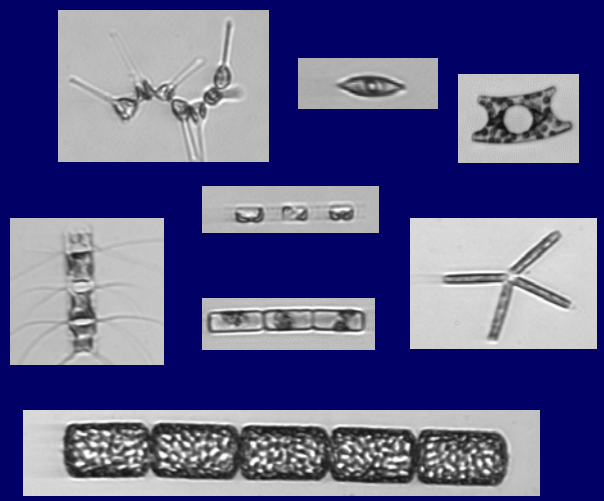
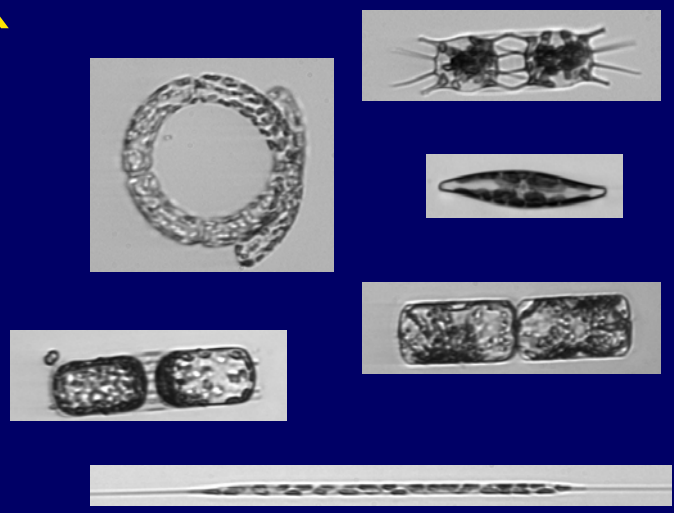
Plankton traits from flow cytometry and imaging-in-flow cytometry

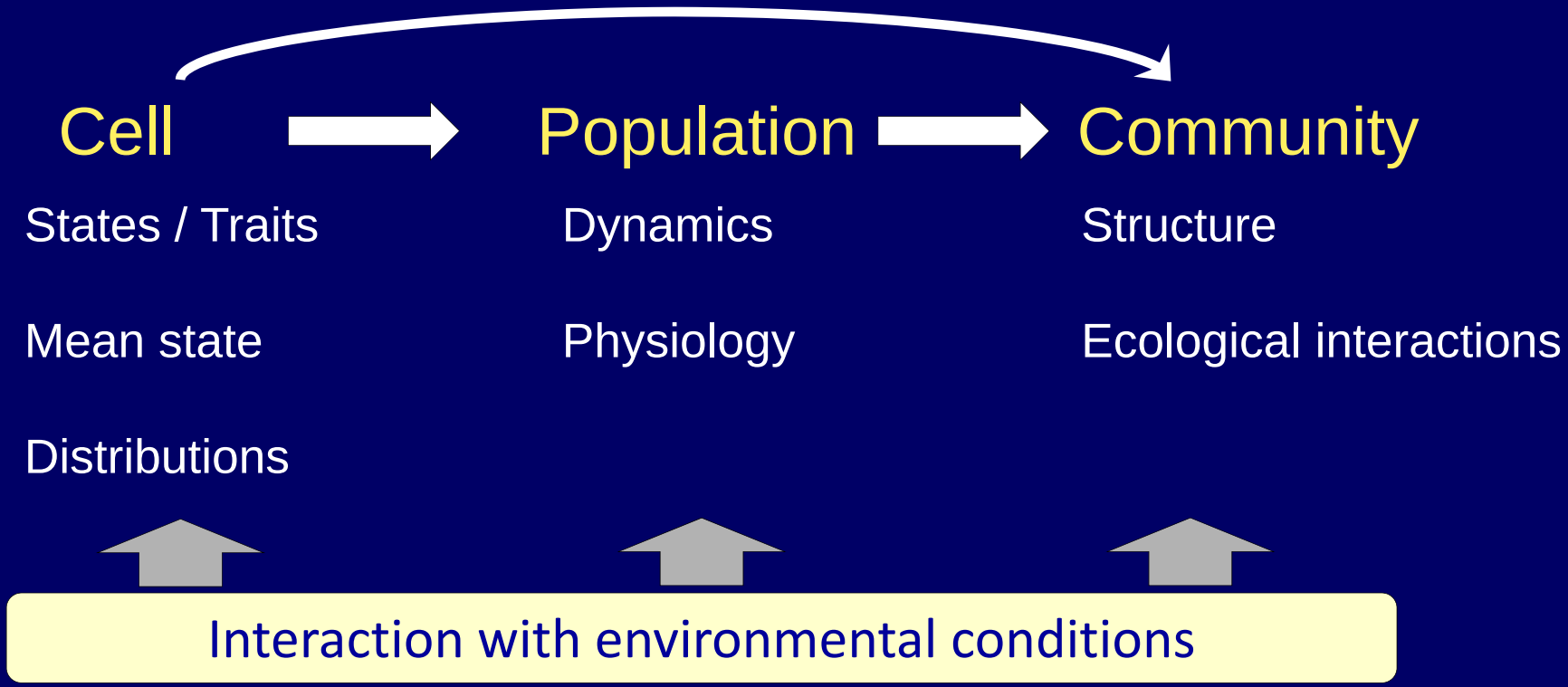
Heidi M. Sosik





Flow Cytometry provides multi-faceted trait information

→ Rapid assessment of many individuals in natural samples

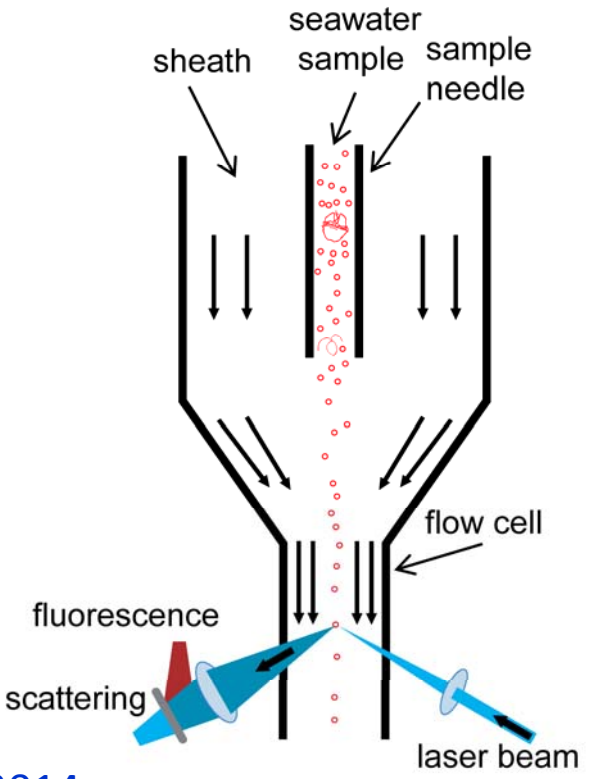


Accessible time scales: Hours to Decades

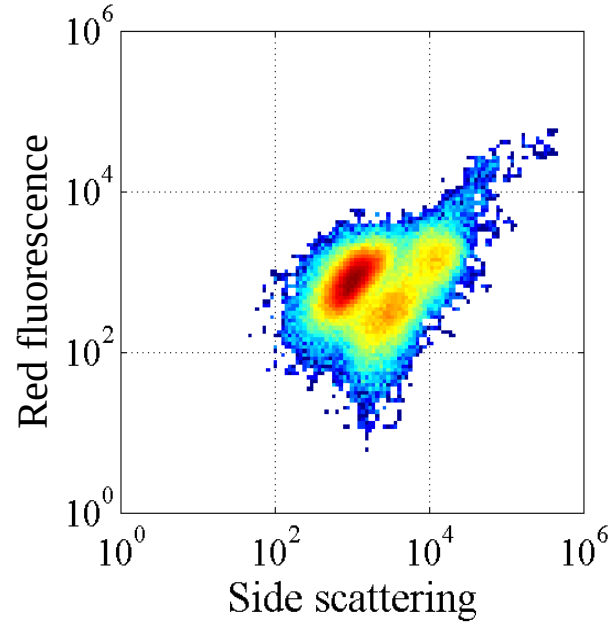
Flow Cytometry

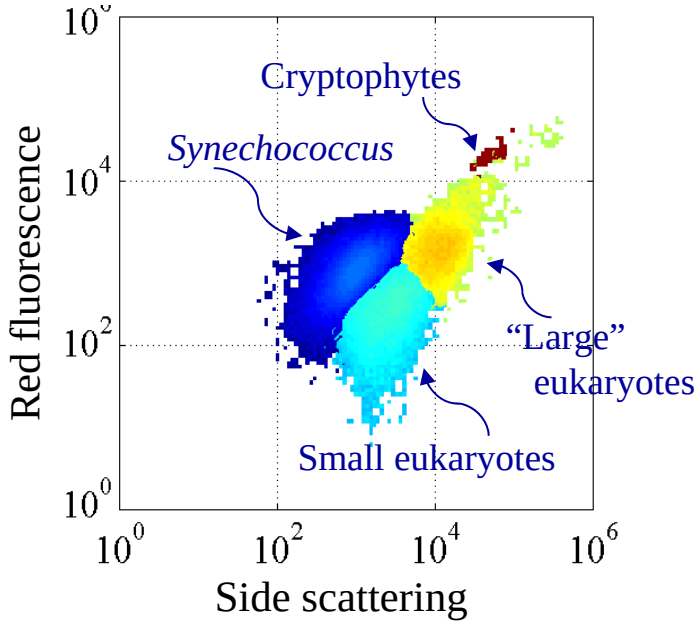
Conventional

Pico-
&
Nano-
plankton



Sosik et al. 2014





Single cell, typical measurements :

