Community Structure and Biogeochemical Role of Planktic Archaea in the Tidal Broadkill River

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Scientific and Technical Advisory Committee Meeting

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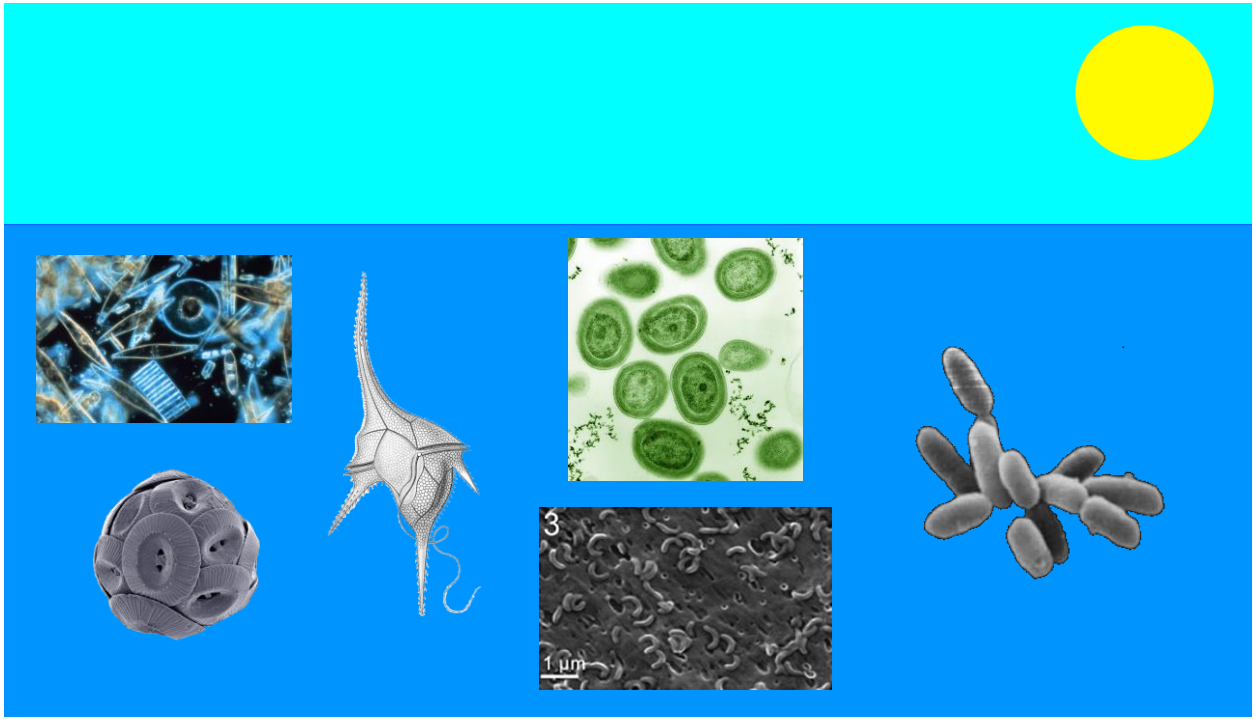
University of Delaware

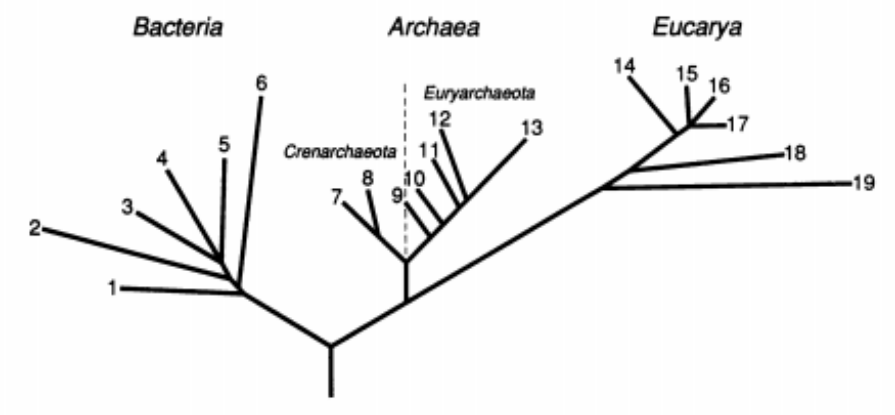
Marine Planktic Archaea



Let’s back up: what are archaea?

Single-celled, prokaryotic

Archaea occupy their own domain of life!



Woese et al. 1990

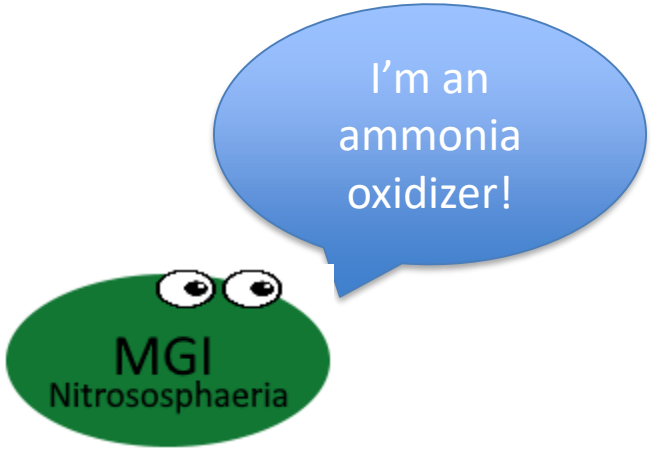
Why are marine planktic archaea important?

