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# Experimentally assessing the plasticity and evolution of cyanobacterial salinity tolerance

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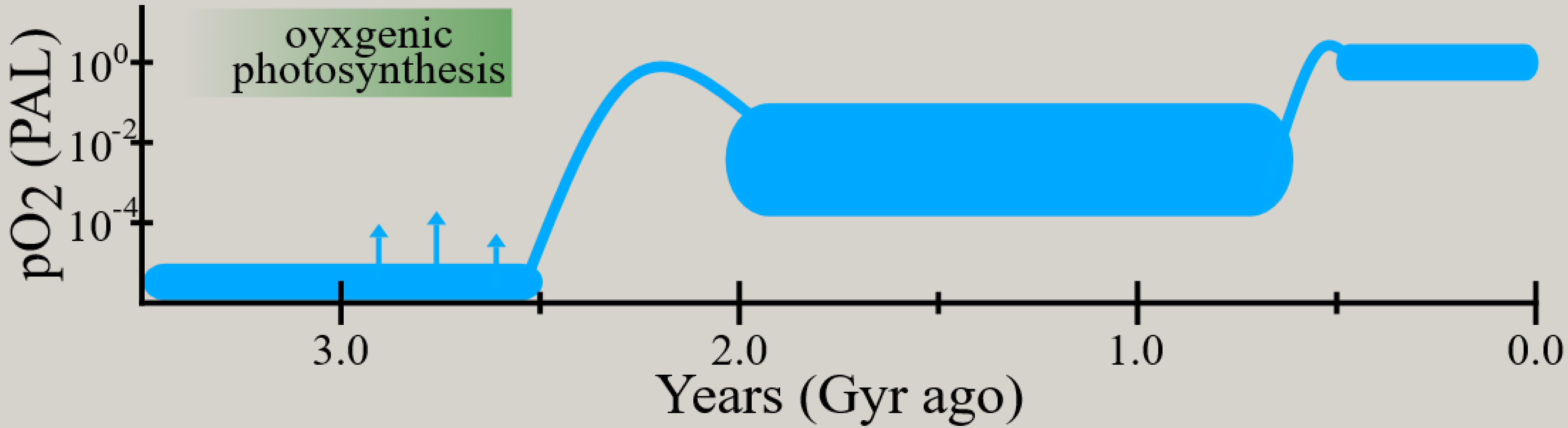
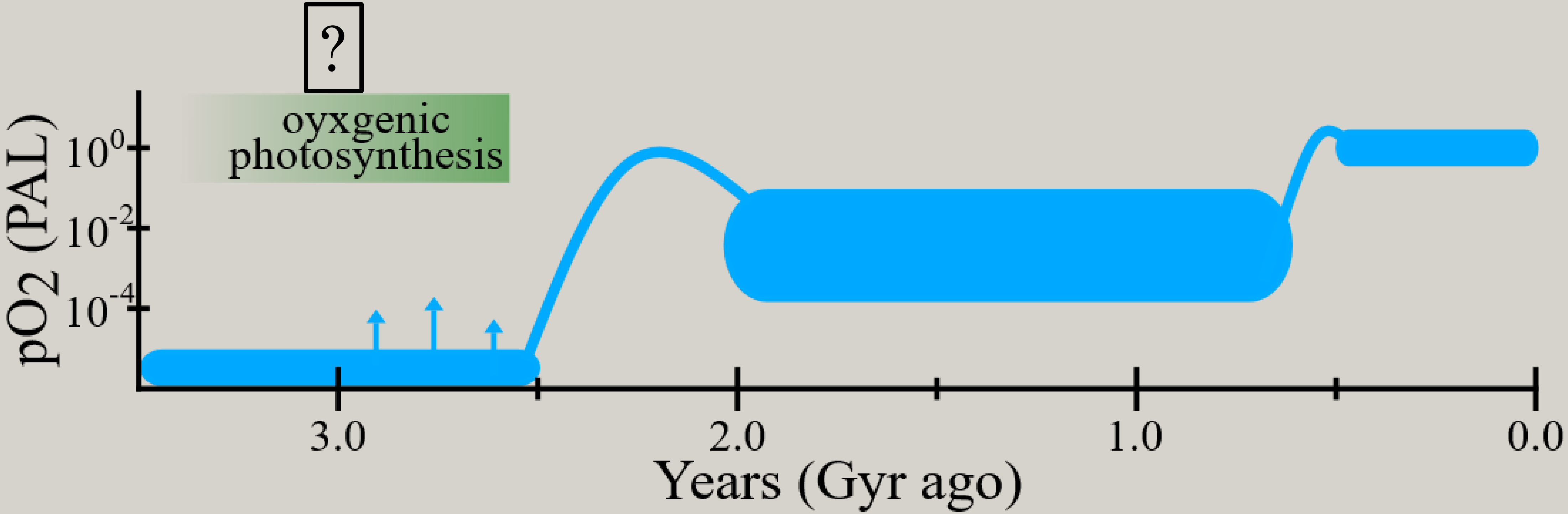
University of Colorado Boulder

AbSciCon 2022 – Recent Advances, Development and New Challenges in Understanding Early Life

