Biogeography of bacterioplankton in estuarine systems

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Speaker Introduction
by Professor Bill Dennison
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Outline

• Marine Biogeochemistry
• Transformation and Transport of Carbon
• Remote Sensing Applications
• Biogeography of Bacterioplankton Communities
Marine Biogeochemistry

- Fate and transformation of carbon in aquatic systems
  - riverine, estuarine, coastal and marine

- Biological, physical and chemical processes
  - primary production, respiration, biodegradation
  - transport, mixing, sedimentation
  - direct effects of salinity, photodegradation

- Terrestrial organic matter (TOM)
  - Significant source of carbon to marine systems
  - Transport and transformation poorly understood
Inputs of TOM to Estuarine Systems

Albemarle Sound post-Hurricane Floyd (23 Sept 99)
Carbon Transport and Transformation Along Estuarine Gradients

- Low salinity
- High nutrients
- High TOM
- High turbidity

RIVER

- High salinity
- Low nutrients
- Low TOM
- Low light attenuation

OPEN OCEAN

Physicochemical effects of salinity

photodegradation

sorption and deposition

biological processing & degradation

CO₂
Remote Sensing

- Facilitate more efficient collection of field data
- Remote sensing algorithms for coastal and estuarine systems are not well defined
- Optical properties of in-water parameters allow detection via airplane and satellite
- Parameters identified by unique absorbance spectra
  - Temperature
  - DOM
  - Chlorophyll
  - TSS/POM
  - Salinity
Remote Sensing along Salinity Gradients

Great Bay/Mullica River Estuary (NJ)
Integrating Biogeochemistry, Remote Sensing and Microbial Parameters

- Refine remote sensing algorithms
- Provide tactical information for littoral zones
- Characterize the composition, degradability, fate of TOM
- Identify role of microbial communities (i.e., bacterioplankton) in mediating carbon transformation and flux
- Identify transferable patterns in the composition of bacterioplankton communities along estuarine gradients
Bacterioplankton in Aquatic Systems

- Found in all natural waters
- Non-pathogenic!
- Small ($\leq 1\text{mm}$) yet abundant ($>10^6 \text{cells/ml}$)
- Comparable in biomass to phytoplankton
- Fundamental in nutrient & carbon remineralization
- Drive water quality parameters (i.e. anoxia, nutrient availability)
- Important role in carbon cycling

(DAPI stained slide of bacterioplankton from Chesapeake Bay)
How does community composition change over space and time in natural systems?
Patterns in Biogeography

- Global plant biomes

Factors regulating plant biogeography include temperature, precipitation, day length...

Image from http://www.blueplanetbiomes.org/world_biomes.htm
Patterns in Biogeography

• Life zones (vertical belting)

- Spatial distribution of plant species throughout the globe is highly predictable and based on a small number of environmental factors.
Microbial Biogeography

- Do bacteria exhibit biogeographic patterns?
  - Random distribution
  - Baas-Becking Hypothesis: “Everything is everywhere…”
  - Systematic or predictable patterns in distribution?

- Estuarine systems
  - Factors believed to regulate diversity covary predictably

Crump et al. 2004
Experimental Approach

1) Investigate changes in the phylogenetic composition of bacterioplankton communities along estuarine gradients
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2) Use denaturing gradient gel electrophoresis (DGGE) as an index of community composition
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2) Use denaturing gradient gel electrophoresis (DGGE) as an index of community composition

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4) Repeat in a wide range of estuarine systems to identify transferable patterns in estuarine bacterioplankton biogeography
Sample Collection

- Sample at 4psu intervals (0 to 32)
- Three stations at 0, 16 and 32psu for cross-inoculation experiment
- Measure CDOM, DOC, dissolved nutrients, chlorophyll, salinity, temperature
- Collect bacterial DNA from whole water and free-living (3μm filtered) fractions
Site Locations

Puget Sound & Snohomish River

Gulf of Mexico & Atchafalaya River

Chesapeake Bay

Delaware Bay

Winyah Bay

Kahana Bay, Oahu

R/V Barnes

R/V Sharp

R/V Pelican
Puget Sound & Snohomish River

- 170km transect from 0 to 32 psu
- Steep salinity gradient (~5km from 0 to 16 psu)
Fingerprinting with DGGE

- Natural bacterioplankton community
- Extract DNA
- Amplify 16s rRNA genes with bacterial primers
- Gel electrophoresis across gradient of denaturants
- Banding pattern represents DNA fingerprint of each community

Images courtesy of Byron Crump
Changes in community composition

- Banding patterns differ among stations
- Changes occur in presence vs. absence as well as density of bands
- Thus, dominant phylotypes shift as one moves from marine to fresh endmembers
Quantifying banding patterns: Multidimensional Scaling (MDS)

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- Distances reflect degree of similarity between samples/banding patterns
Visualizing similarities

- There is an obvious shift in composition along the estuarine gradient.

- Changes in composition reflect distinct systems as well as environmental gradients.
Salinity and CDOM

• Changes in composition are well correlated with both salinity and CDOM

• Is this conservative mixing, direct effect of salinity, or response to organic matter substrates?
Hypotheses on Shifting Structure

• Changes in composition are related to residence time and hydrographic characteristics.

• This provides a model for testing hypothesis regarding mechanisms driving biogeography of estuarine bacterioplankton.
Conclusions

• Estuarine bacterioplankton exhibit biogeographic variability

• Community composition is correlated with salinity and DOM source.

• Role of dispersal vs. environment in biogeographic patterns needs to be identified.
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Question Time

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