- We know a lot less about the role they play in the environment than bacteria
- It turns out they’re actually very important
- Allow me to introduce you to the most abundant marine planktic archaea…

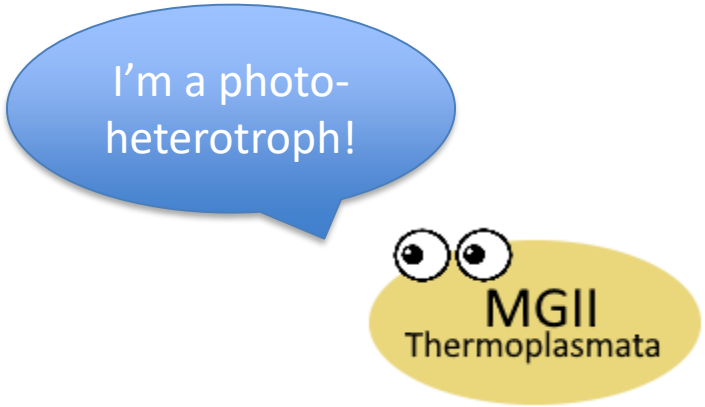
Marine Group I (MGI)

- Phylum Thermoprotea
  - Class Nitrososphaeria
- Globally abundant in mesopelagic
- Metabolism: ammonia oxidation

  $NH_3 \rightarrow NO_2^-$
- Better at it than bacteria!



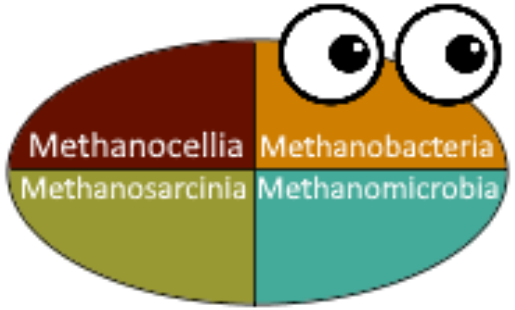
Marine Group II (MGII)



- Phylum Thermoplasmatota
  - Class Thermoplasmata
- Photoheterotrophic
  - Can’t make their own food but can get energy from the sun
  - Degrade organic matter

Methanogens

- Not typically seen in marine water column
  - Typically found in marine sediment
- Reduce CO_2 to CH_4
  - Inhibited by oxygen



What's lacking in the literature?

- Estuaries

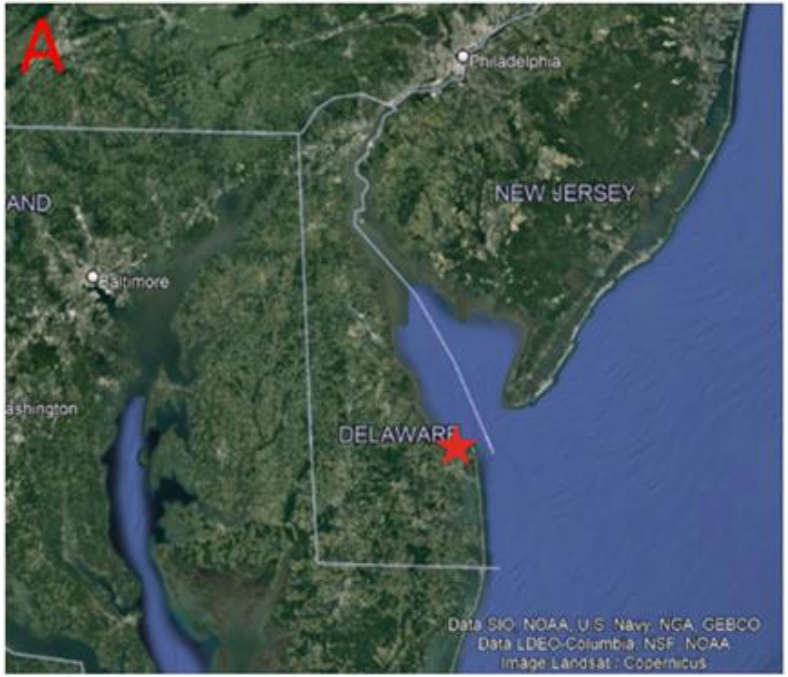
- Time series

- Estuarine time series

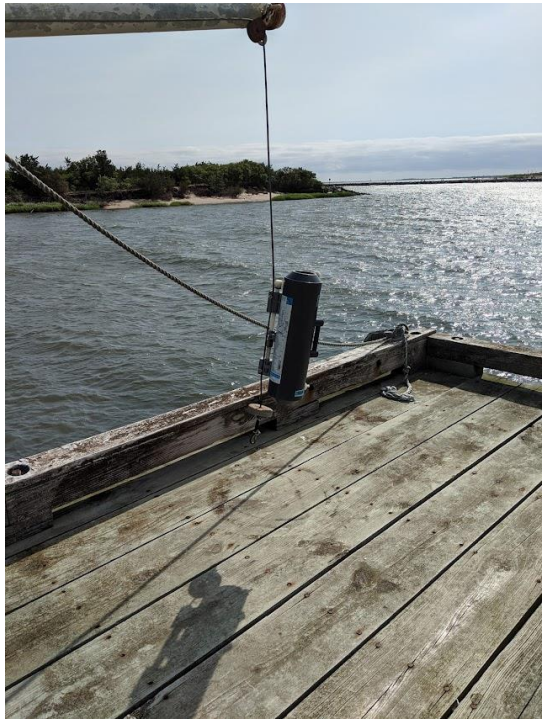
Objectives

- 1. Take year-long census of archaeal community in an estuary to learn about how the community changes over time
- 2. Investigate possible drivers of overall community structure
- 3. Investigate the changes in abundance of particular taxa, with focus on MGI, MGII, methanogens