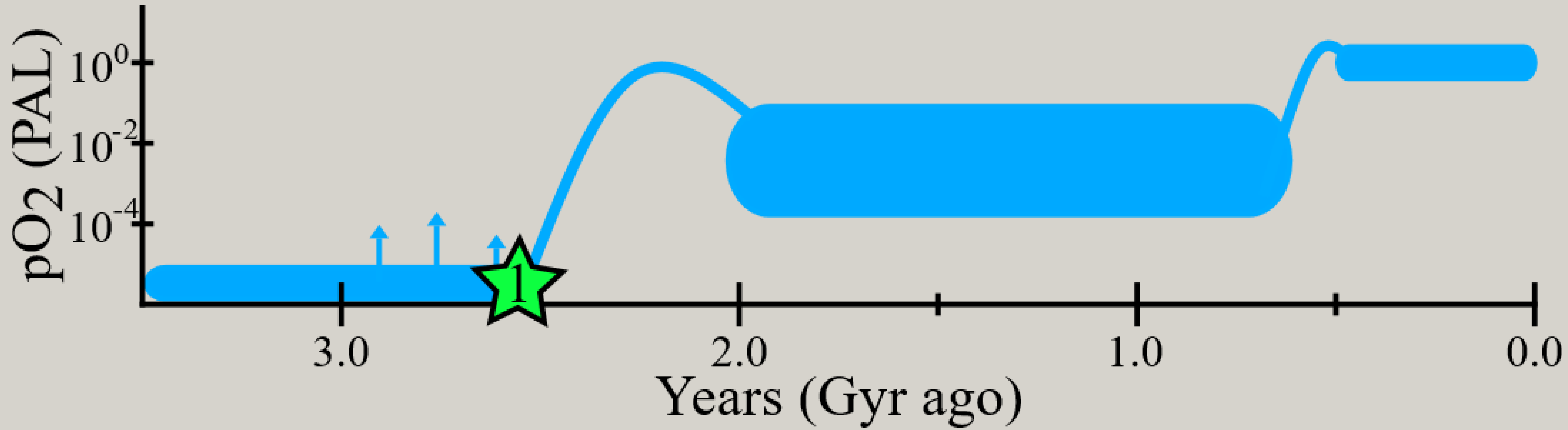
# Cyanobacteria and the Great Oxidation Event (GOE)



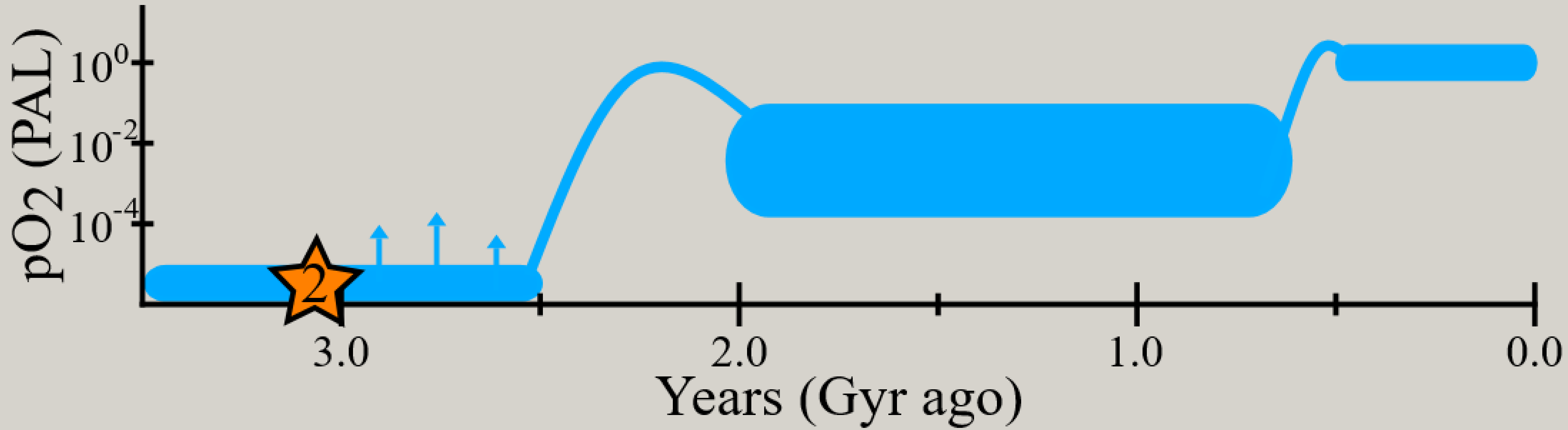
# There are competing hypotheses about the timing of the origin of oxygenic photosynthesis and the GOE



