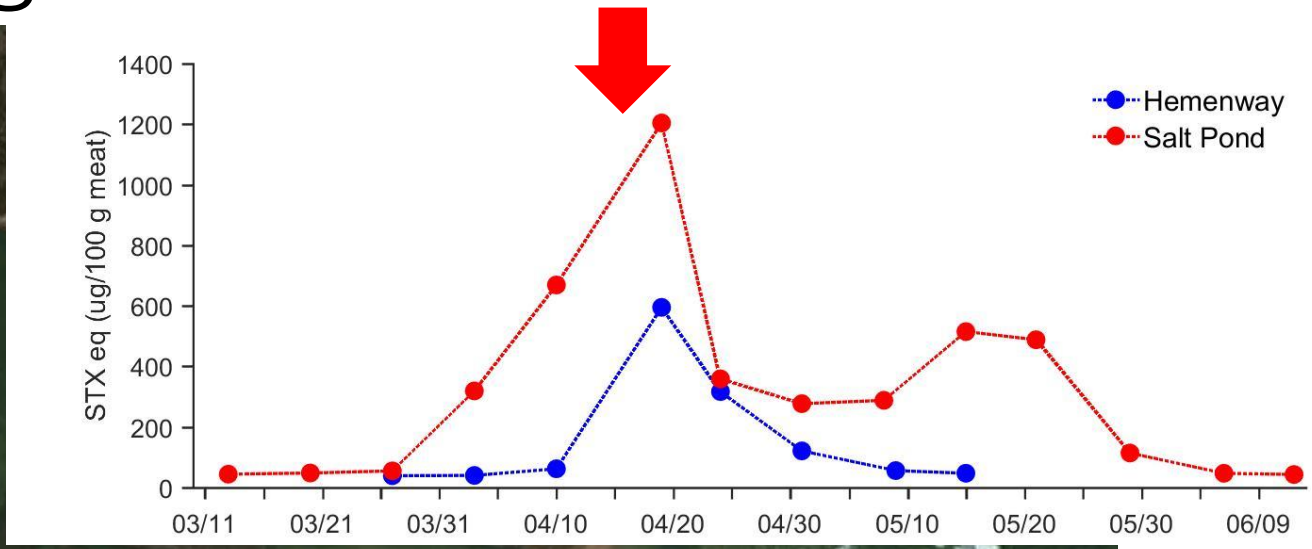
2016 late-development and termination phase surveys



Brosnahan, Sosik et al. in prep

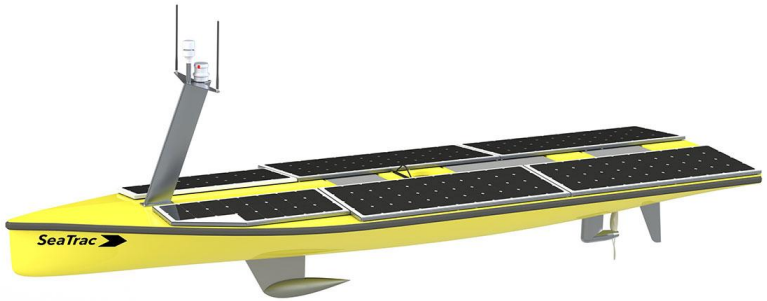
Shellfish toxicity driven by planozygote surface localization