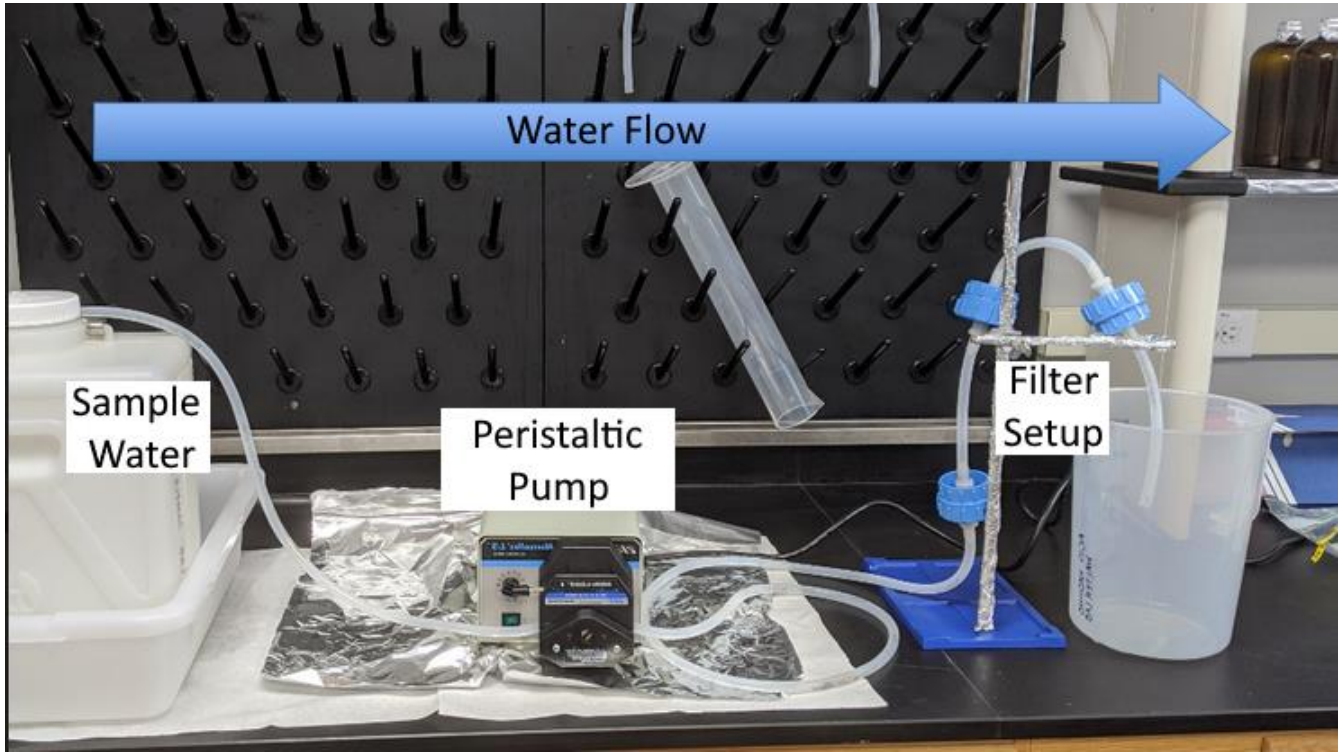
Sampling Location



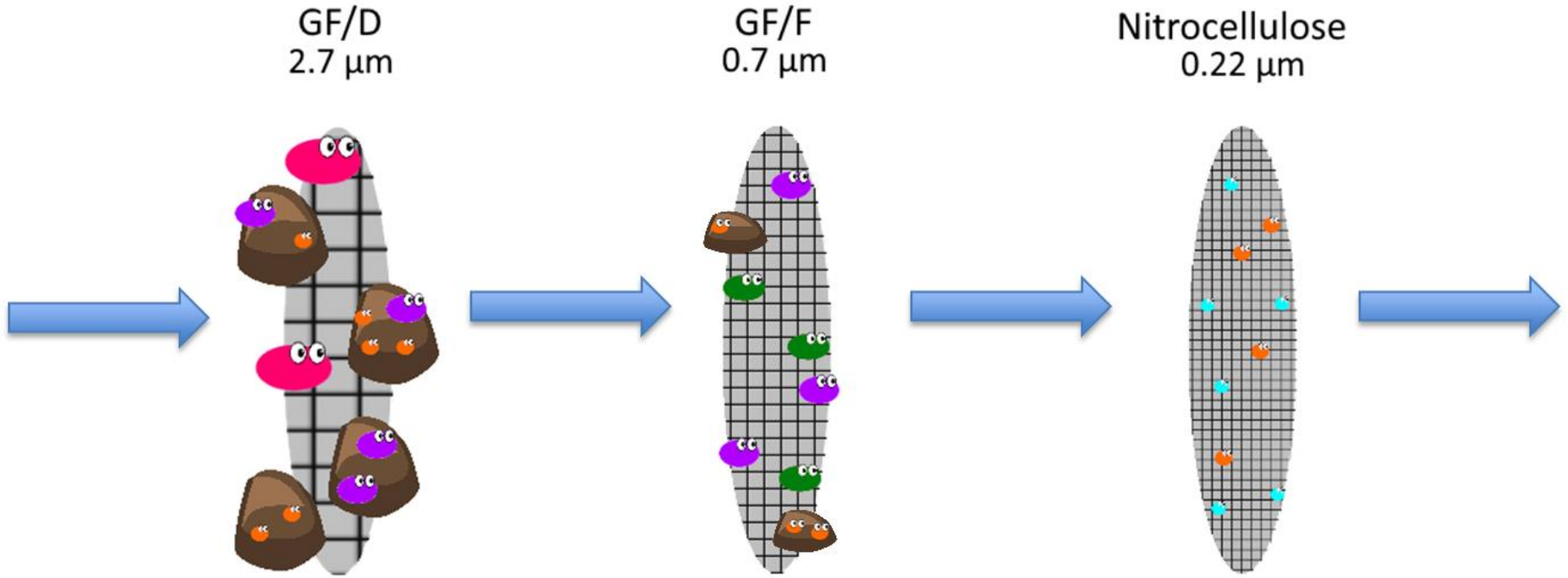
Sampling Setup



Filtration

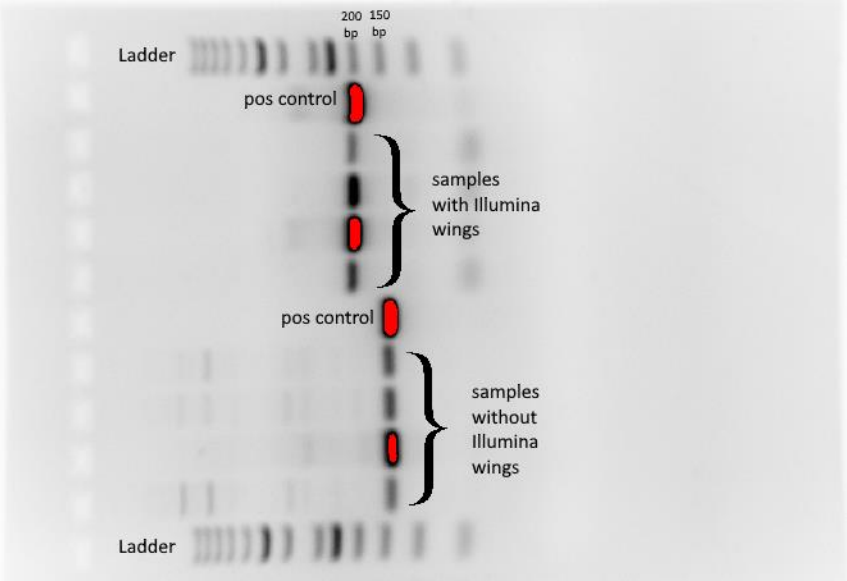


Filtration

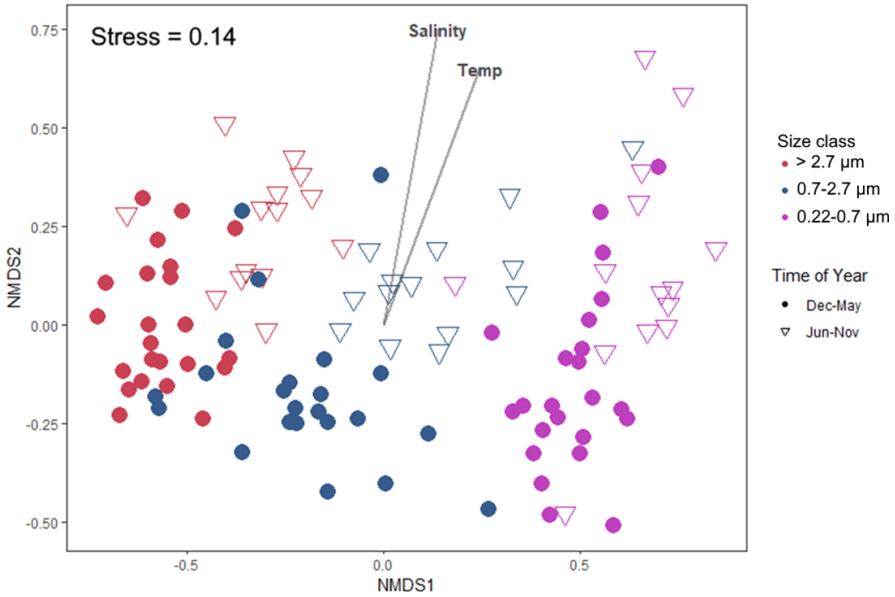


DNA Processing