- Chlorophyll fluorescence
- Light scattering (forward, side angle)
- Phycoerythrin fluorescence

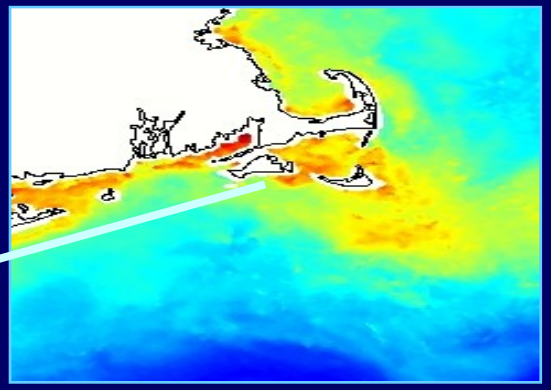
Phytoplankton Time Series at MVCO

Martha's Vineyard Coastal Observatory (MVCO)

Cabled site with power and two-way communications

Picoplankton

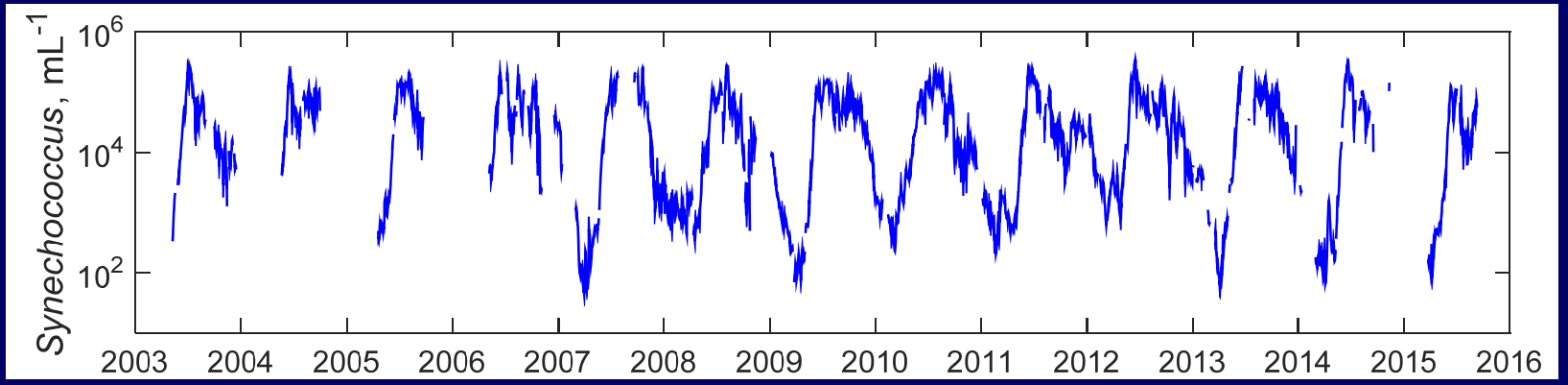
FlowCytobot



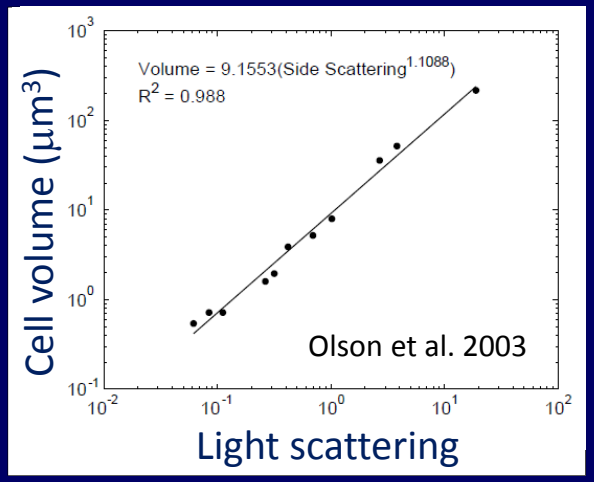
Automated features for extended deployment

Standard analysis, biofouling control, real time humidity sensing & intake valve control

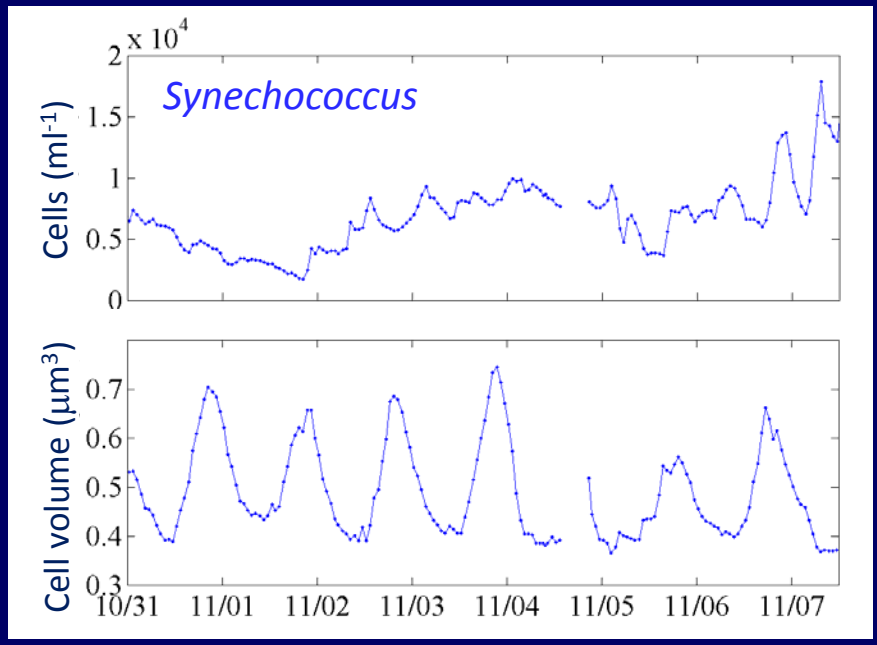
Physiological regulation of seasonal population dynamics



FlowCytobot

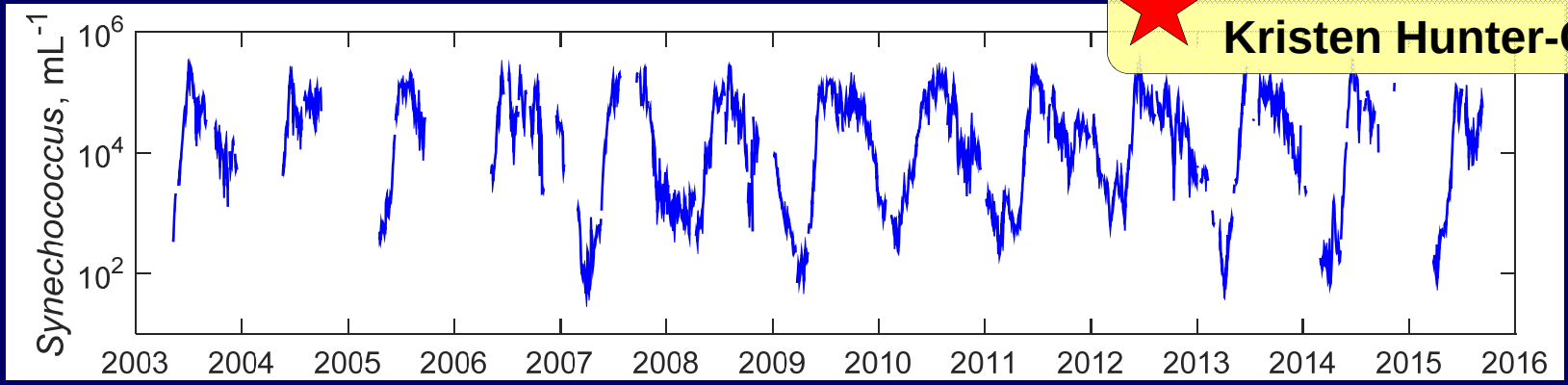


Cell volume from laser scattering



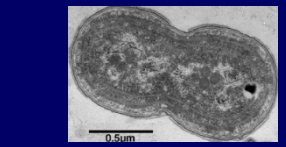
Physiological regulation of seasonal population dynamics

