ESTUARINE BACTERIOPLANKTON METABOLISM AND DIVERSITY ACROSS A SEASONAL OXYGEN GRADIENT

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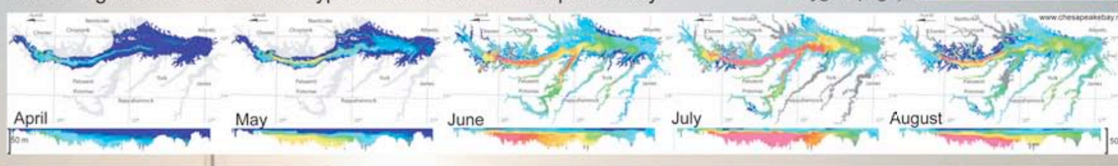
ABSTRACT

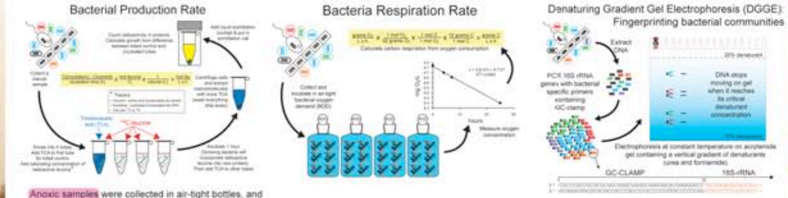
The Chesapeake Bay contains chemical and biological gradients that influence bacterioplankton communities. In spring, heterotrophic bacteria create anoxia and establish a seasonal oxygen gradient lasting until fall. During the summer of 2004, depth profiles through the oxygen gradient were analyzed for phylogenetic community composition and cell abundance, production, and respiration. The composition of bacterioplankton communities was characterized with denaturing gradient gel electrophoresis (DGGE) of PCR-amplified 16S ribosomal DNA. As anoxia set in, community composition shifted in both surface and bottom waters, but displayed only small differences between oxic and anoxic waters. Bacterial abundance was initially similar throughout the water column, but as anoxia set in an unusual sheathed cell became numerically dominant in anoxic and hypoxic waters. Bacterial production was only slightly lower in anoxic versus oxic waters, and reached peaks just above and just below the oxycline. Respiration was highest at the top of the gradient and decreased in the middle, but increased near the bottom of the oxycline in extremely hypoxic waters. These results indicate that the seasonal oxygen gradient influences the composition and activity of bacterioplankton communities

2004 Progression of Seasonal Hypoxia & Anoxia in Chesapeake Bay



Elevated nutrient inputs to the Chesapeake Bay and other stratified estuaries enhances phytoplankton production of organic matter. Some of this organic matter sinks below the halocline and is consumed by heterotrophic bacteria. Because these bacteria use oxygen this can lead to anoxic conditions in estuarine bottom waters which persists because re-oxygenation from the atmosphere is limited by salinity stratification.

METHODS

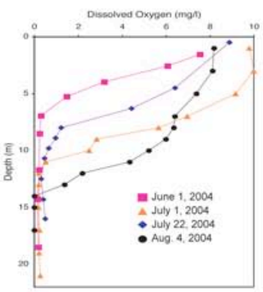


Anoxic samples were collected in air-tight bottles, and processed and incubated in an anaerobic chamber

Oxygen Profiles at Mid-Bay

June: Hypoxic deep water
July: Anoxic deep water
Aug.: Shrinking anoxic zone

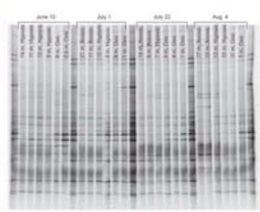
Oxycline mirrors halocline



HYPOTHESES

1. Anoxic bottom water contains a different bacterioplankton community than oxic surface waters, and supports reduced rates of production and respiration
2. The hypoxic interface contains a third bacterioplankton community different from the oxic and anoxic water, and supports elevated production and respiration
3. Both seasonal and permanent oxygen gradients exhibit similar patterns of bacterial growth and community composition, because the time scale to develop a microbial community is shorter than the development of seasonal anoxia

Bacterial Community Composition

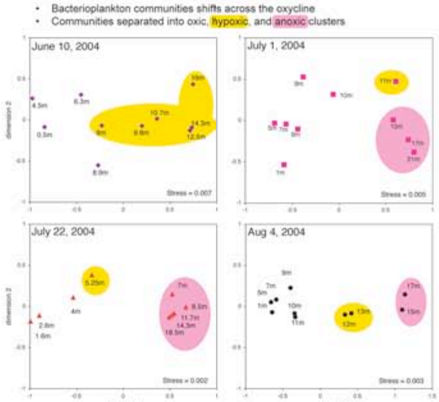


Each band on a DGGE gel represents a different organisms, and bands at the same height in the gel represent the same organism in different samples.

Similarity values were calculated for each pair of samples, and results were expressed as Multidimensional Scaling (MDS) plots

MDS cluster analyses:
Distance between points indicates relative similarities among bacterioplankton communities

- Bacterioplankton communities shifts across the oxycline
- Communities separated into oxic, hypoxic, and anoxic clusters



Bacteria Cell Abundance

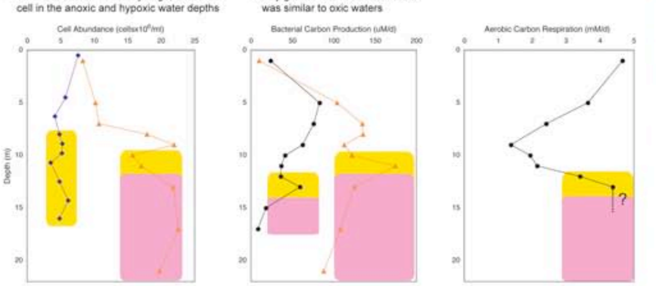
- July abundance was 5X higher than June
- July abundance peaked in anoxic water
- This is due to an unusually large, sheathed cell in the anoxic and hypoxic water depths

Bacteria Growth

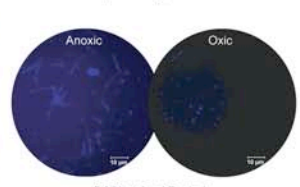
- Bacterial growth rate peaks in hypoxic waters
- July growth rate in anoxic waters was similar to oxic waters

Respiration

- Respiration rates peaked near the surface and in hypoxic waters



Microscopic images of bacteria



DAPI-stained Bacteria

CONCLUSIONS

1. Results revealed small but detectable differences in bacterioplankton commmunities across the oxygen gradient
2. DGGE banding patterns from oxic, hypoxic, and anoxic samples show a great deal of overlap
3. It is possible that estuarine bacteria have flexible metabolisms and are able to grow well in both oxic and anoxic environments
4. No detection of reduced rates of production
5. Anaerobic cells were larger and more abundant, which suggests that grazing pressure was reduced