- DNA extracted from filters
- PCR with archaea-specific primers
  - Amplify DNA
- Targeting 16S rRNA genes
  - Nametags for microbes
- Gel electrophoresis to confirm



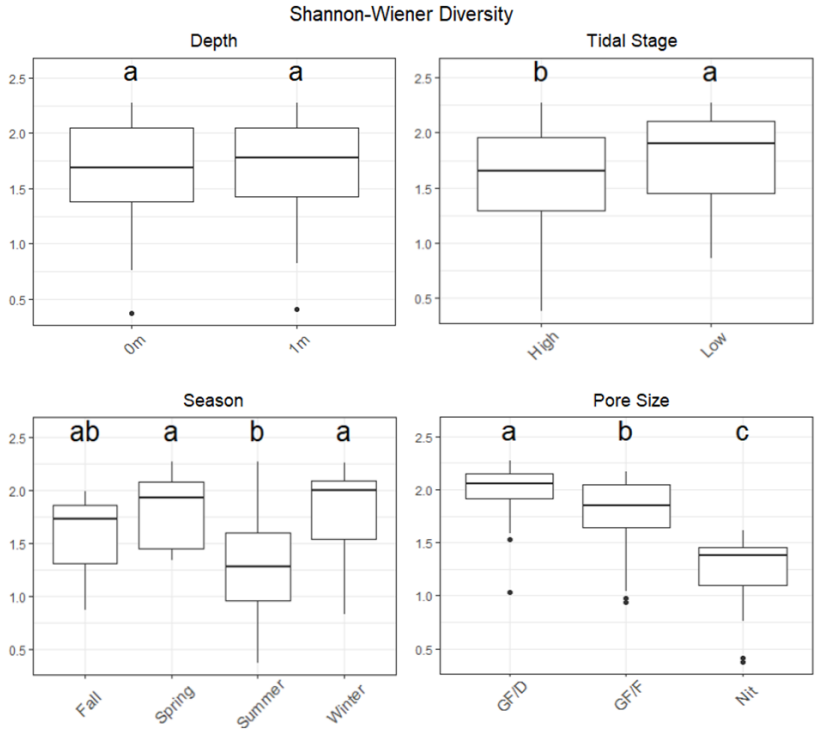
What Shapes the Community?