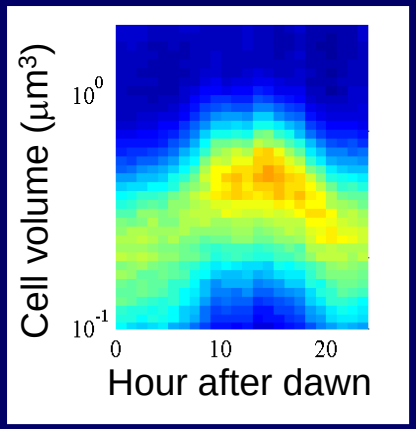
-- See POSTER --
Kristen Hunter-Cevera

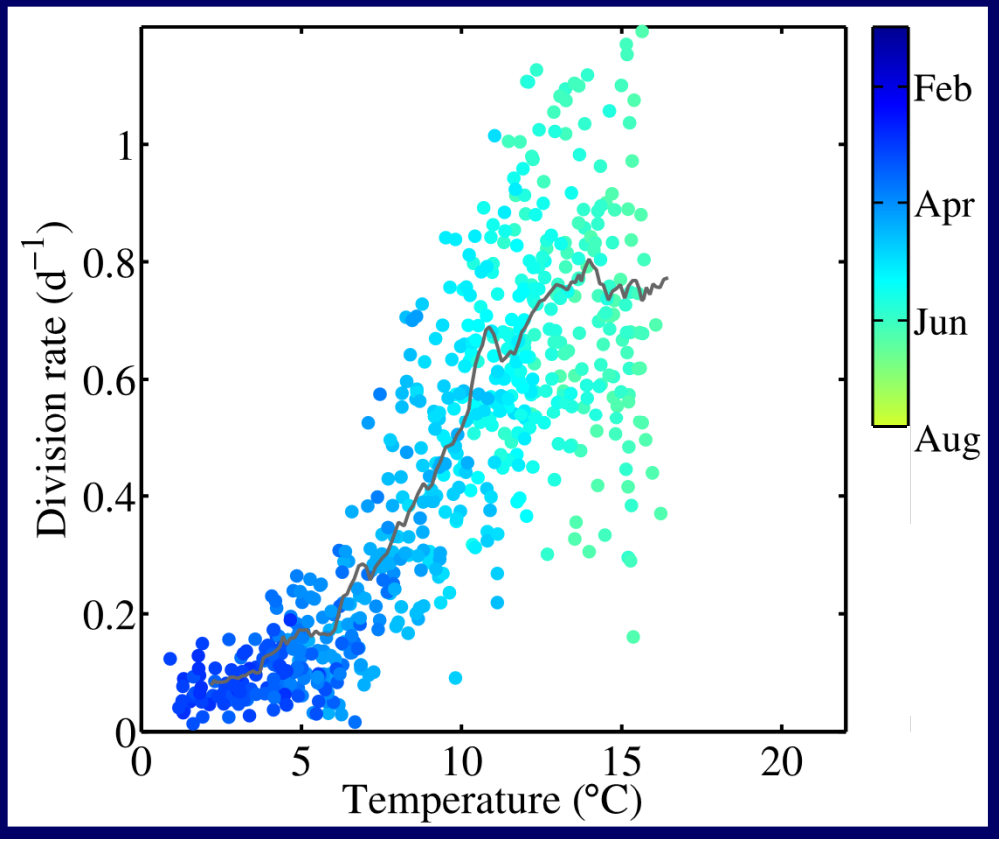


Diel changes in cell size distribution from FlowCytobot time series

size-structured matrix population model

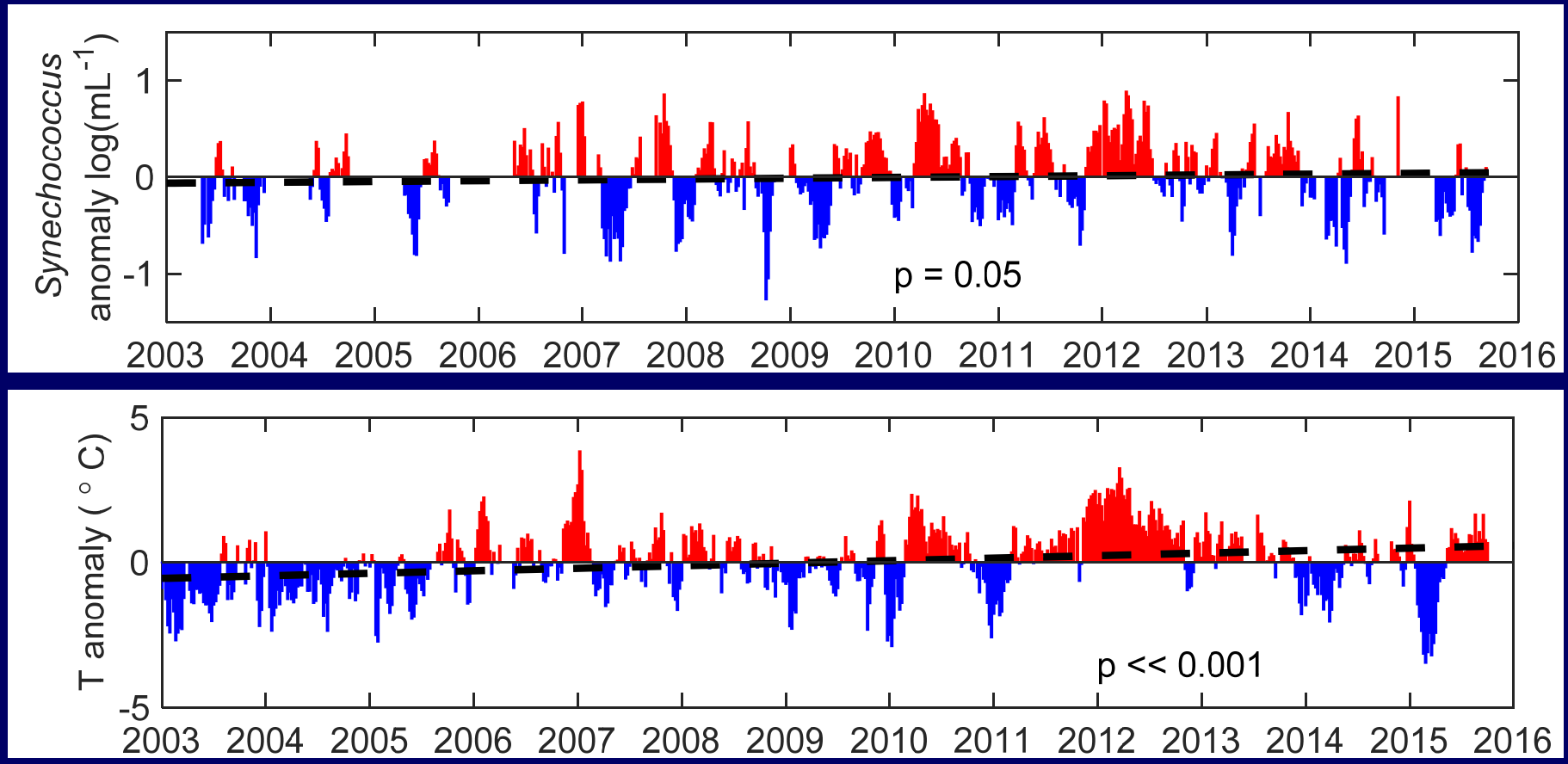






Hunter-Cevera et al. 2014

Multi-year trends in populations

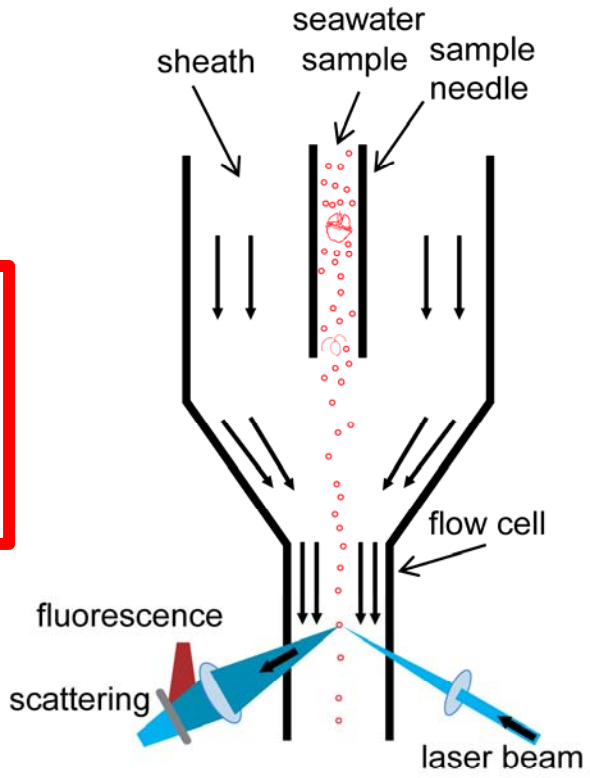


How do interactions between physiological traits and environment conditions propagate to multi-year trends?

What about larger cells?

