Salinity Tolerance in Cyanobacteria: evaluating assumptions in ancestral state reconstructions

Authors: Jennifer Reeve[1a] and Boswell Wing[1]
1: University of Colorado Boulder, Department of Geological Sciences
a: jennifer.reeve@colorado.edu

University of Colorado Boulder

Abstract: 327-266

The Context:
- Cyanobacteria drove Great Oxidation Event (GOE, 2.3 Gya)
- Did they evolve oxygenic photosynthesis just before GOE or long before?
- Some geochemical evidence says benthic lacustrine oxidations before GOE
- Ancestral state reconstructions (ASR) sometimes support freshwater origin which matches this evidence

The Question:
- ASR provides look into the past
- To date ASRs of cyanobacteria have viewed salinity as binary discrete trait
- Results for discrete don't always agree, maybe the answer is in the middle?

The Results:
- Discrete mapping gives fresh ancestor ~75% of runs and marine ancestor ~25% (Fig 1)
- Using simple assignment of optima (Fig 2) versus optima from distributions (Fig 3) yields similar results (estuarine origin)
- The continuous models show that the modern taxa seem to lose influence on the state of the ancestral nodes quickly
- These cases are still simplifying the reality of salinity tolerance to a large degree, in reality, growth can occur across a range of salinities (Fig 4)

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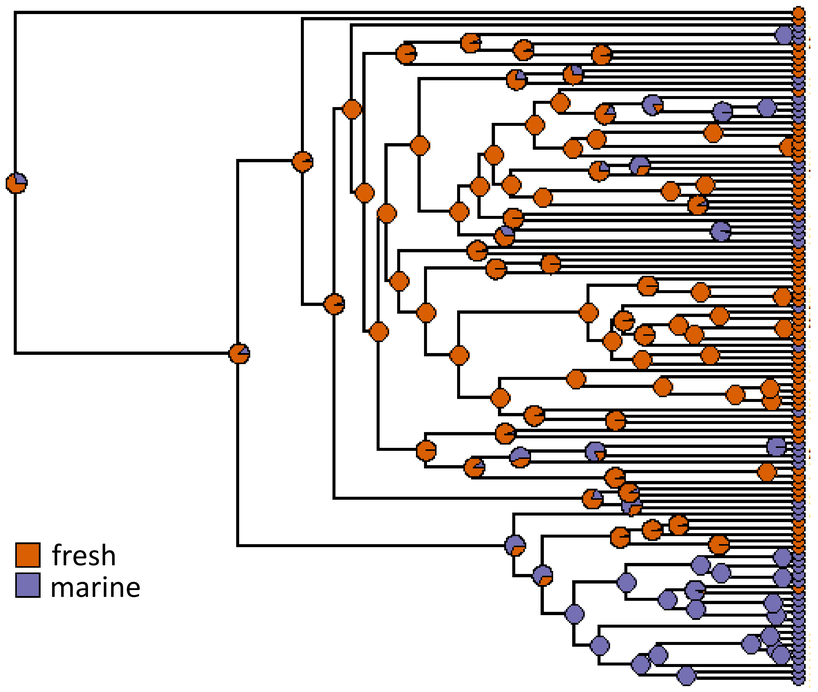

Figure 1: All-rates-differ model ASR mapping of salinity as a discrete trait based on habitat of isolation. Probabilities of node states shown in pie charts. Tree and character mapping from Uyeda et. al. 2016

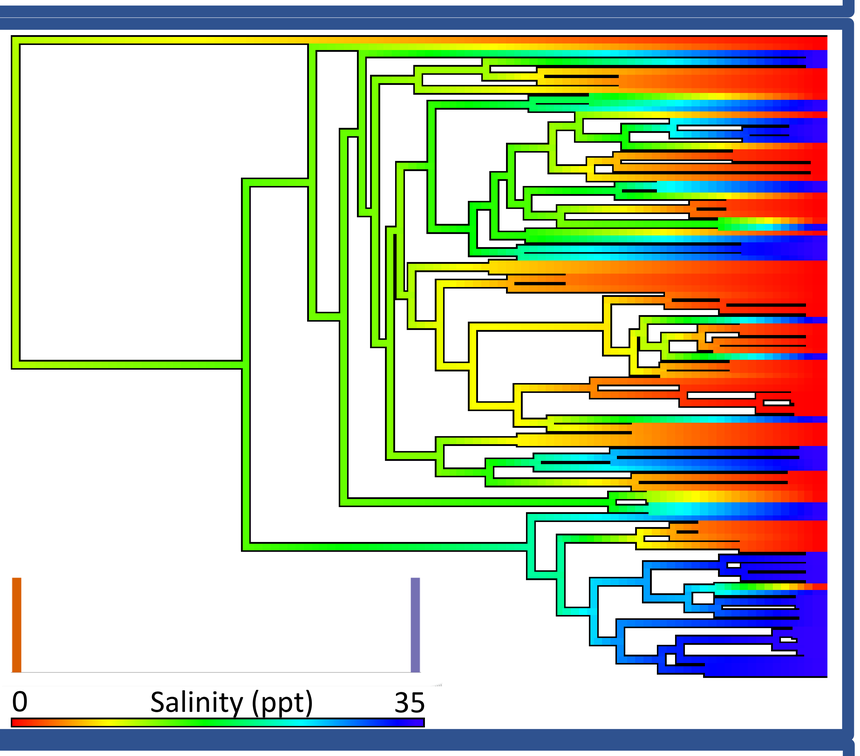

Figure 2: Maximum likelihood ASR of salinity as a continuous trait with optimum salinity of growth determined from habitat of isolation. Tip values assigned as fresh = 0 ppt (blue), marine = 35 ppt (orange).