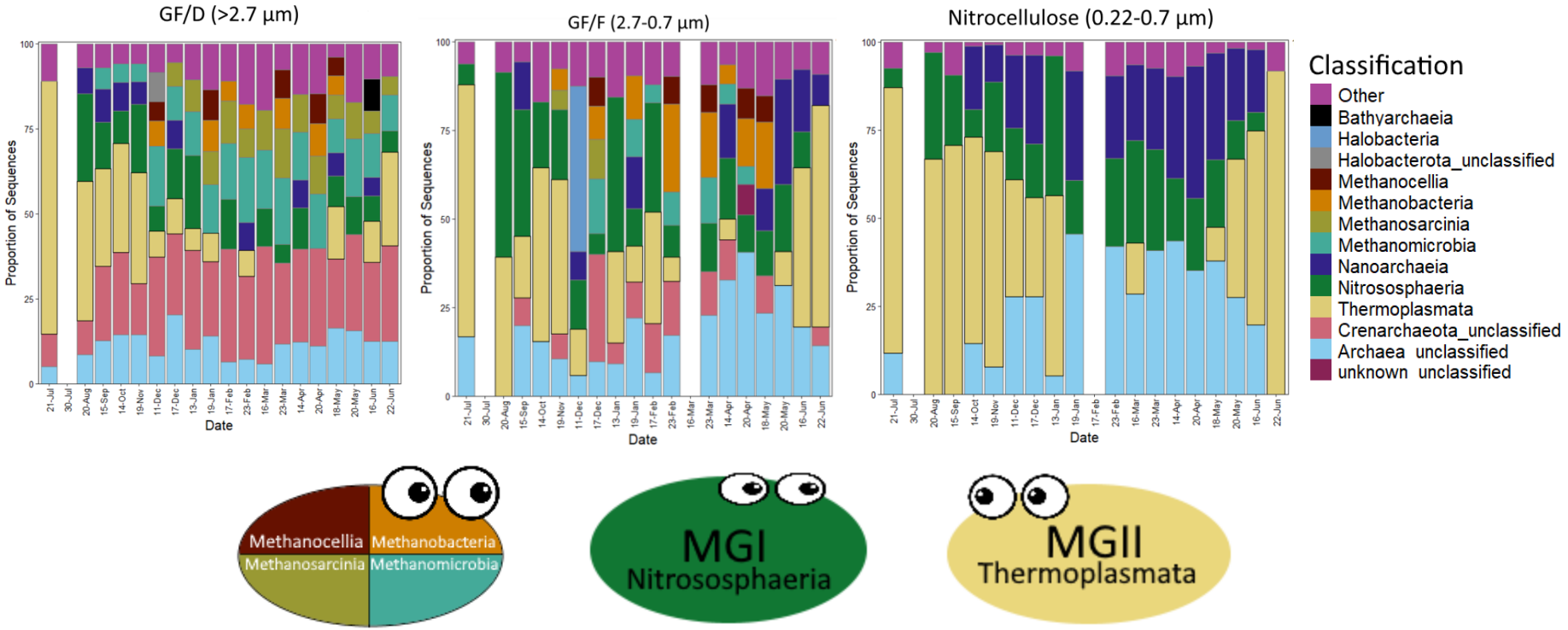
- NMDS plot
  - Points represent samples
  - Points closer together have more similar archaeal community
- Most important factor: size fraction
- Second most important: time of year

Alpha Diversity

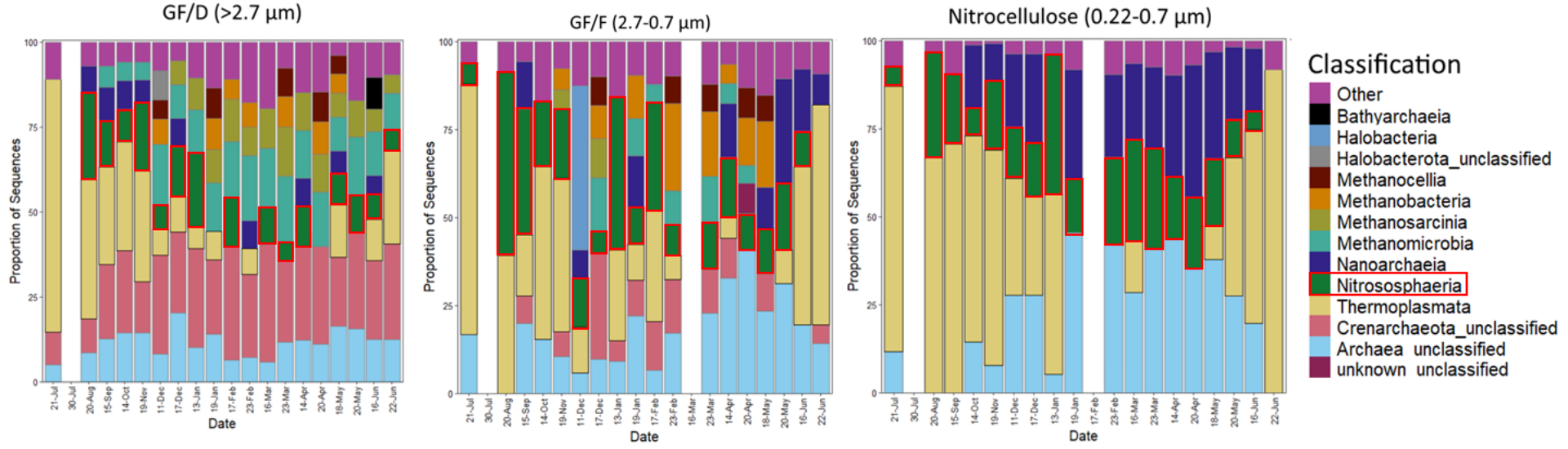
- Lower diversity at high tide
- Lowest diversity in summer, highest in spring and winter
- Decreasing diversity with decreasing size fraction