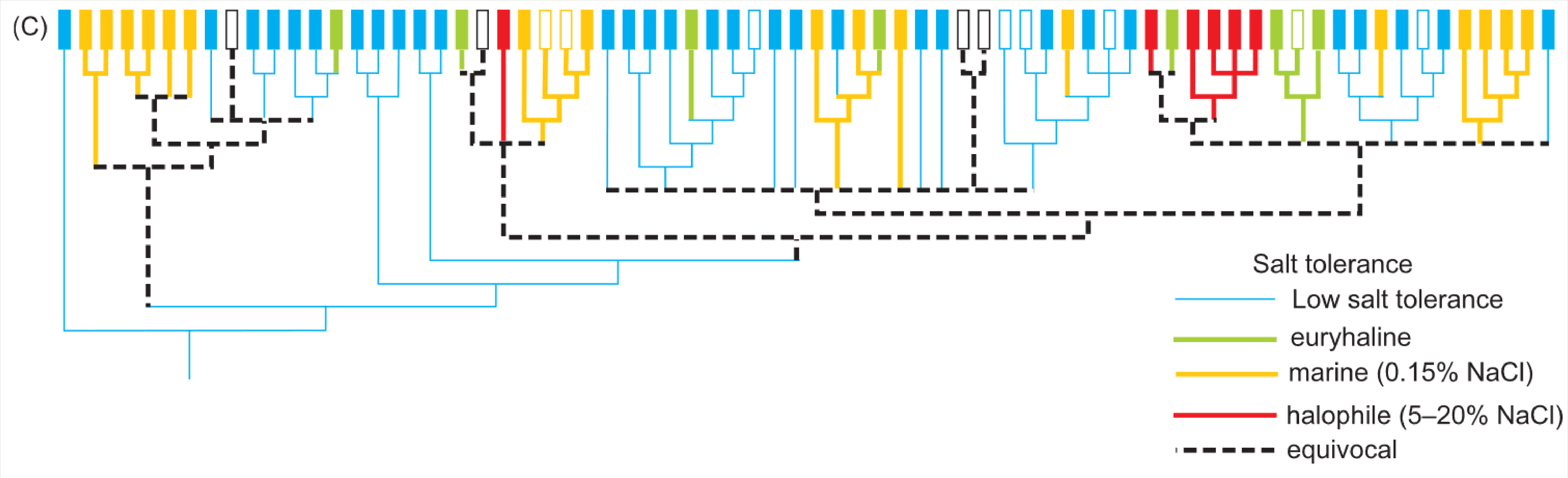
# Hypothesis 1: Oxygenic photosynthesis evolved just prior the GOE



# Hypothesis 2: Oxygenic photosynthesis evolved well before the GOE but was ecologically restricted



# The transition from terrestrial to marine environments has been posited as a major constraint




Sánchez-Baracaldo et. al. 2005

# Research questions

Does habitat predict salinity tolerance?

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Is salinity tolerance discrete?

We surveyed the literature to develop a database of cyanobacterial responses to changes in salinity

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| Papers | Species | Growth rates | Salinity range |
|---|---|---|---|
| > 20 | > 75 | > 1000 | 0 – 230 ppt |

Salt-Tolerant *Synechococcus elongatus* UTEX 2973 Obtained Engineering of Heterologous Synthesis of Compatible Solute Glucosylglycerol

Jinyu Cui[1,2,3†], Tao Sun[1,2,4†], Lei Chen[1,2,3*] and Weiwen Zhang[1,2,3,4*]

Responses of Cyanobacteria to Low Level Osmotic Stress: Implications for the Use of Buffers

By DEBORAH J. MOORE,[1*] ROBERT H. REED[1] AND WILLIAM D. P. STEWART[2]

*Anabaena* sp. to salt stress

M. N. Jha, G. S. Venkataraman* and B. D. Kaushik

Aquaculture Research, 2010, 41, 1348–1355 doi: 10.1111/j.1365-2109.2009.02423.x

**Effects of salinity on the growth and proximate composition of selected tropical marine periphytic diatoms and cyanobacteria**

Osmotic adjustment and organic solute accumulation in cyanobacteria from freshwater and marine habitats

R. H. Reed and W. D. P. Stewart

Photosynthetic pigment production and metabolic and lipidomic

AZRA BANO AND PIRZADA J. A. SIDDIQUI*

Carbohydrate Accumulation and Osmotic Stress in Cyanobacteria

By ROBERT H. REED,* DOUGLAS L. RICHARDSON, STEPHEN R. C. WARR AND WILLIAM D. P. STEWART

Multiphasic osmotic adjustment in a euryhaline cyanobacterium

(Osmotic stress, *Synechocystis*; carbohydrate accumulation; ion transport)

Robert H. Reed, Stephen R.C. Warr, Douglas L. Richardson *, Deborah J. Moore and William D.P. Stewart

*Synechococcus* sp.

Influence of salinity on the growth and biochemical composition of the cyanobacterium *Synechococcus* sp.

Néstor Rosales, José Ortega, Roberta Mora, Ever Morales*

Growth and morphology of *Anabaena* strains (Cyanophyceae, Cyanobacteria) in cultures under different salinities

B.K. Stulp & W.T. Stam

Proteomic analyses of the cyanobacterium *Arthrospira* (*Spirulina*) *platensis* under iron and salinity stress

Mostafa M.S. Ismaiel[a,b,*], Michele D. Piercey-Normore[a], Christof Rampitsch[c]

Effect of salinity on some physiological and biochemical responses in the cyanobacterium *Synechococcus elongatus*

Maryam Rezayian[1,2], Vahid Niknam[2], and Mohammad Ali Faramarzi[1,*]

Effect of Carbon Content, Salinity and pH on *Spirulina platensis* for Phycocyanin, Allophycocyanin and Phycoerythrin Accumulation

Gaurav Sharma[1], Manoj Kumar[2], Mohammad Irfan Ali[1] and Nakuleshwar Dut Jasuja[1*]

Salt effects on 77K fluorescence and photosynthesis in the cyanobacterium *Synechocystis* sp. PCC 6803

Hendrik Schubert and Martin Hagemann

Synthesis of glucosylglycerol in salt-stressed cells of the cyanobacterium *Microcystis firma**

M. Hagemann, N. Erdmann, and E. Wittenburg

Antioxidative responses of *Nostoc ellipsosporum* and *Nostoc piscinale* to salt stress

Maryam Rezayian[1] · Vahid Niknam[1] · Mohammad Ali Faramarzi[2]

of salinity on growth, pigmentation, $N_2$ on and alkaline phosphatase activity of cultured *Trichodesmium* sp.