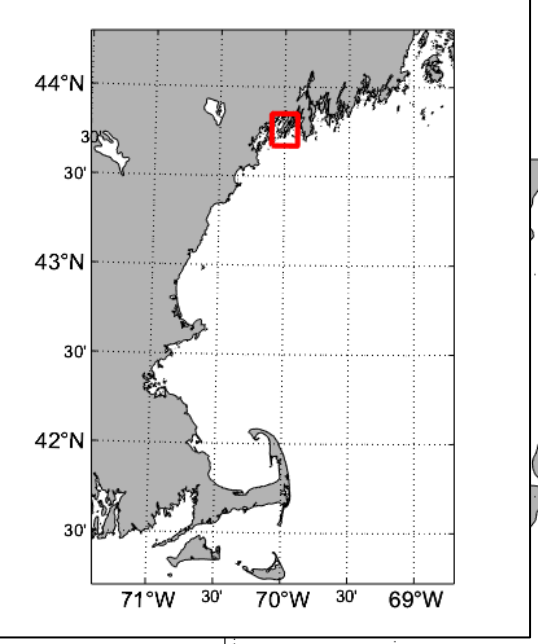


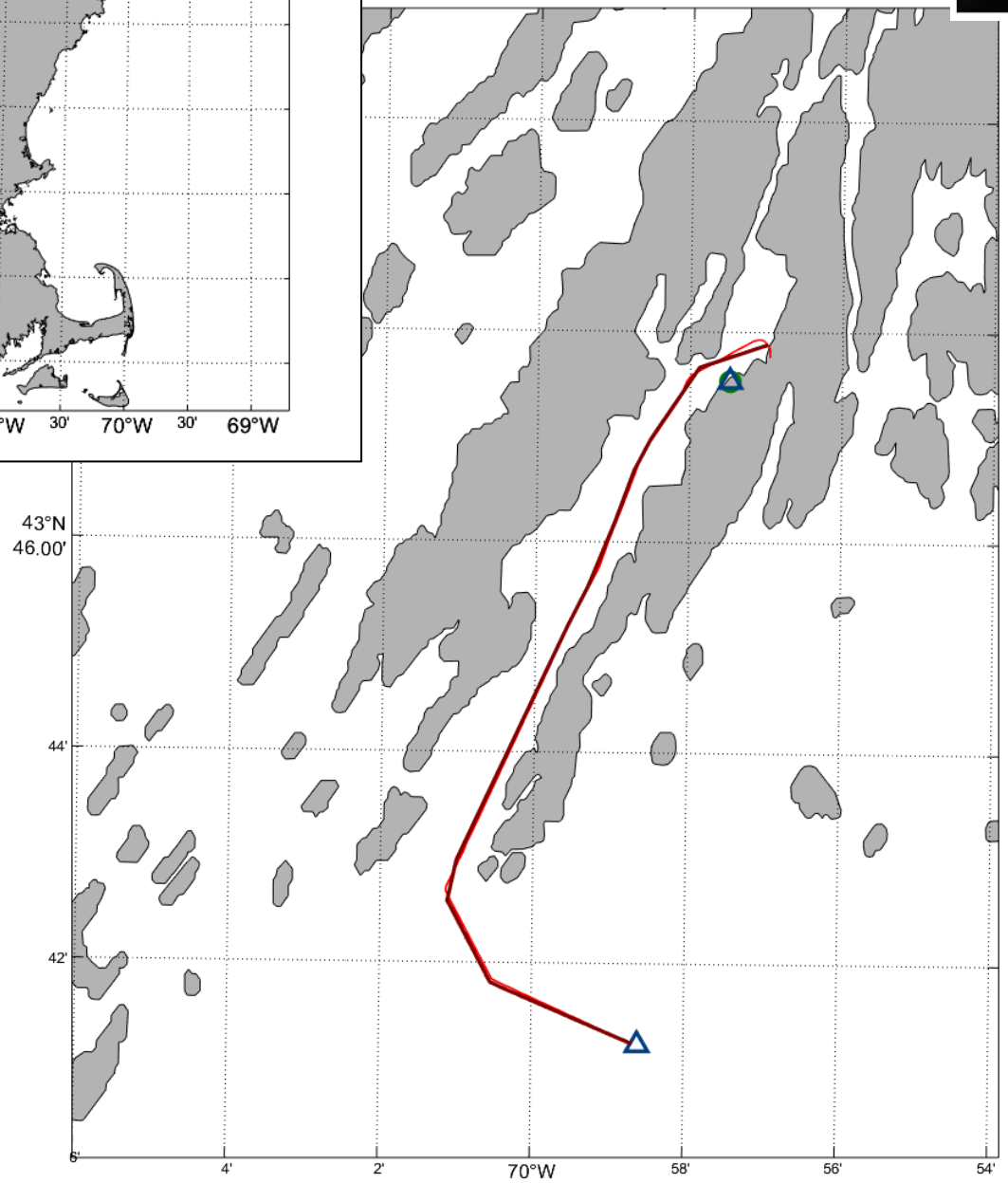


SeaTrac autonomous boat

- Large solar array, high efficiency hull – provides ~50W continuous power for scientific sensors
- Conventional hull design eases sensor integration
- Able to support continuous IFCB observation for months at a time