Flow Cytometry

Conventional



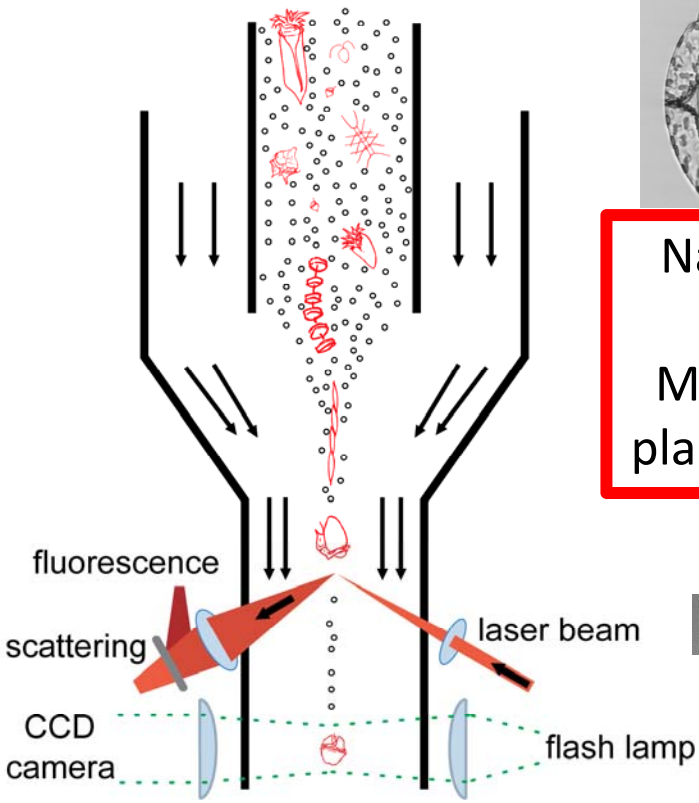
Sosik et al. 2014

Pico- & Nano-plankton

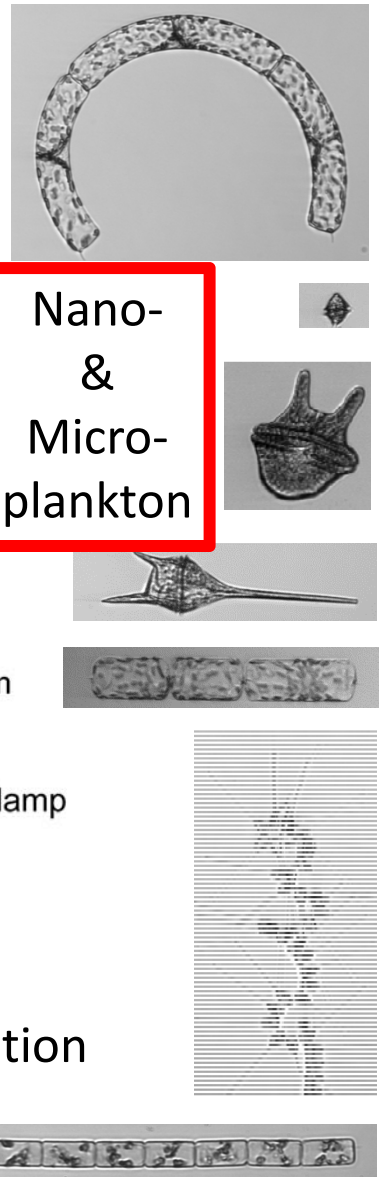
Single cell, typical measurements :

- Chlorophyll fluorescence
- Light scattering (forward, side angle)
- Phycoerythrin fluorescence

Imaging-in-Flow



Nano- & Micro-plankton



Same as conventional

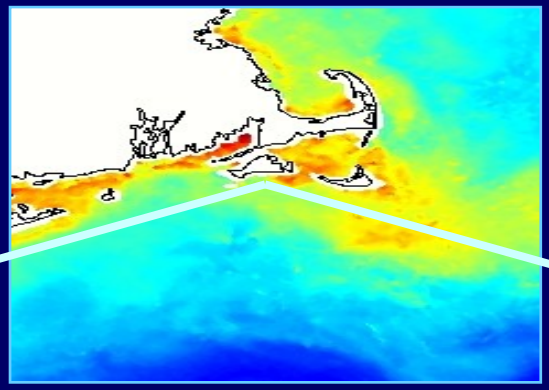
Plus images

~ 1 μm resolution

Phytoplankton Time Series at MVCO

Martha's Vineyard Coastal Observatory (MVCO)

Cabled site with power and two-way communications



Picoplankton

FlowCytobot

Automated features for extended deployment

Standard analysis, biofouling control, real time humidity sensing & intake valve control

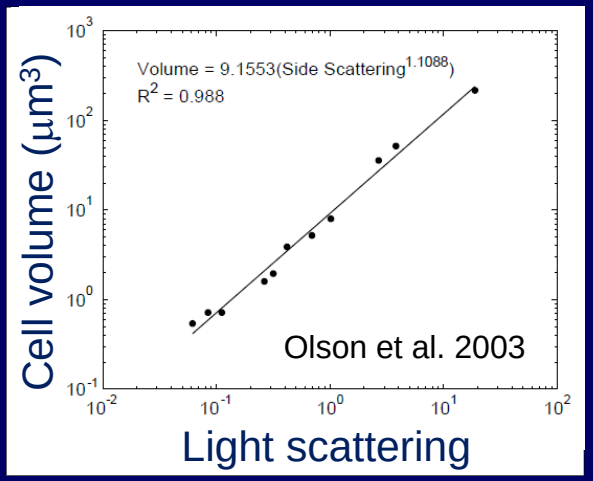
Microplankton

Imaging FlowCytobot

Size and biomass distributions

Pico/nanoplankton

FlowCytobot



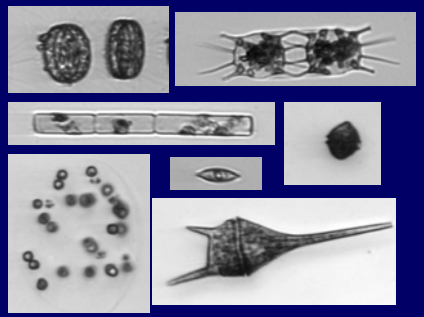
Volume from laser scattering

$$\text{Carbon} = \sum_i C_i$$

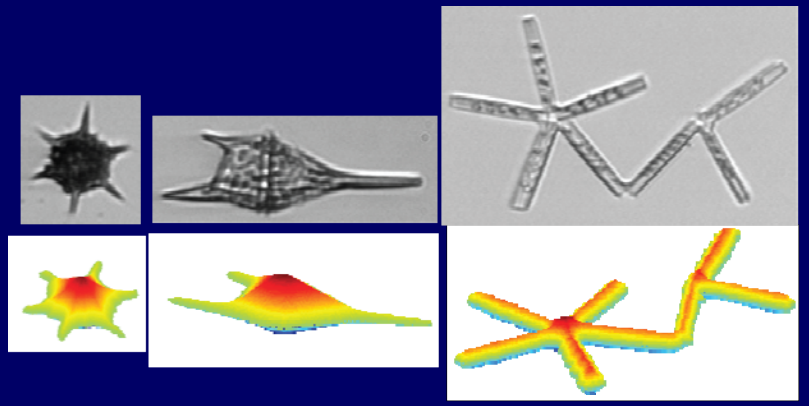
$$C_i = f(V_i)$$

e.g., Menden-Deuer and Lessard 2000

Nano/microplankton



Imaging FlowCytobot
Olson and Sosik 2007

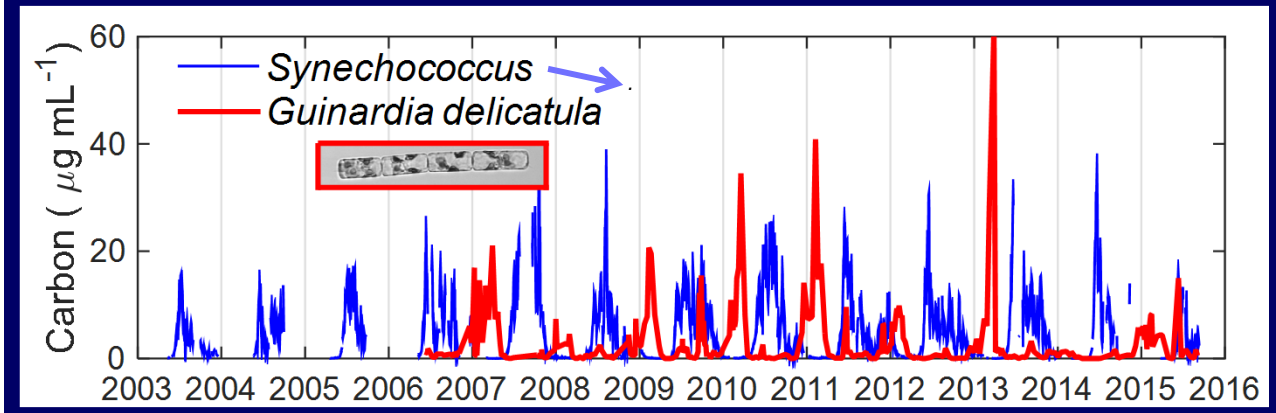


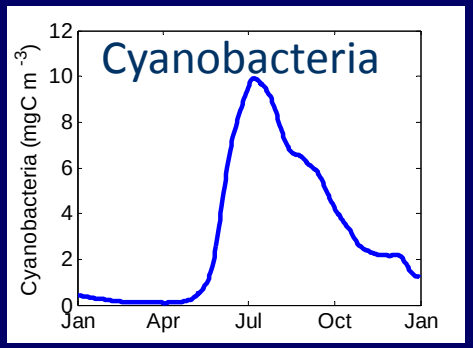
Volume from image analysis
"distance map" approach