Fei-Xue Fu*, P. R. F. Bell

*vstis* PCC6803: a euryhaline cyanobacterium

D.L. Richardson, R.H. Reed and W.D.P. Stewart

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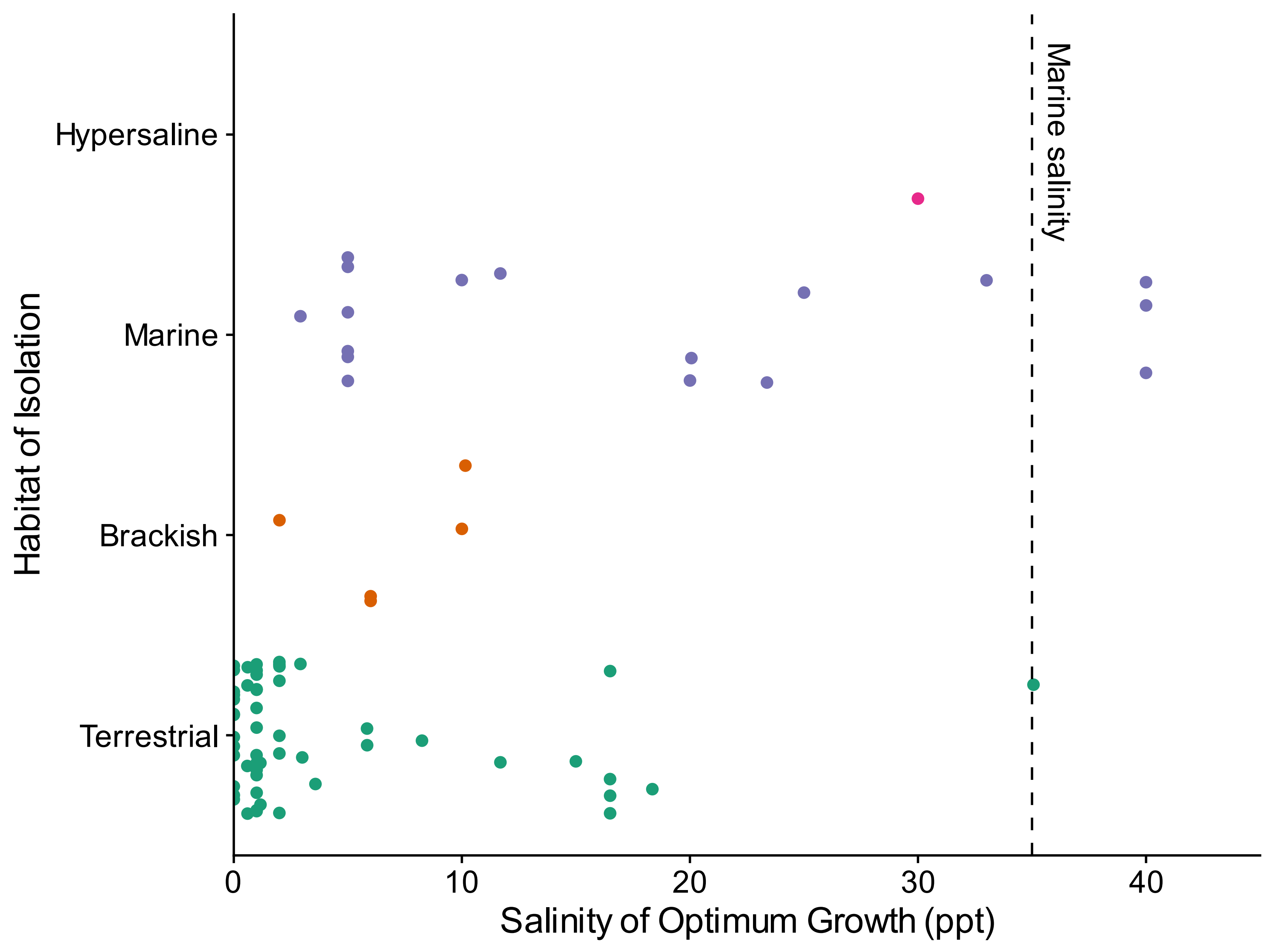