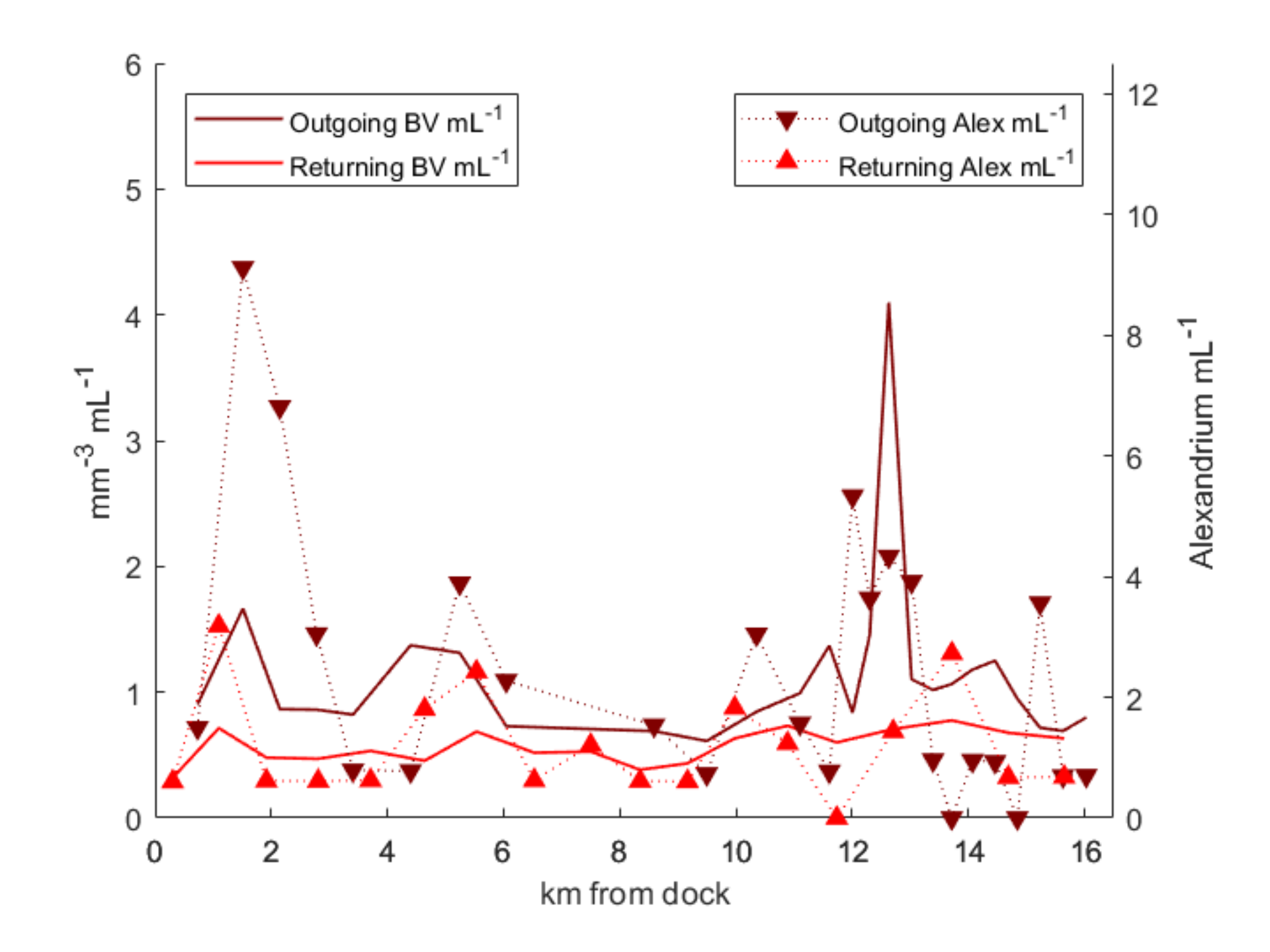


Shore-based IFCB
ESP installations
Return track
Outgoing track

Like Nauset, Harpswell is a PSP hot spot

PSP likely driven by inshore populations of cysts, local hydrodynamic patterns

Lumbos Hole monitoring station, very similar bathymetry to Nauset kettle holes

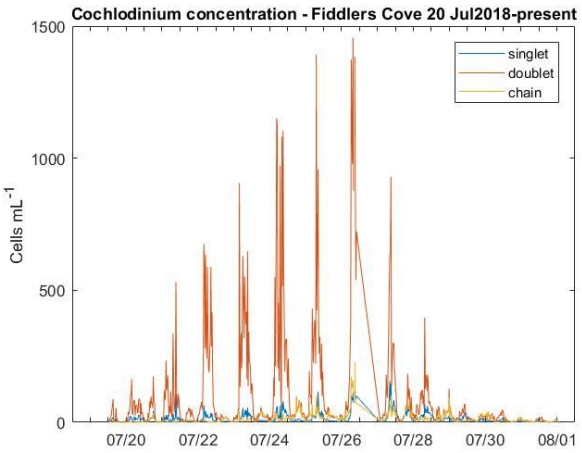

Outgoing BV mL-1
Returning BV mL-1
Outgoing Alex mL-1
Returning Alex mL-1
mm-3 mL-1
Alexandrium mL-1
km from dock
0
1
2
3
4
5
6
0