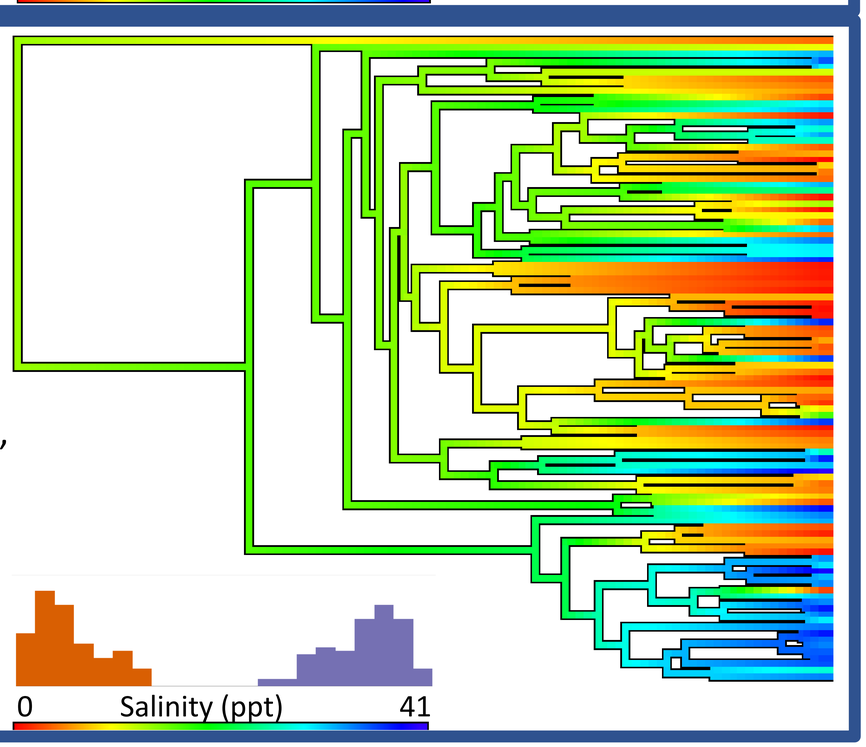

Figure 3: Maximum likelihood ASR of salinity as a continuous trait. Fresh salinities determined from bounded distribution (blue), marine from normal distribution with mean of 35 ppt (orange).

The Takeaway: Switching to continuous models of salinity produces estuarine ancestor. Using continuous models allows for the inclusion of more biological reality in future models.

Future Directions:
- Use known salinity optima for strains
- Use additional parameters from reaction norms
- Investigate influence of reaction norm on adaptation to changes in salinity

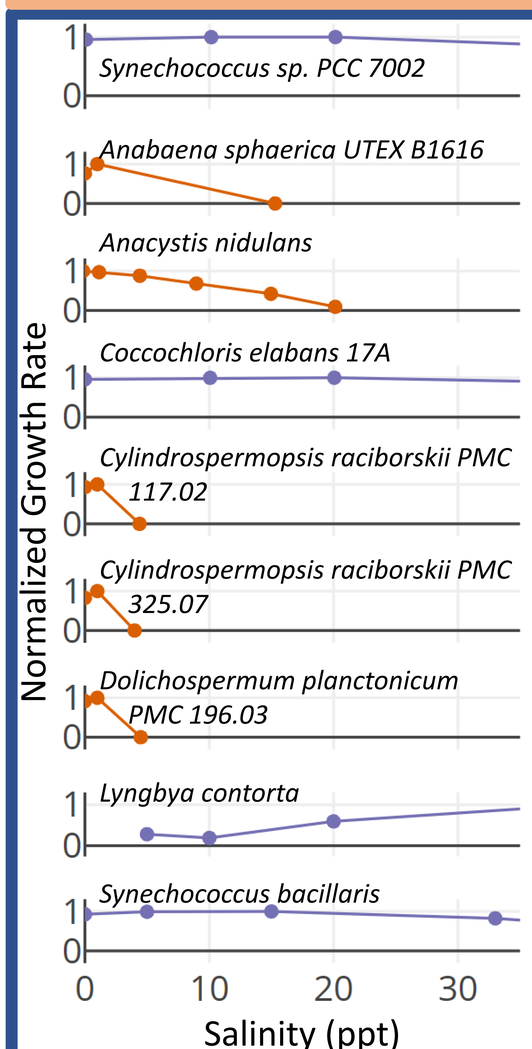

Figure 4: Growth of cyanobacterial strains across freshwater to marine salinity