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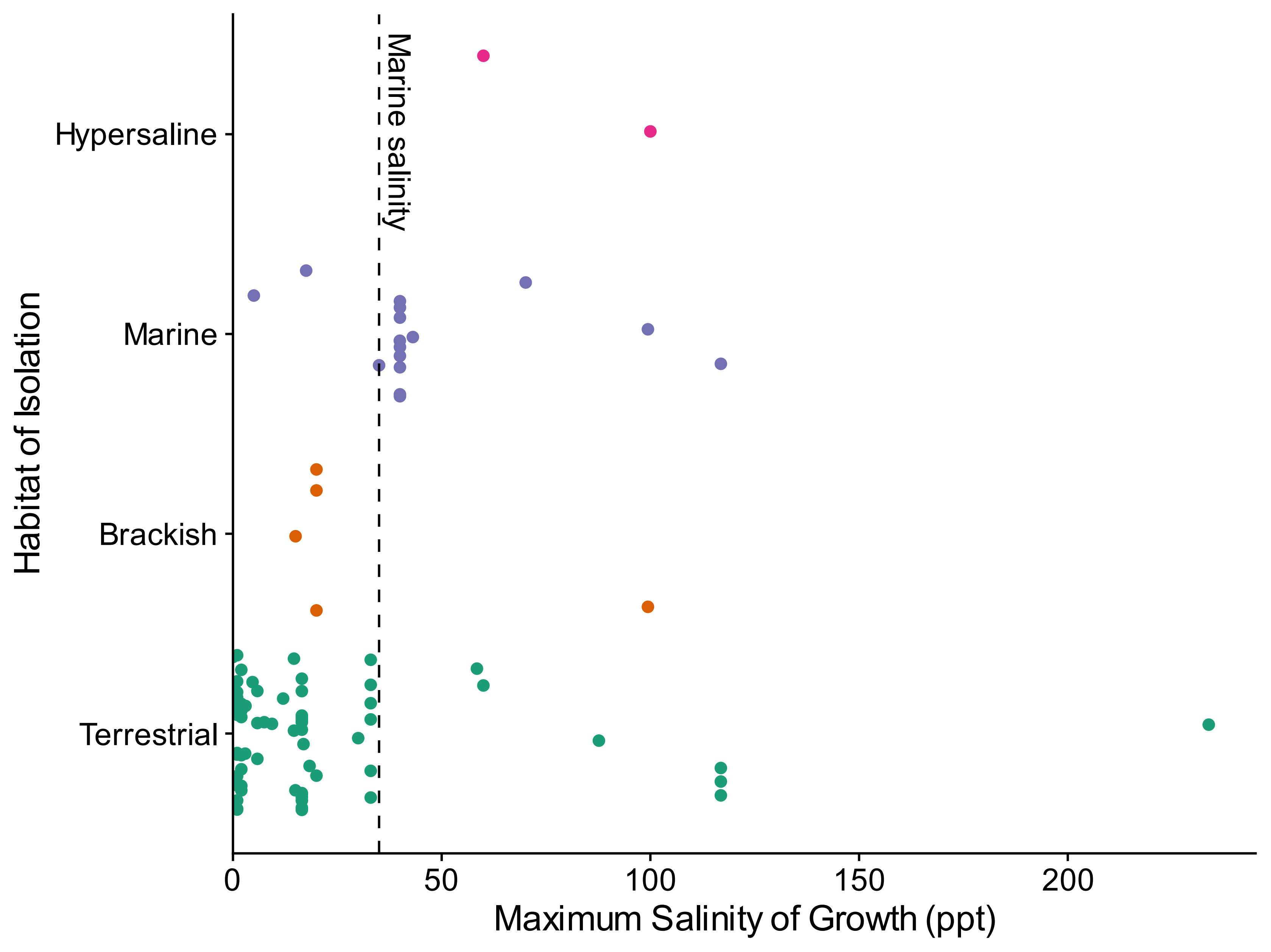

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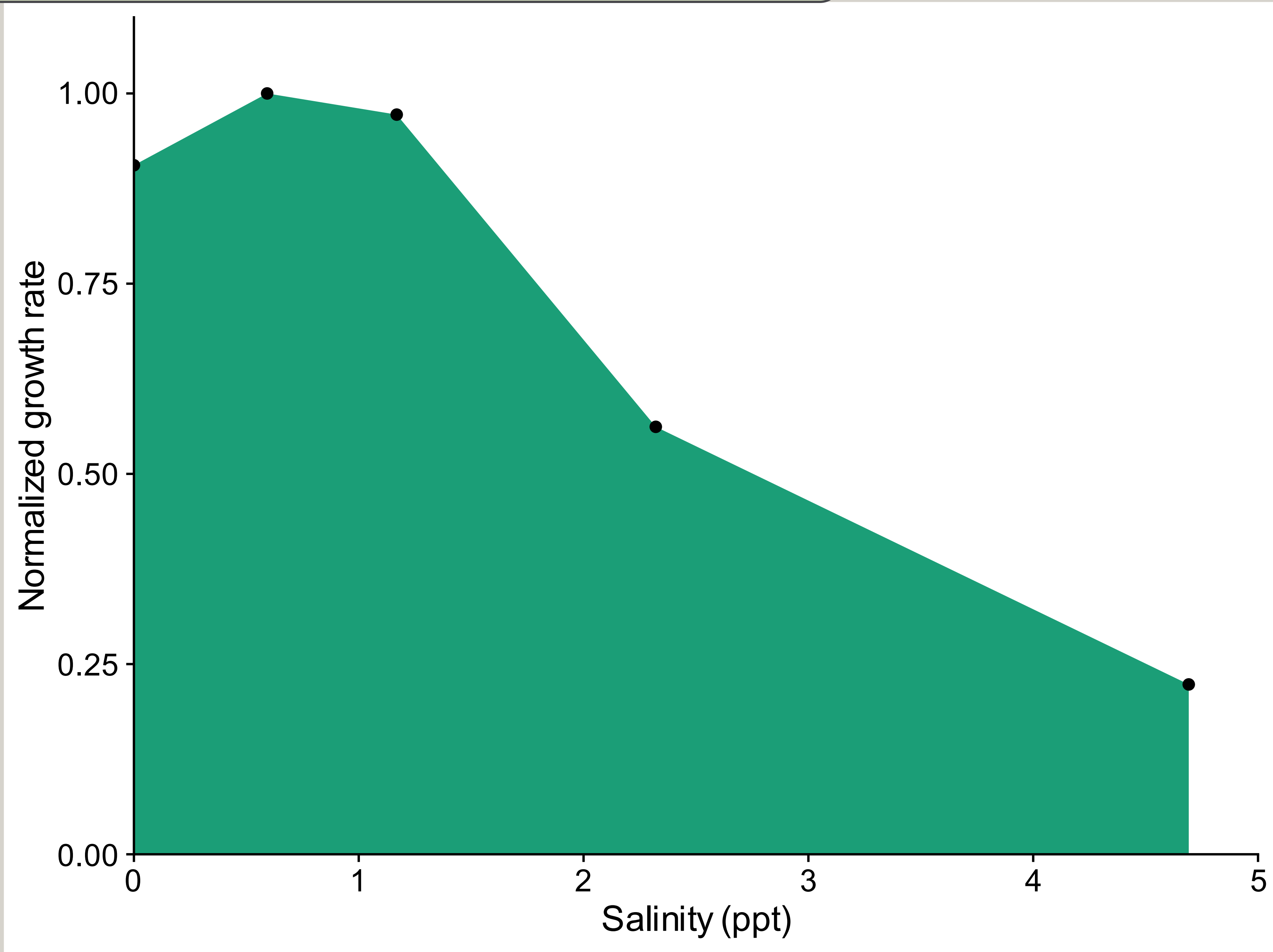

