Novel Insights from Multiscale Plankton Time Series at the Martha's Vineyard Coastal Observatory

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Phytoplankton Diversity and Dynamics

What factors control phytoplankton diversity and dynamics?
How are they changing through time?

Approach: time series observations
with high resolution & long duration

cabled observatory facilities
new in situ sampling and analysis systems

individual cells → taxa → communities
Martha’s Vineyard Coastal Observatory (MVCO)

Cabled to shore since 2001
Continuous power & Ethernet into the ocean
Open to new users - research and industry
Web-based data access – realtime & archived

Long term data records:
- temperature,
- salinity,
- currents,
- wind,
- waves,
- tides,
- pressure,
- radiation,
- rainfall,
- humidity

http://www.whoi.edu/mvco
Automated features for extended deployment

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

Observational capabilities

Enumeration, identification, and cell sizing
Thousands of individual phytoplankton
Phytoplankton Time Series at MVCO

Martha’s Vineyard Coastal Observatory (MVCO)
Cabled site with power and two-way communications

FlowCytobot

Picoplankton

Microplankton

FlowCytobot

Imaging FlowCytobot
Phytoplankton Time Series at MVCO

Many species at MVCO
~600 million images since 2006

Image processing
Feature extraction
Supervised machine learning

Sosik and Olson 2007

Diatoms

Cells mL⁻¹

Ditylum brightwellii

manual
automated

2007 2008 2009 2010 2011 2012 2013 2014
Seasonal variability & diversity

Dominant pico- and micro-phytoplankton species

**Synechococcus**

**Guinardia delicatula**

Diatoms

Cyano-bacteria

Atmospheric inputs (dust, precipitation, gas)

Injection of new nutrients by diffusion and advection

Sedimentation

Fishes

Excretion

Production of dissolved organic carbon

Non-carbon nutrient uptake

Trophic transfer of carbon
Decadal-scale increase in pico-cyanobacteria at MVCO

Multi-year trends in picoplankton
Seasonal variability in picoplankton

Diel changes in cell size distribution from FlowCytobot time series
size-structured matrix population model

Hunter-Cevera et al. 2014
Interannual variability in diatoms

Nanoflagellate parasites consume cytoplasm and reproduce inside diatom host cells.
Interannual variability in diatoms
Interannual variability in diatoms

Infection rate explains bloom magnitude

Peacock et al. 2014
Summary

Submersible flow cytometry provides unprecedented capability for long term phytoplankton community analysis at observatories

Who’s there? How are they changing?

Picophytoplankton on the New England shelf
- extreme seasonality, strongly temperature-dependent
- pattern of long term increase

Diatoms on the New England shelf
- same taxa recur year after year
- seasonality in taxon-specific blooms is typical, but with high interannual variability in bloom amplitude
- novel ecological interactions, such as parasitic infection, are important in seasonality and potential long term change
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http://ifcb-data.whoi.edu/

Thank You!
Open data access
Standard formats
Processing pipelines
End-to-end provenance
Imaging FlowCytobot
Data example

Nano/microplankton
-Associated images
(all same scale)
Future Directions

Imaging FlowCytobot redesign complete
→ Commercially available

New Technology
- Image-based cell sorting
- Imaging with stains, etc.
- Acoustic focusing

New Applications
- Diatom growth rates?
- Protozoan grazing?
Synechococcus population at MVCO is diverse
Actual and relative abundance patterns

Synechococcus cells mL$^{-1}$

Oligotype relative abundance

- O1
- O1-I
- O2
- O2-M
- O3
- O3-M
- O4
- O4-I
- O5
- O5-I?
Warming temperatures and the spring bloom

Synechococcus cells mL$^{-1}$
- $10^4$
- $5 \cdot 10^4$
- $10^5$
Warming temperatures and the spring bloom

[Graph showing the relationship between year day and temperature at 6 °C, with data points and trend lines indicating a decreasing pattern over the years 2003 to 2013.]
Phytoplankton

Primary producers

Essential roles in marine ecosystems and biogeochemical cycles

Enormous Diversity

Atmospheric inputs (dust, precipitation, gas)

Phytoplankton

200 m

mesoplankton

2 mm

nekton

Large autotrophs

Large zooplankton

Fishes

Sedimentation

Injection of new nutrients by diffusion and advection

Trophic transfer of carbon

Production of dissolved organic carbon

Non-carbon nutrient uptake

Excretion

OEUVRE ~~~~~~~~~ Per Jonsson, with revisions by committee