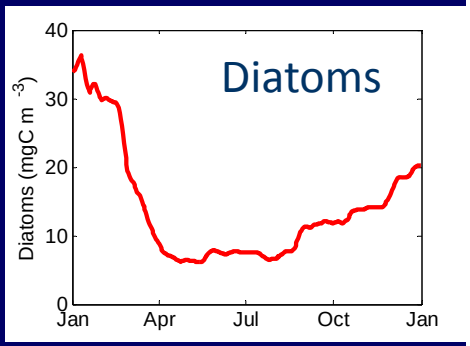
Sosik and Olson 2007
Moberg & Sosik 2012

Size and biomass budgets

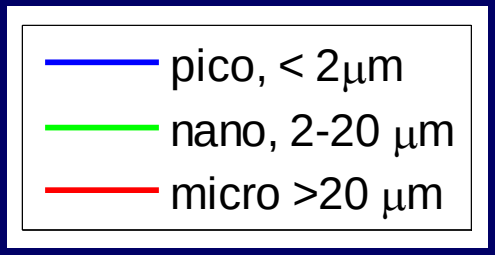
Individual cells → Taxa → Communities

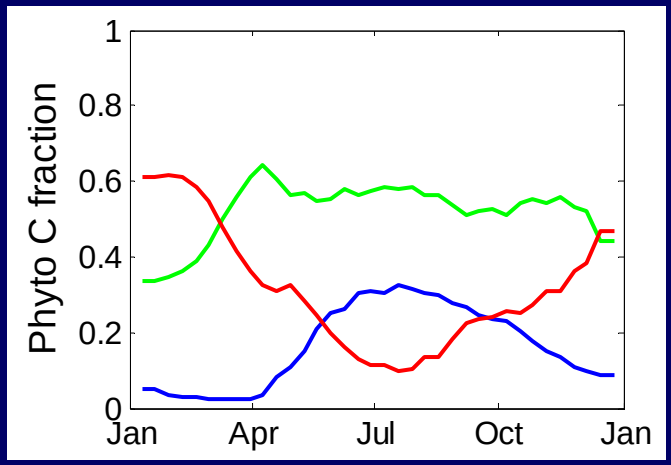




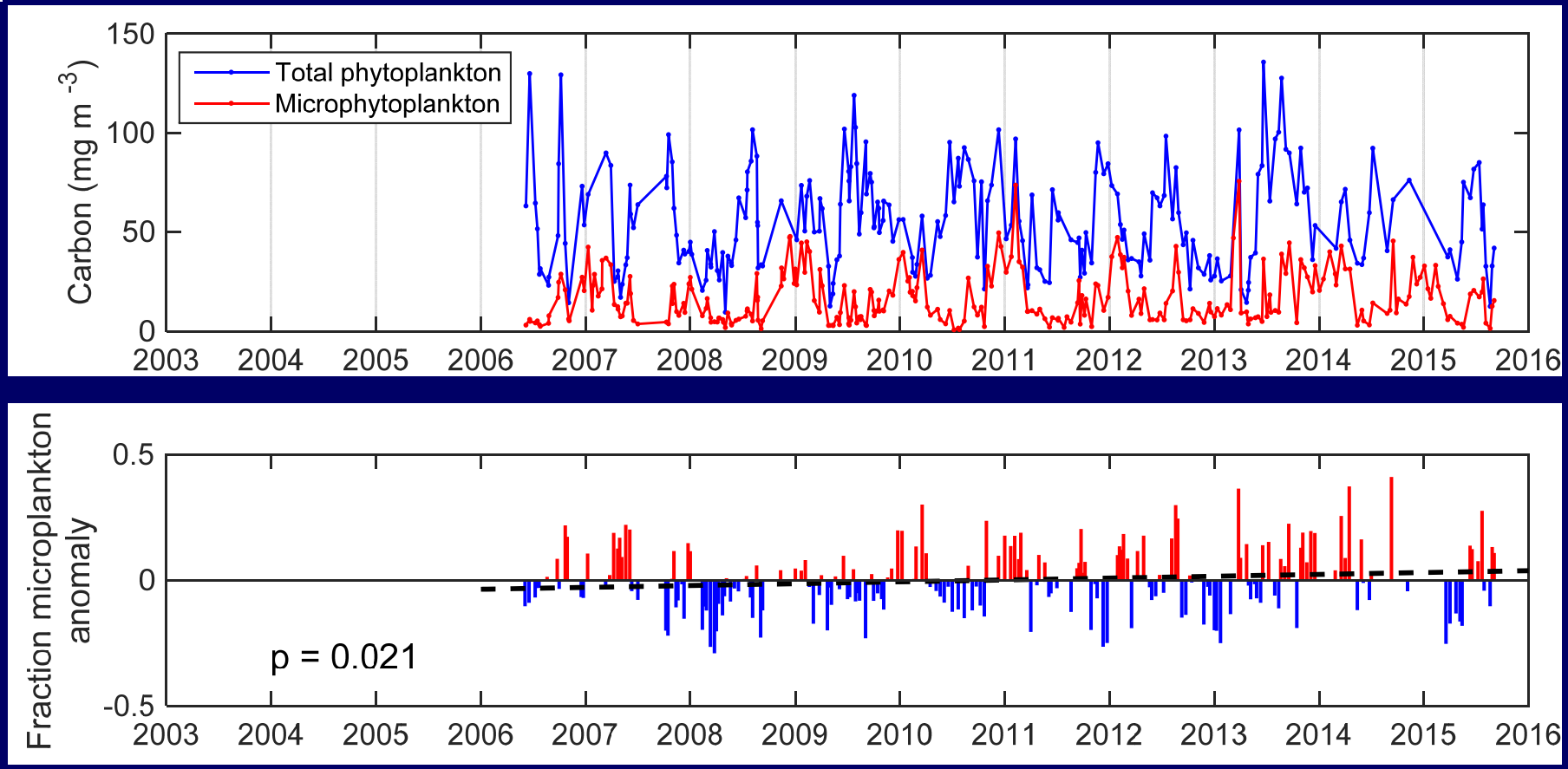


Individual cells → Size-classes → Communities



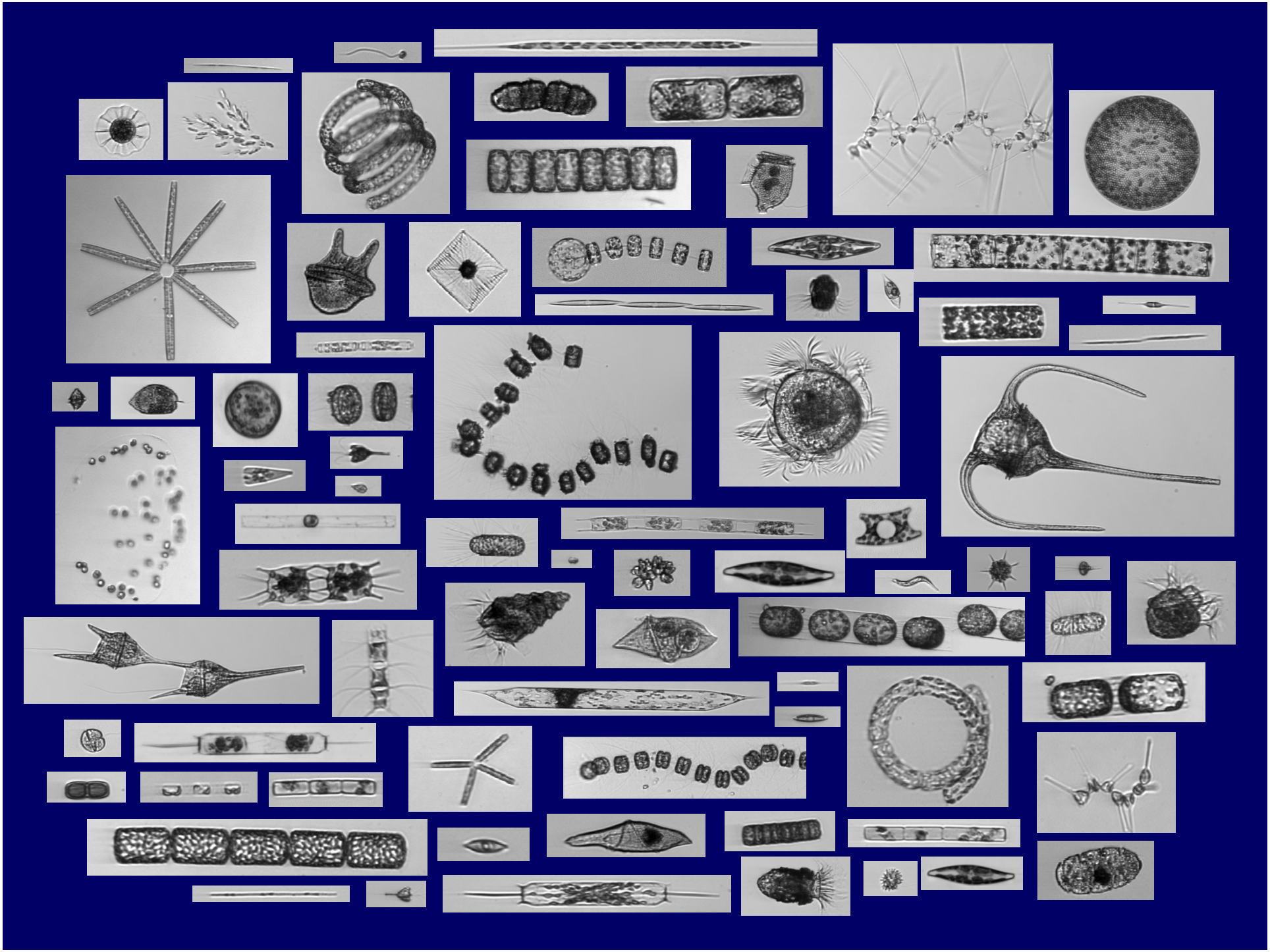


Multi-year trends in communities

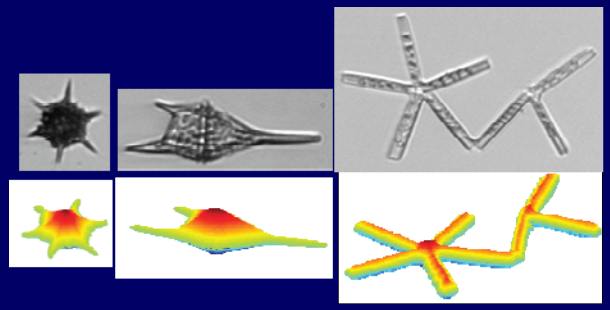


How do interactions between populations and environmental conditions propagate to multi-year trends?