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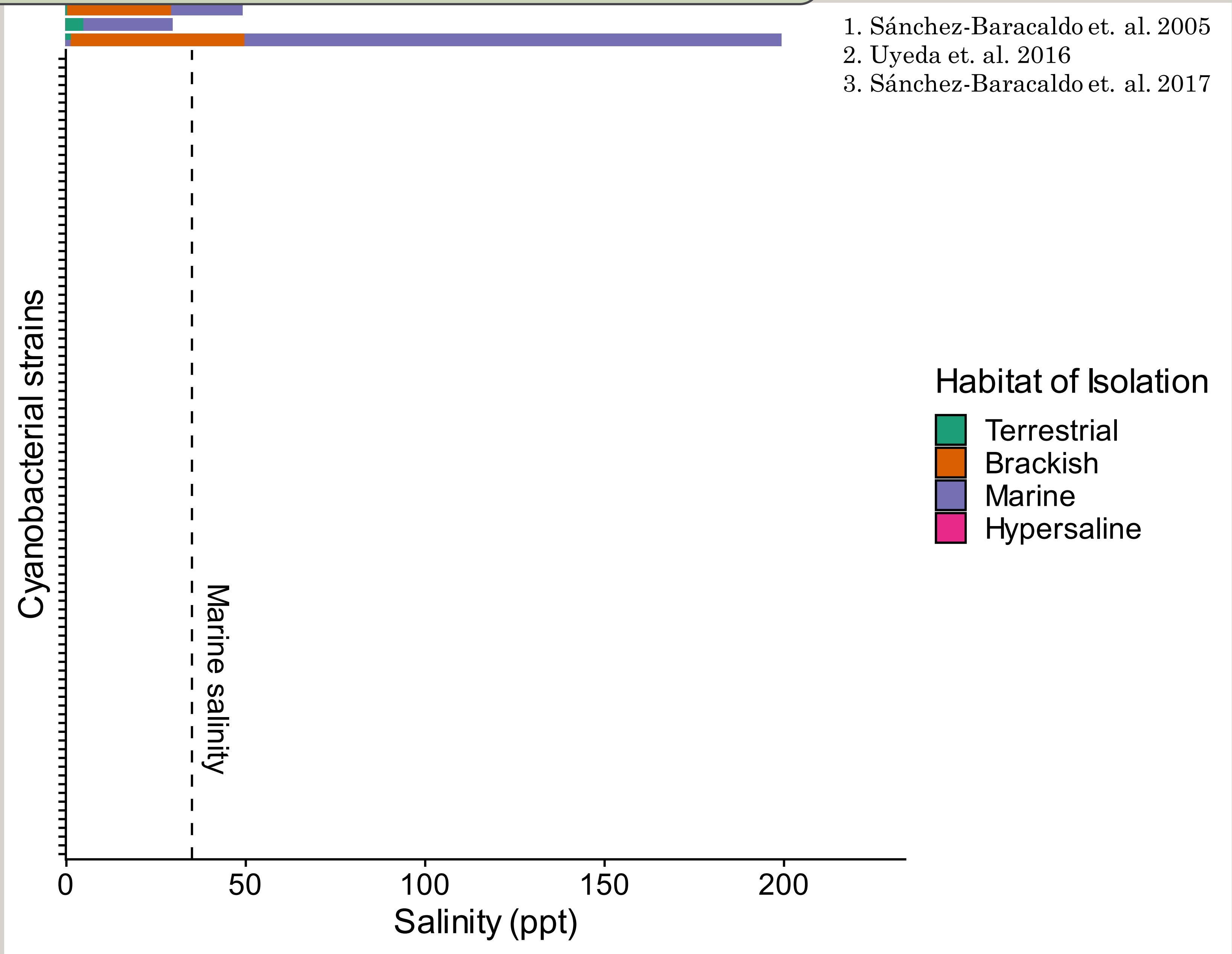