2
4
6
8
10
12
0
2
4
6
8
10
12
14
16

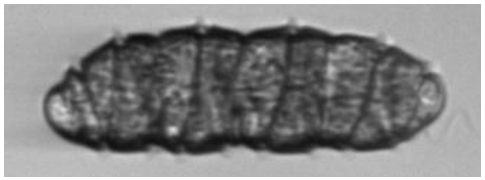
PhytO-ARM: Phytoplankton Observing for Automated and Remote Management

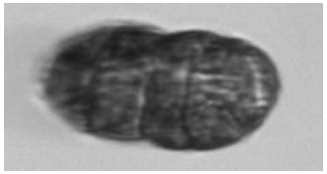
Goal: Open-source improved Nauset observatory design for adoption by aquaculture farms

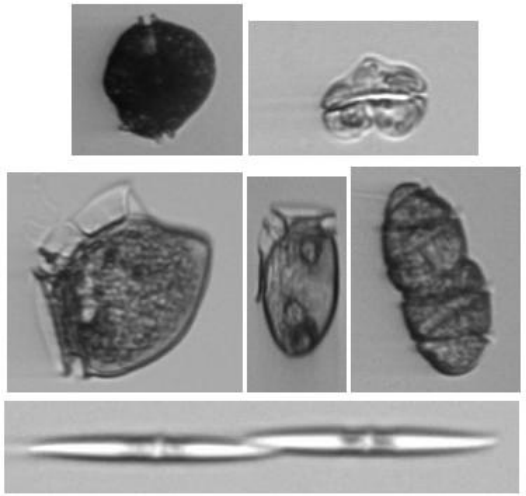
Systems to be installed in Massachusetts, Maine, Rhode Island and Florida

First deployment was a rapid response effort versus *K. brevis* in Florida last year