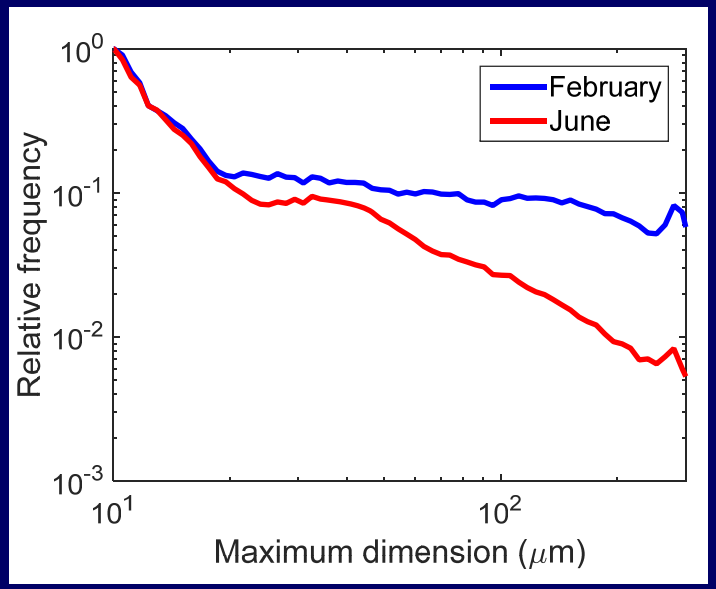
Are size classes sufficient for these questions?

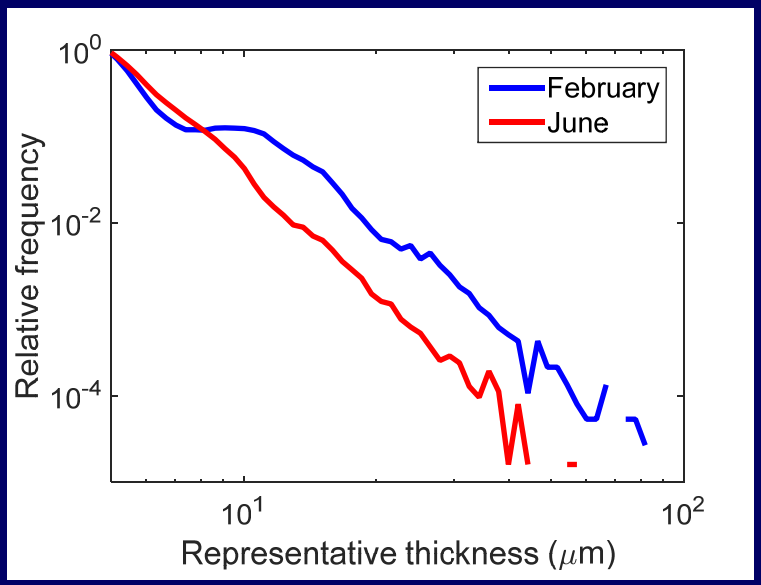


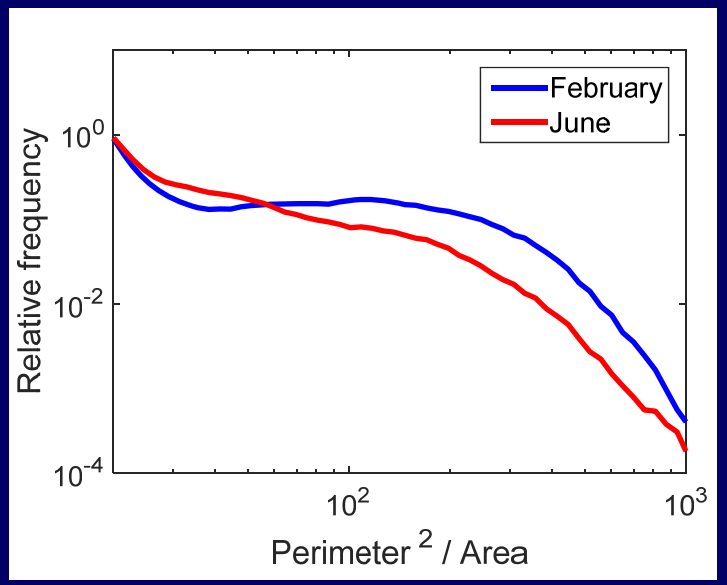
Diverse shape & size metrics



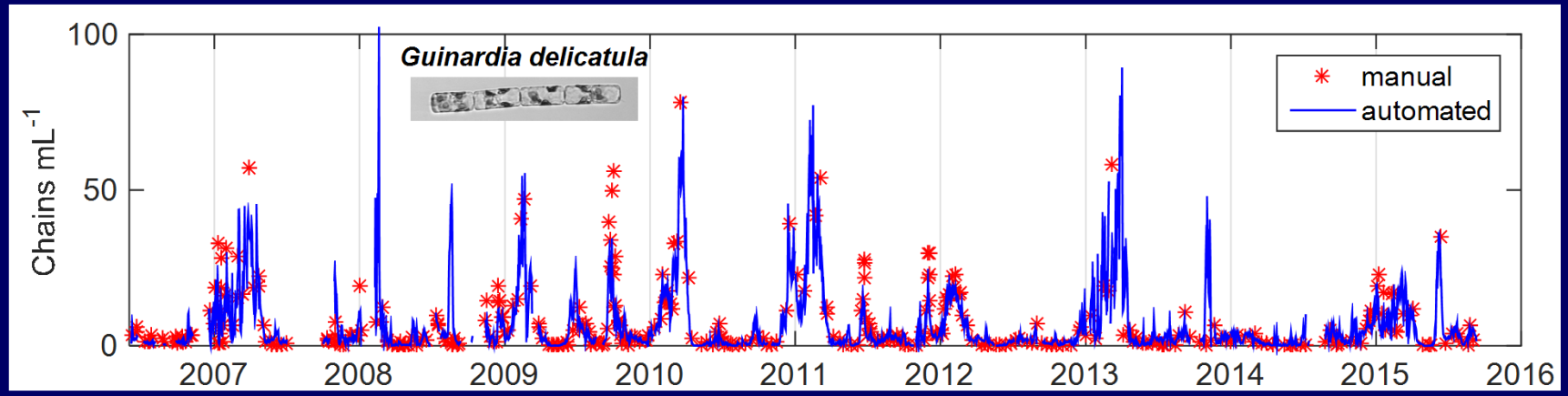
Which indices are relevant for ecological and physiological trade-offs?