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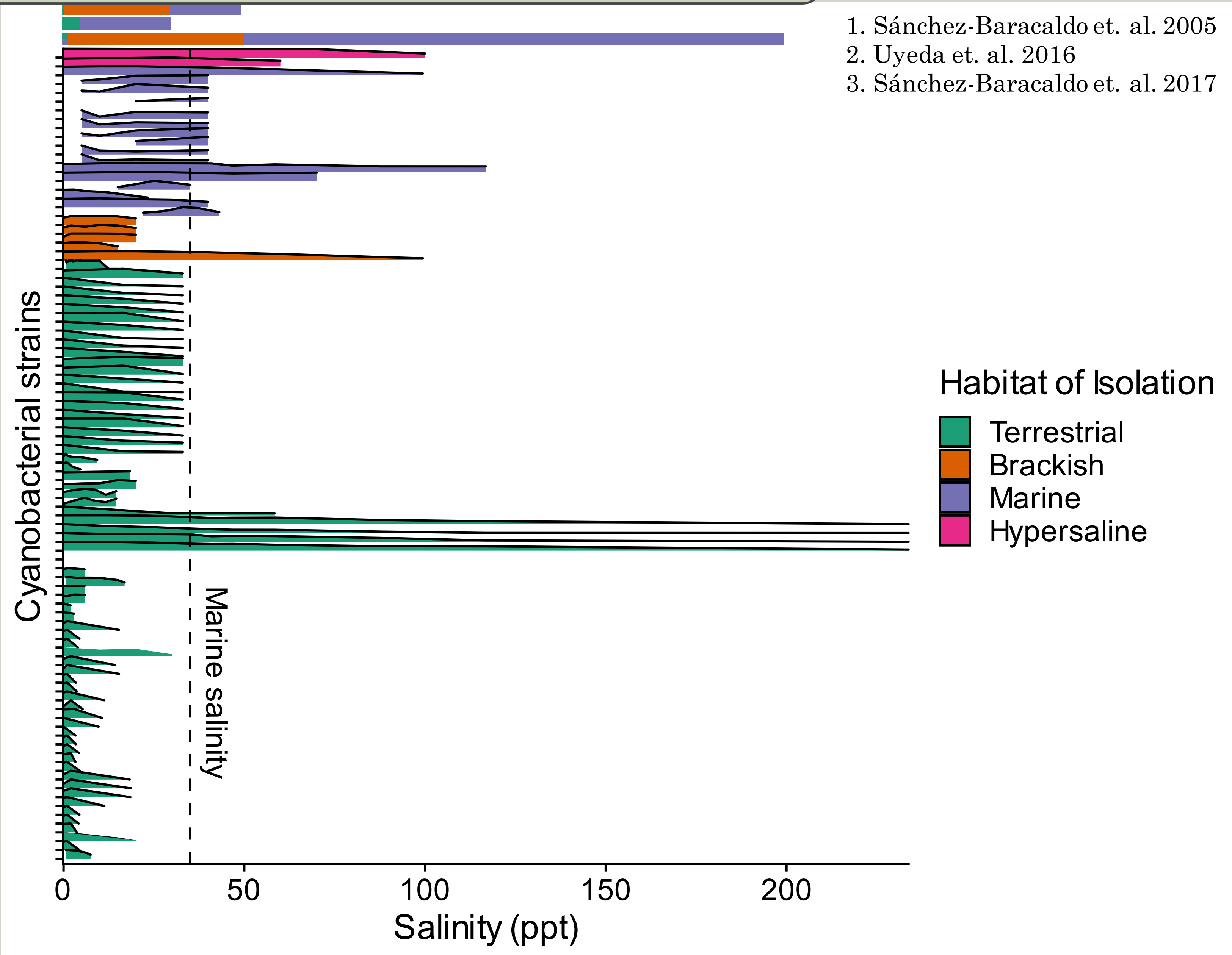



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2. Uyeda et. al. 2016
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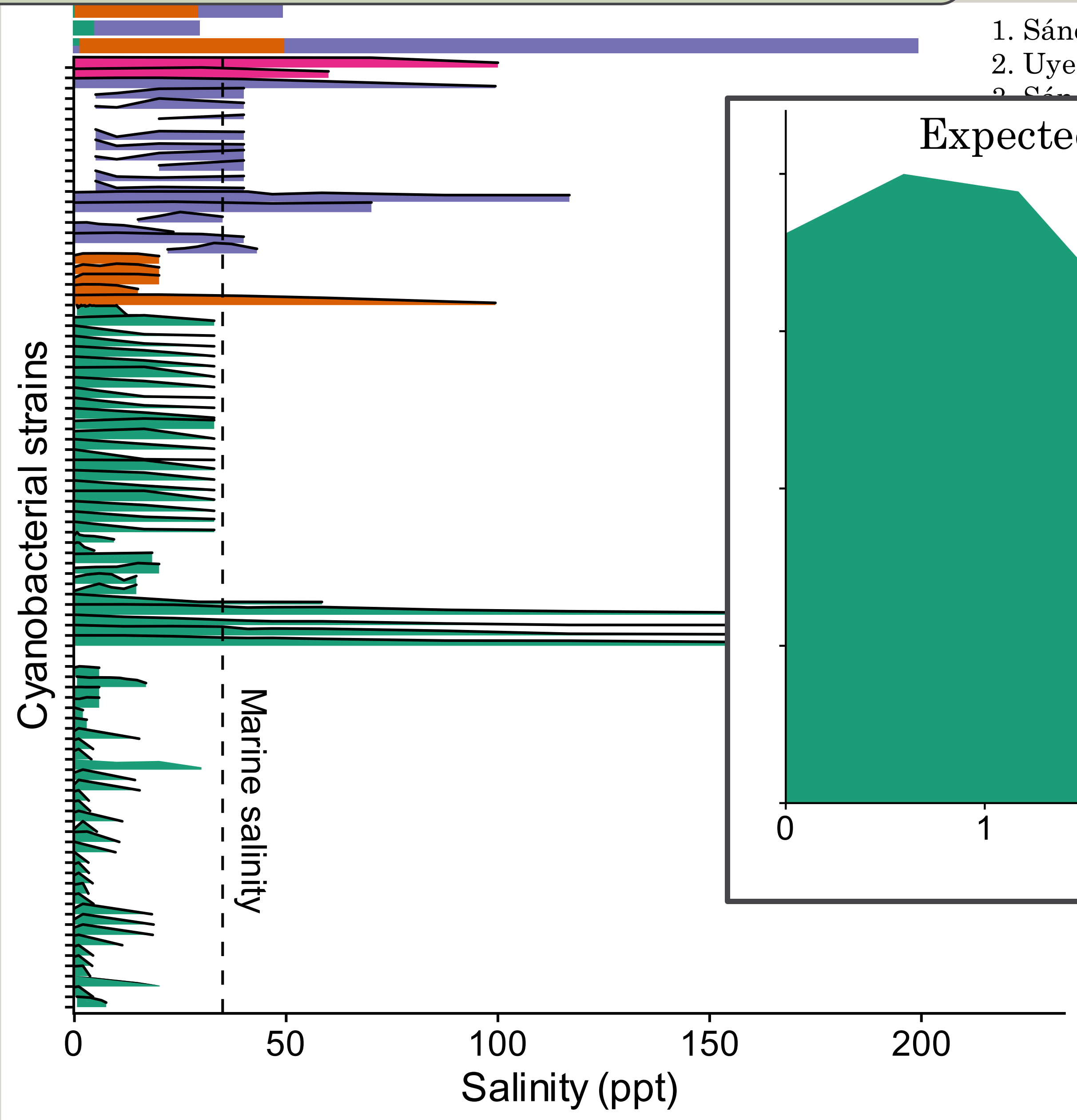