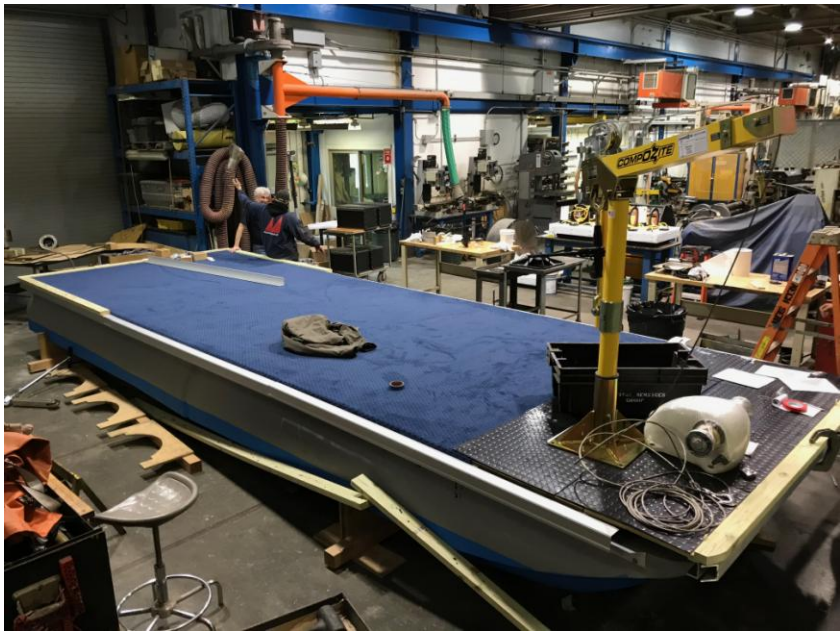






Event response raft

- Pontoon barge platform
- Trailered for rapid deployment/redeployment
- Will support IFCB, ESP and other sensors
- Streamlined mooring deployment/recovery



Summary

In situ sensors provide continuous, real-time information about the status of HABs

New sensor platforms are enabling strategic and adaptive deployments

Better observation of blooms in situ will help us anticipate the response of HAB organisms to environmental change

Acknowledgments

Woods Hole Oceanographic Institution
Don Anderson
Bruce Keafer
David Kulis
Finn Morrison
Natalie Kukshtel
Stephanie Lim
Rob Olson
Heidi Sosik

Virginia Institute of Marine Science
Juliette Smith
Marta Sanderson

NOAA/NOS Marine Biotoxins
Greg Doucette
Tina Mikulski

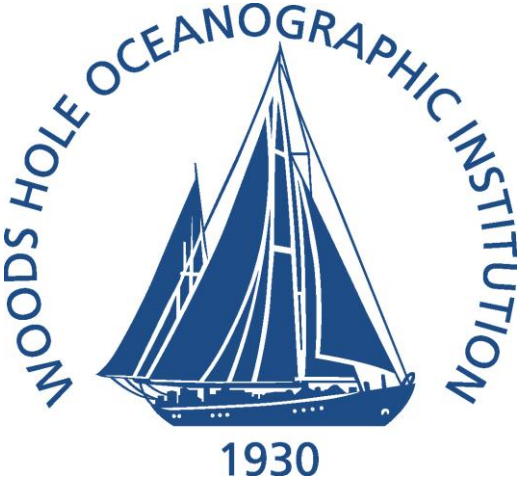
Monterey Bay Aquarium Research Institute
Chris Scholin
Brent Roman
Roman Marin
Christina Preston

McLane Research Labs
Yuki Honjo
Ivory Engstrom
Tom Fougere

Ward Aquafarms
Dan Ward

Bowdoin College
Collin Roesler
Sue Drapeau

NERACOOS
Ru Morrison
Jackie Motyka



Sea Grant

MIT Sea Grant college program

NSF

NIH
National Institutes of Health

Woods Hole Center for OCEANS & HUMAN HEALTH