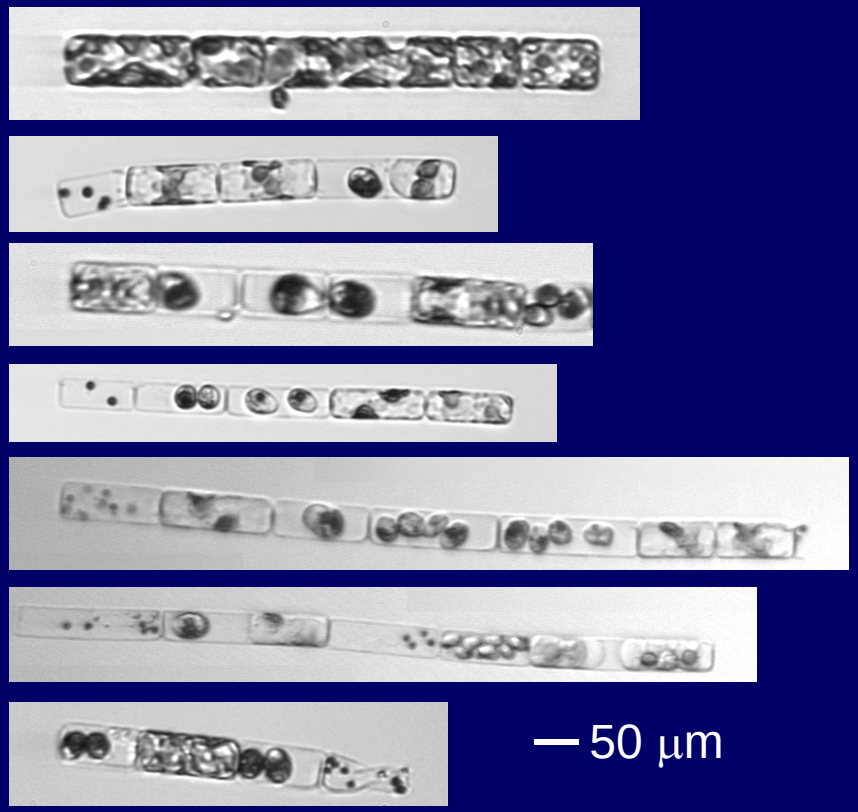


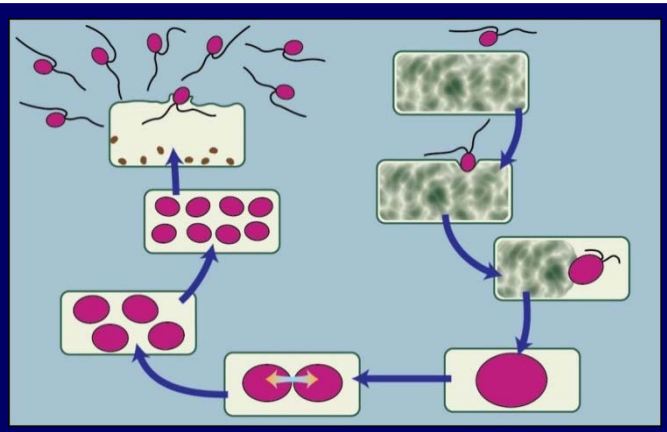




Seasonal-interannual variability linked to ecological traits



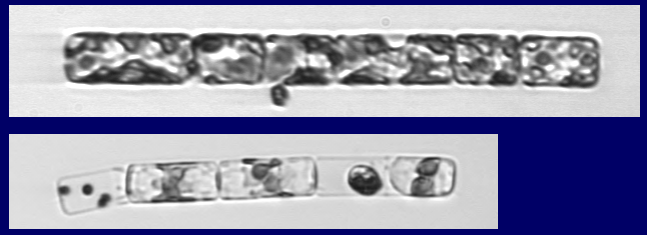




Nanoflagellate parasites consume cytoplasm and reproduce inside diatom host cells

Peacock et al. 2014

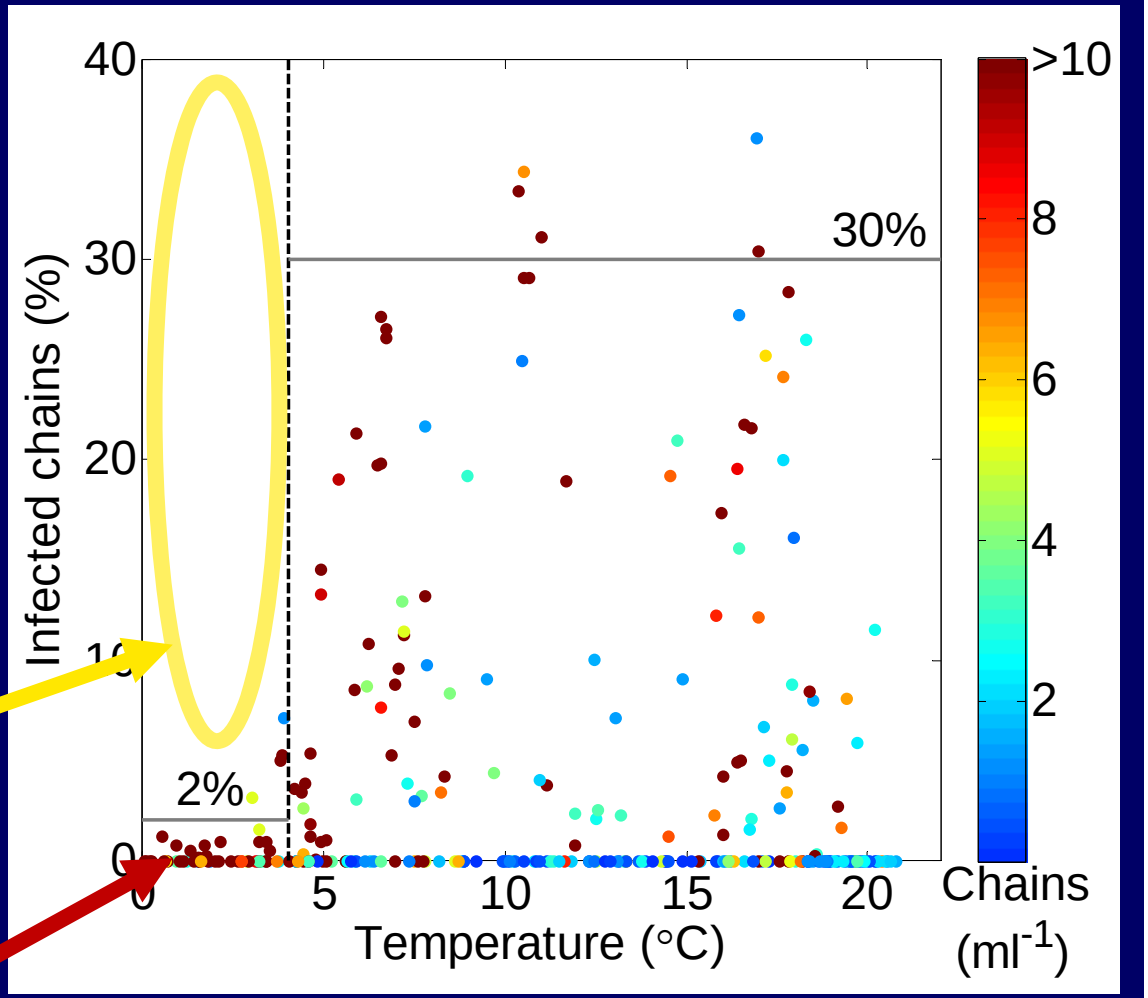
Temperature dependence of parasite infection



Cold waters provide refuge from parasite

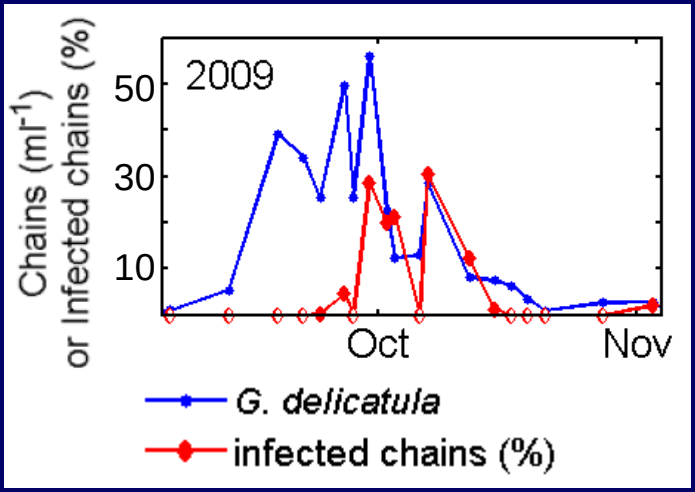
Absence of infection when water temperature <4°C