Looking at Individual Classes



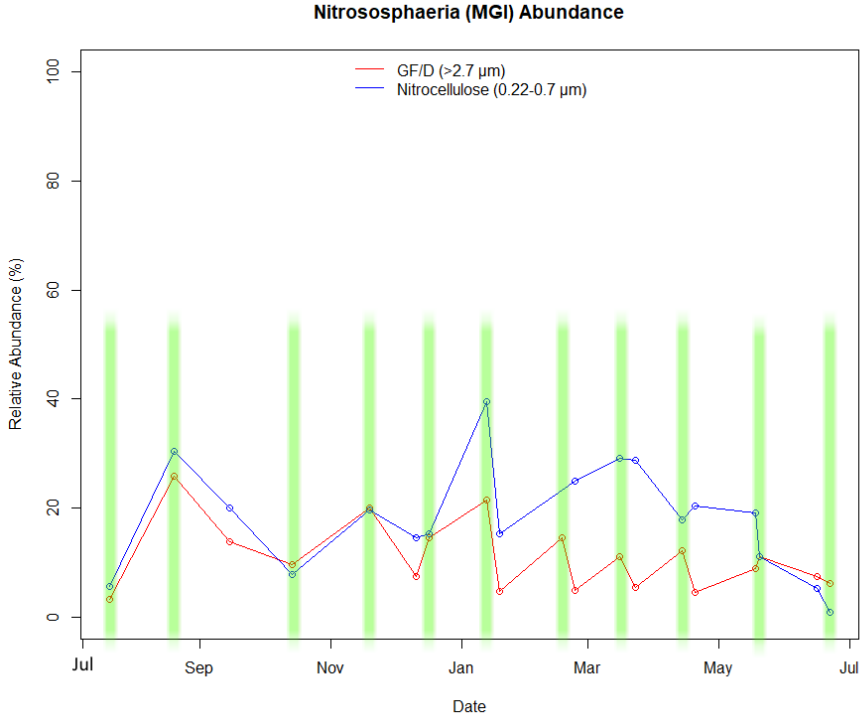
Marine Group I (Nitrososphaeria)



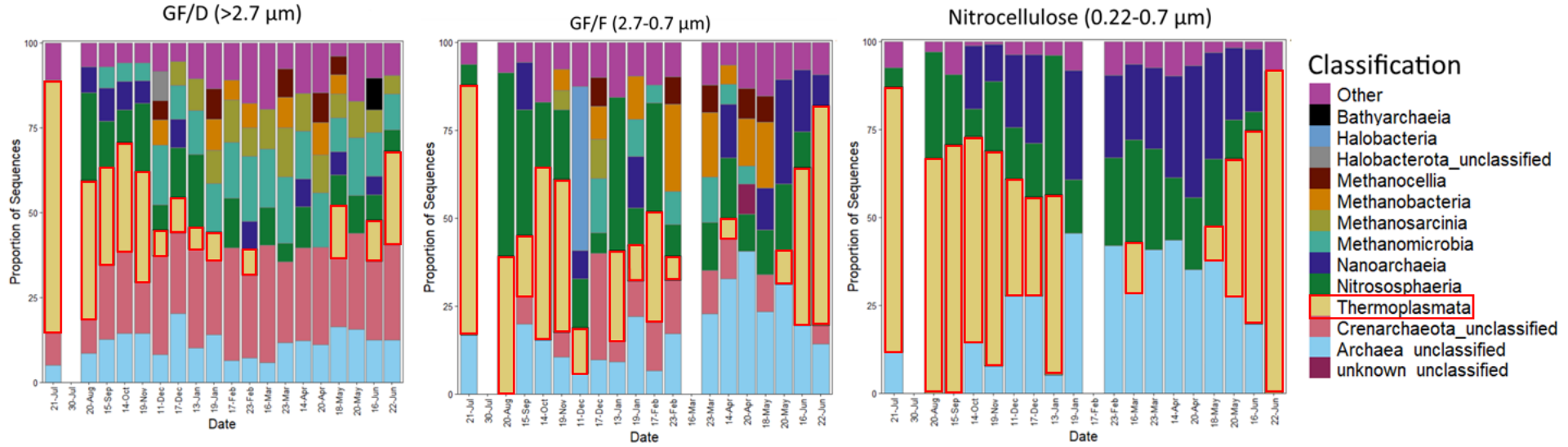
More abundant in smaller two size classes (ISA p-val = 0.0014)

MGI

- Higher abundance at high tide (ISA p-val = 0.0045)
  - More pronounced effect in largest size fraction
- No seasonal trend



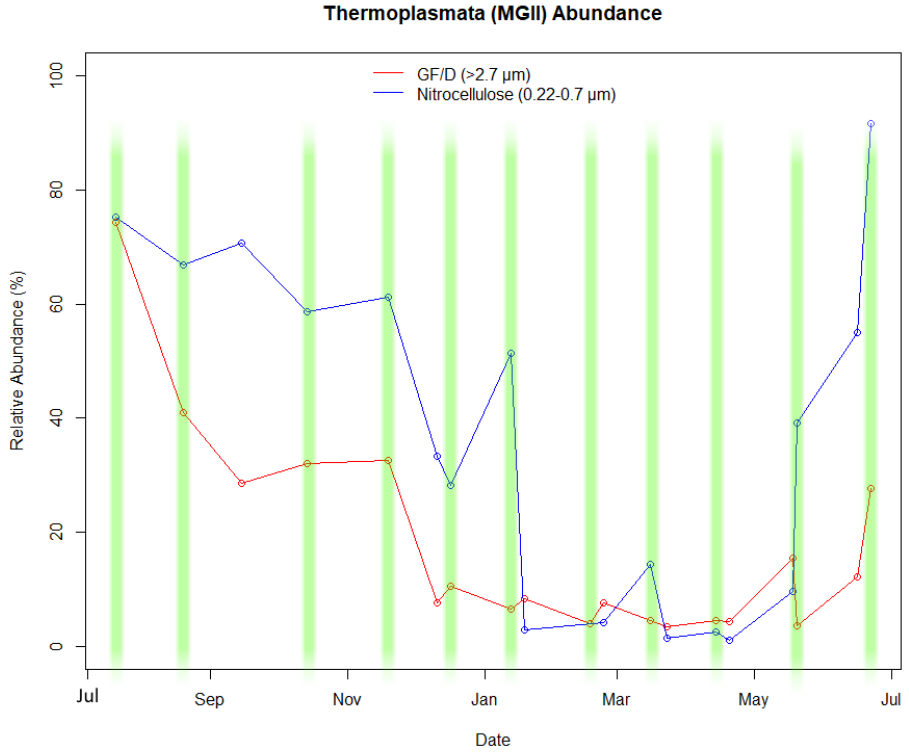
Marine Group II (Thermoplasmata)