Largest blooms of host diatom tend to occur during cold winter periods



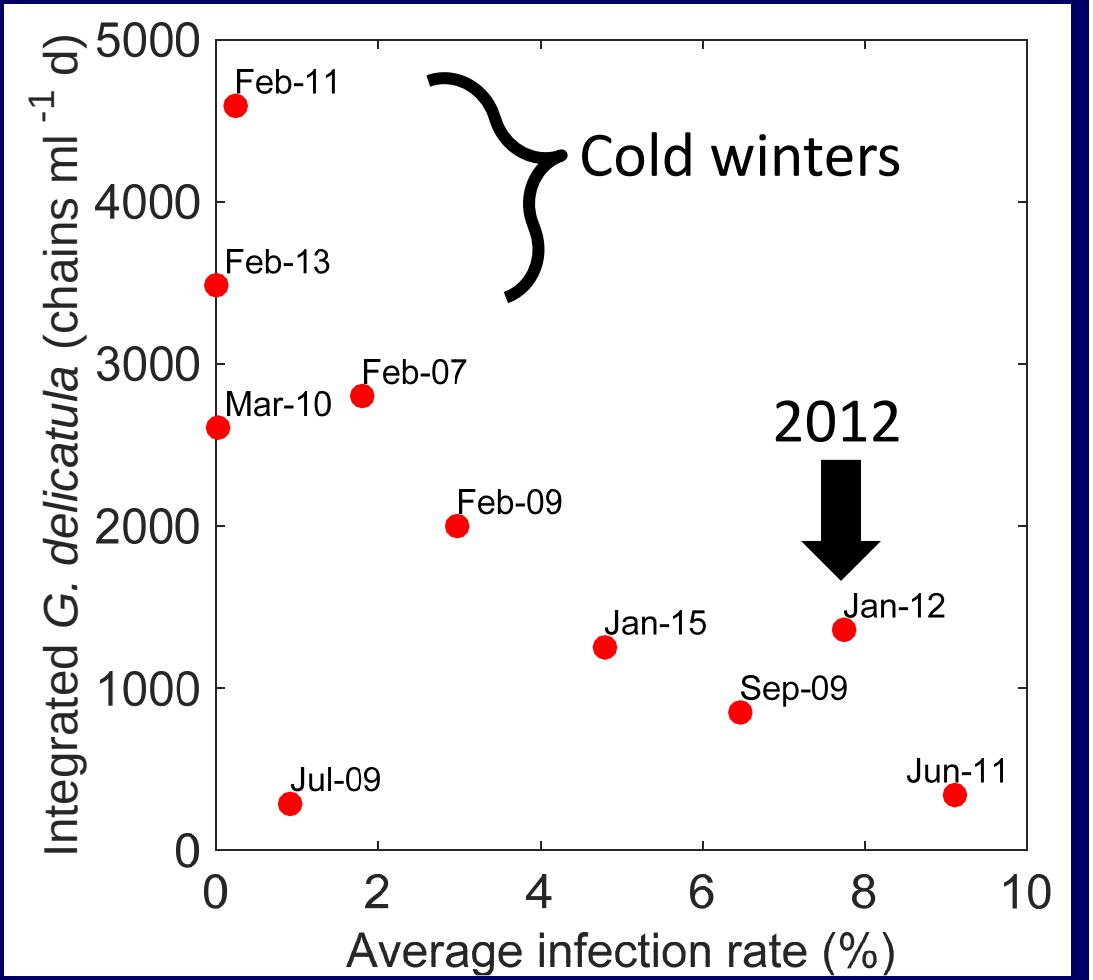
Peacock et al. 2014

Interannual bloom variability linked to parasitism



Infection rate explains bloom magnitude

2012
- Record warm winter
- Parasites present all winter
- Smallest winter bloom

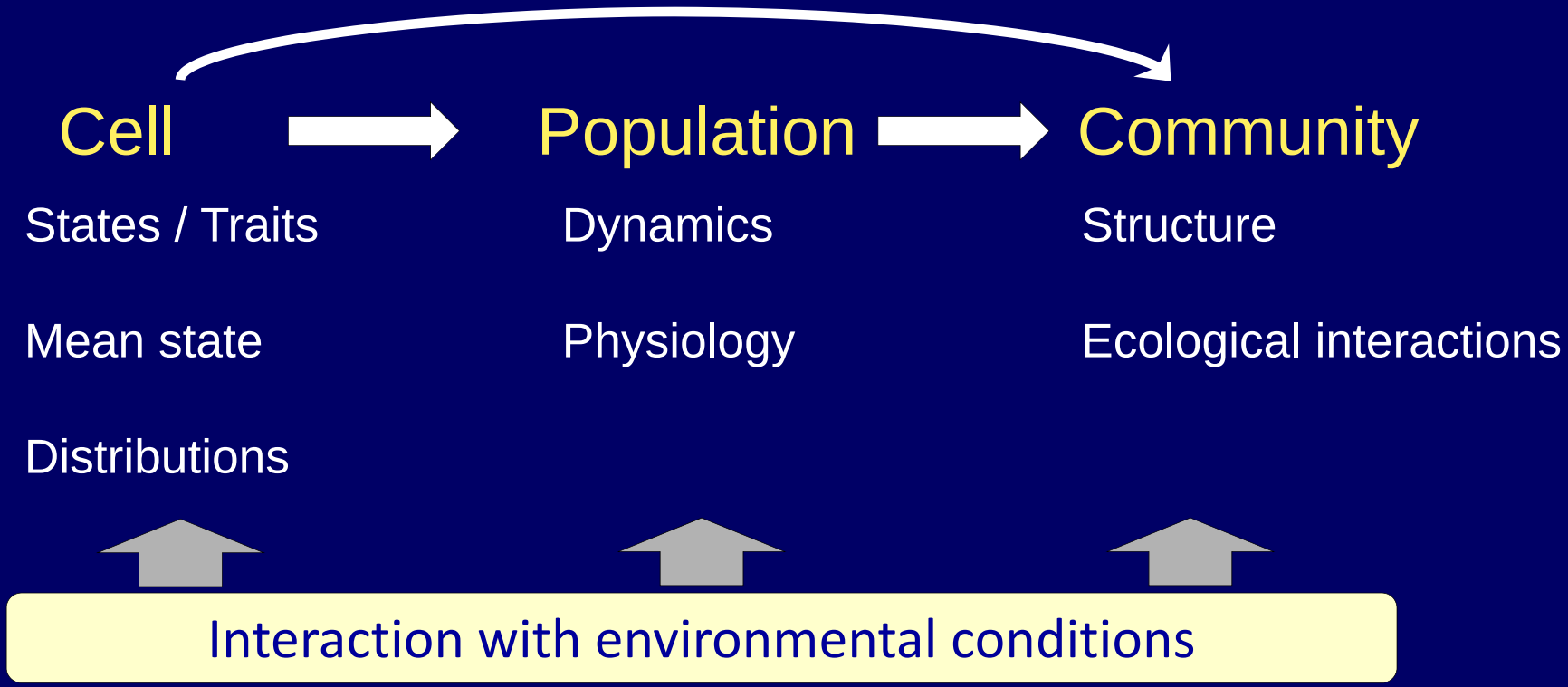


Peacock et al. 2014

Implications as warming trend continues?

Flow Cytometry provides multi-faceted trait information

→ Rapid assessment of many individuals in natural samples



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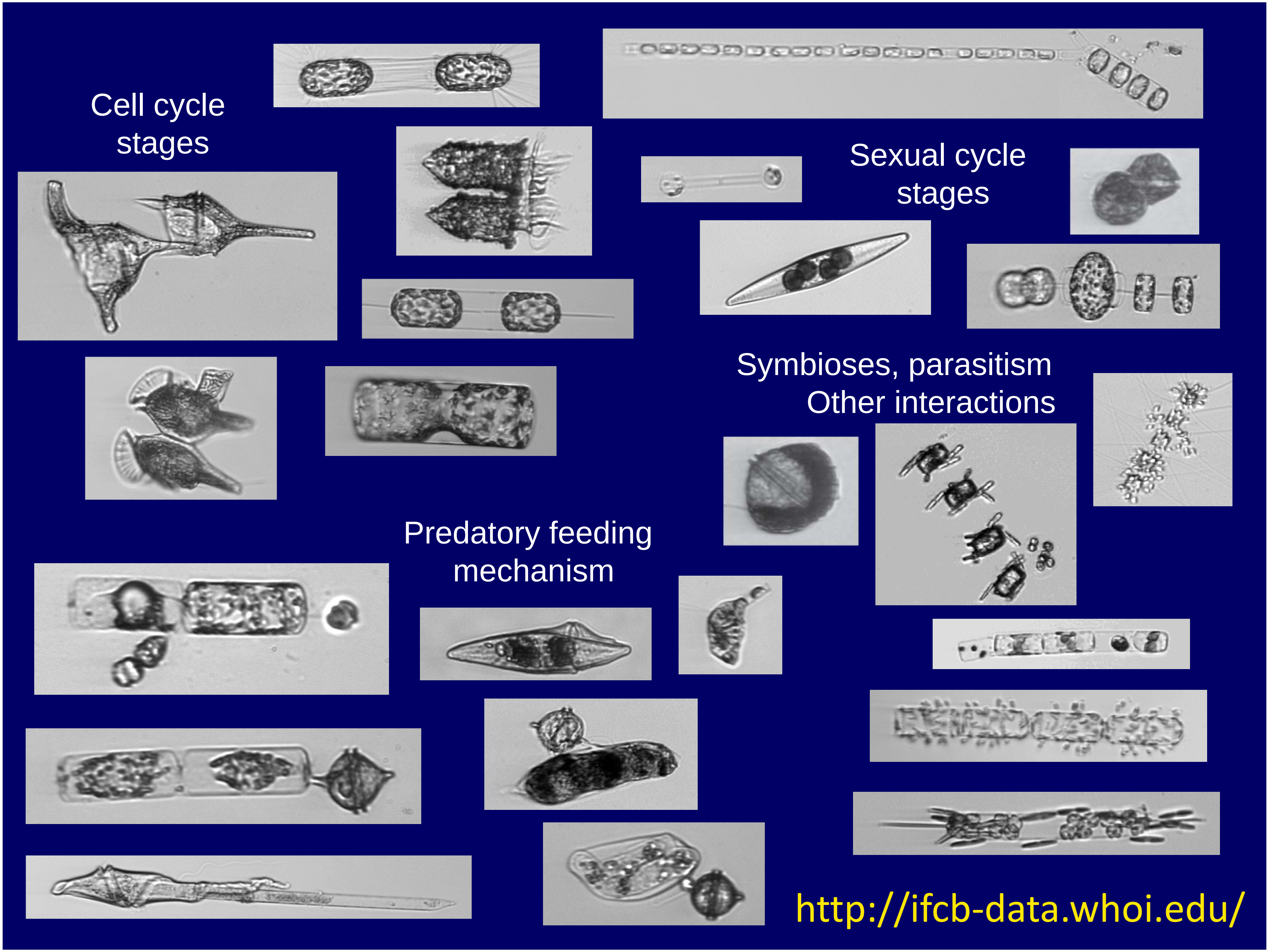
Cell cycle stages
Sexual cycle stages
Symbioses, parasitism
Other interactions
Predatory feeding mechanism
http://ifcb-data.whoi.edu/

Acknowledgments

http://ifcb-data.whoi.edu/

Rob Olson

MVCO Operations Team

Kristen Hunter-Cevera, Emily Peacock,
Taylor Crockford, Joe Futrelle, Alexi Shalapyonok,
Emily Brownlee, Emily Moberg

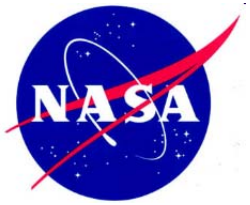

Image Informatics

http://ifcb-data.whoi.edu/

- Open data access
- Standard formats
- Processing pipelines
- End-to-end provenance