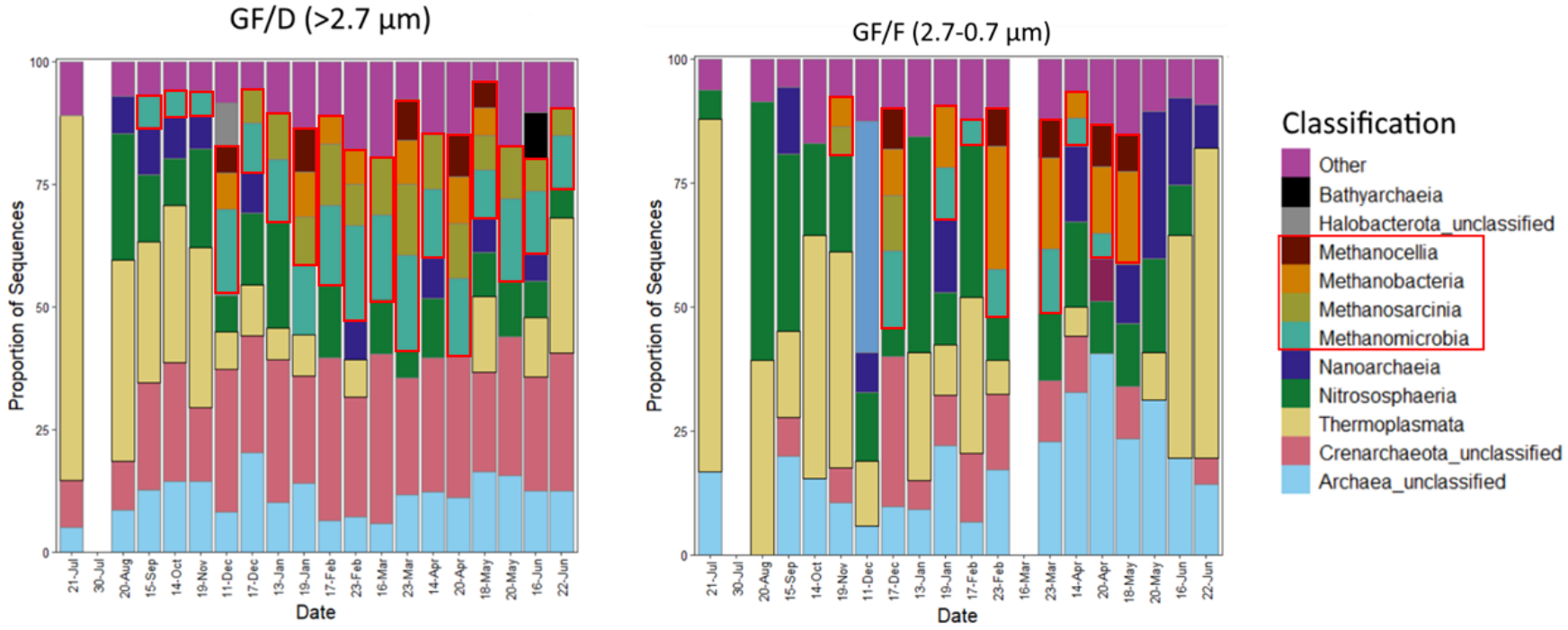
Most abundant in smallest size fraction (ISA p-val = 0.0012)

MGII

- Slightly more abundant at high tide (ISA p-val = 0.0015)
- More abundant in summer and fall (ISA p-val 1E-04)
- Big summer bloom, especially in smallest size fraction

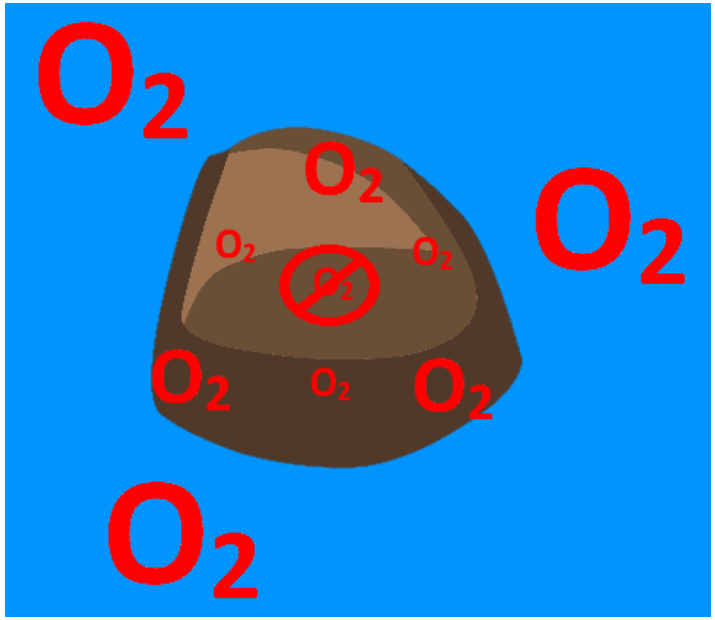


Methanogens



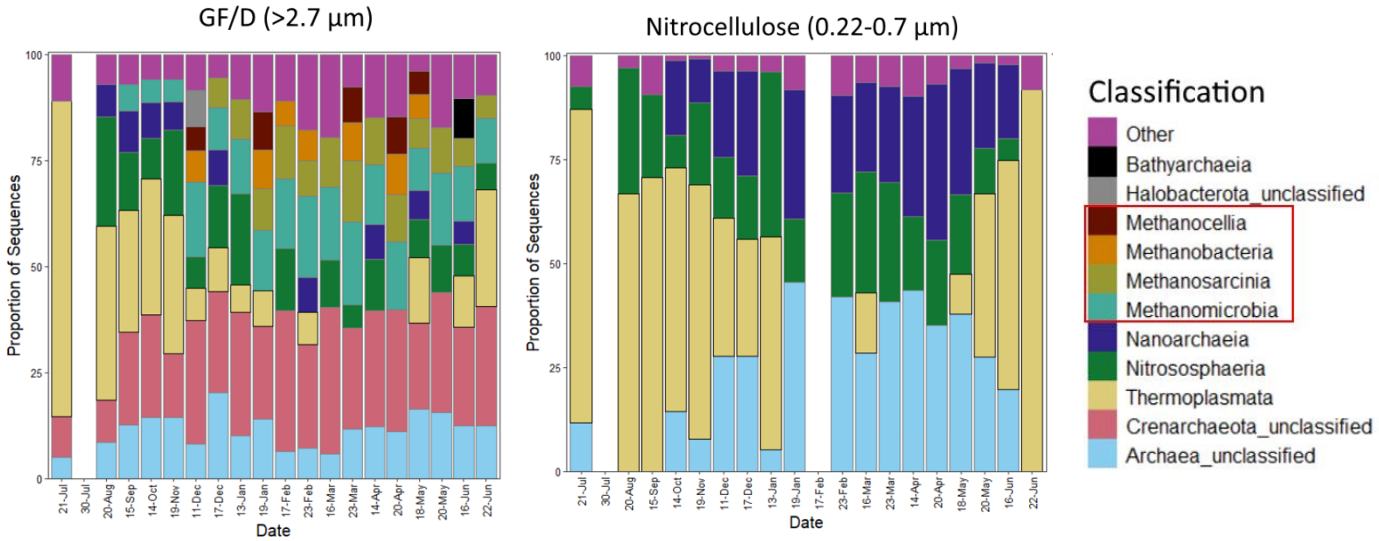
Particle Microhabitats

- Some metabolic strategies are oxygen-inhibited
- Particle interiors can be anoxic
- Particle-associated anaerobic microbes can carry out their metabolic activities



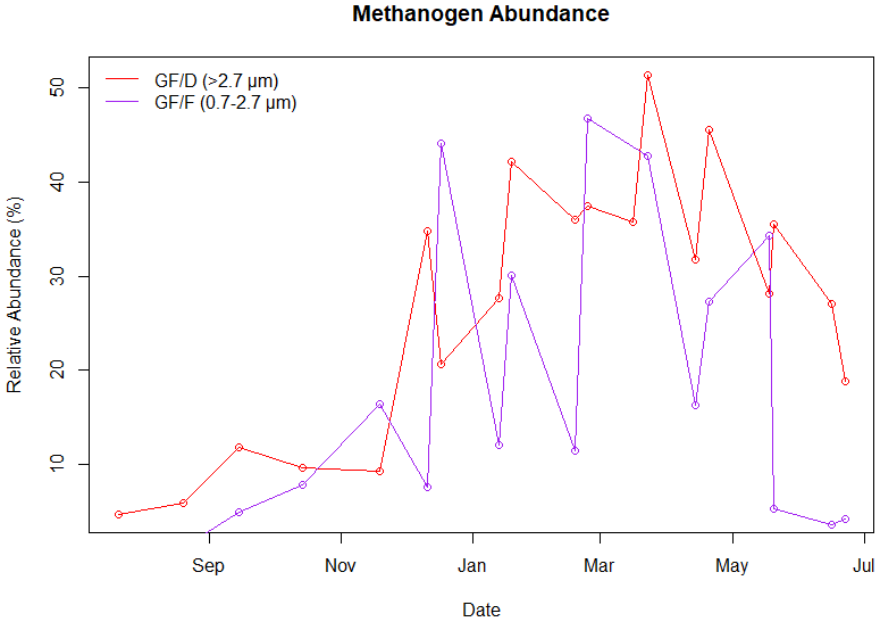
Methanogens

- Methanogens more abundant in larger size fractions
- Nearly absent in smaller
- Suggests use of particles, potential for active metabolism in water column



Methanogens

- More abundant in winter and spring (ISA p-vals 0.001-0.0024)
- No expectation of seasonal trends in sediment
- Caused by temperature? Unlikely, methanogens not inhibited by high temperature
- Actual decrease in abundance or increase in MGII abundance?



Implications of Methanogen Presence

- Potential for active methane production in water column
  - Less likely to be consumed before entering atmosphere?
- Uncertainty: magnitude of in-situ methane production

Conclusions

- Archaeal community of the Broadkill River water column more diverse than open ocean
  - Varies a lot over the year
- Big, important divide b/w particle-associated and free-living groups
- Methanogens are present and most abundant in spring/winter

Refs

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- Yoshimura, K. M., York, J., & Biddle, J. F. (2018). Impacts of salinity and oxygen on particle-associated microbial communities in the Broadkill River, Lewes DE. *Frontiers in Marine Science*, *5*(MAR). https://doi.org/10.3389/fmars.2018.00100
- Images: Wikimedia Commons, Google Earth

Thank you! Questions?