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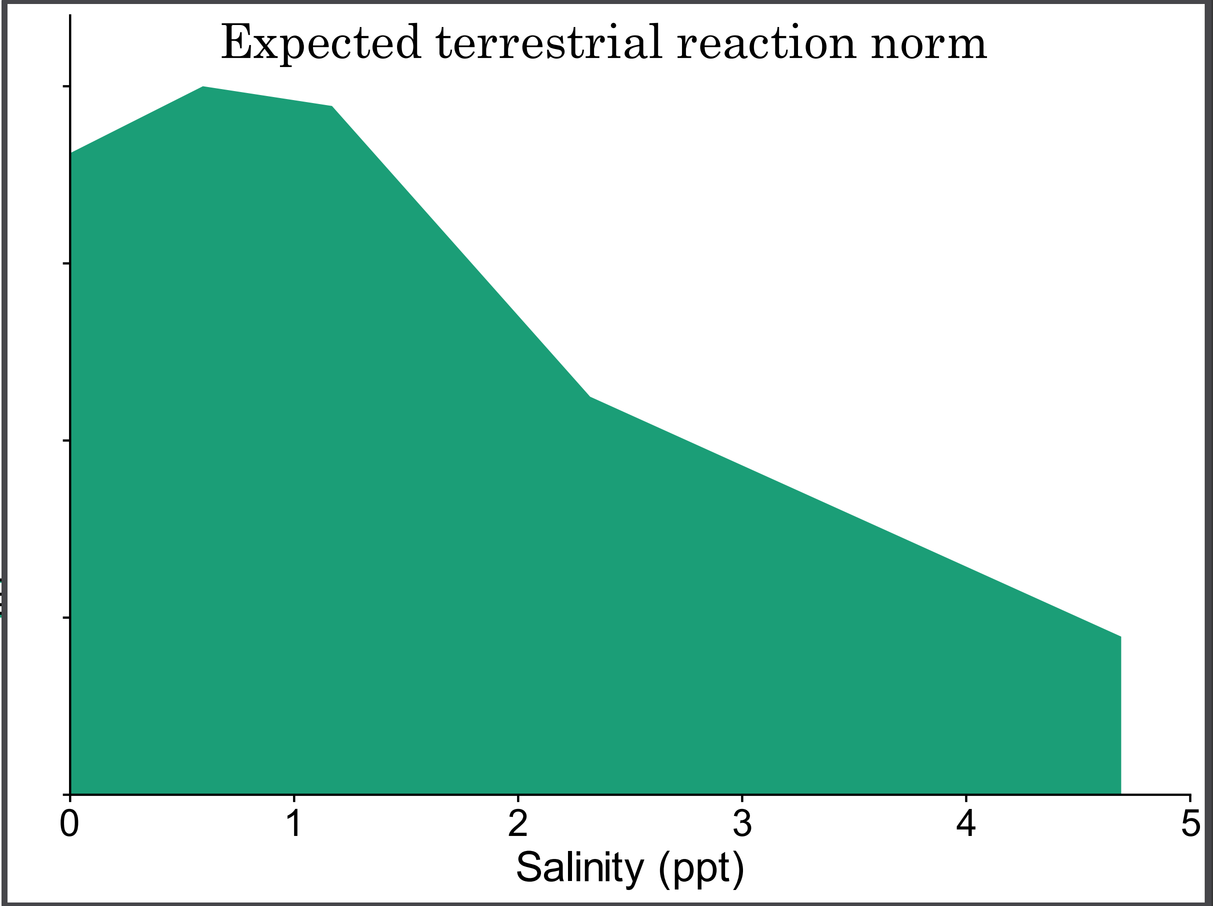

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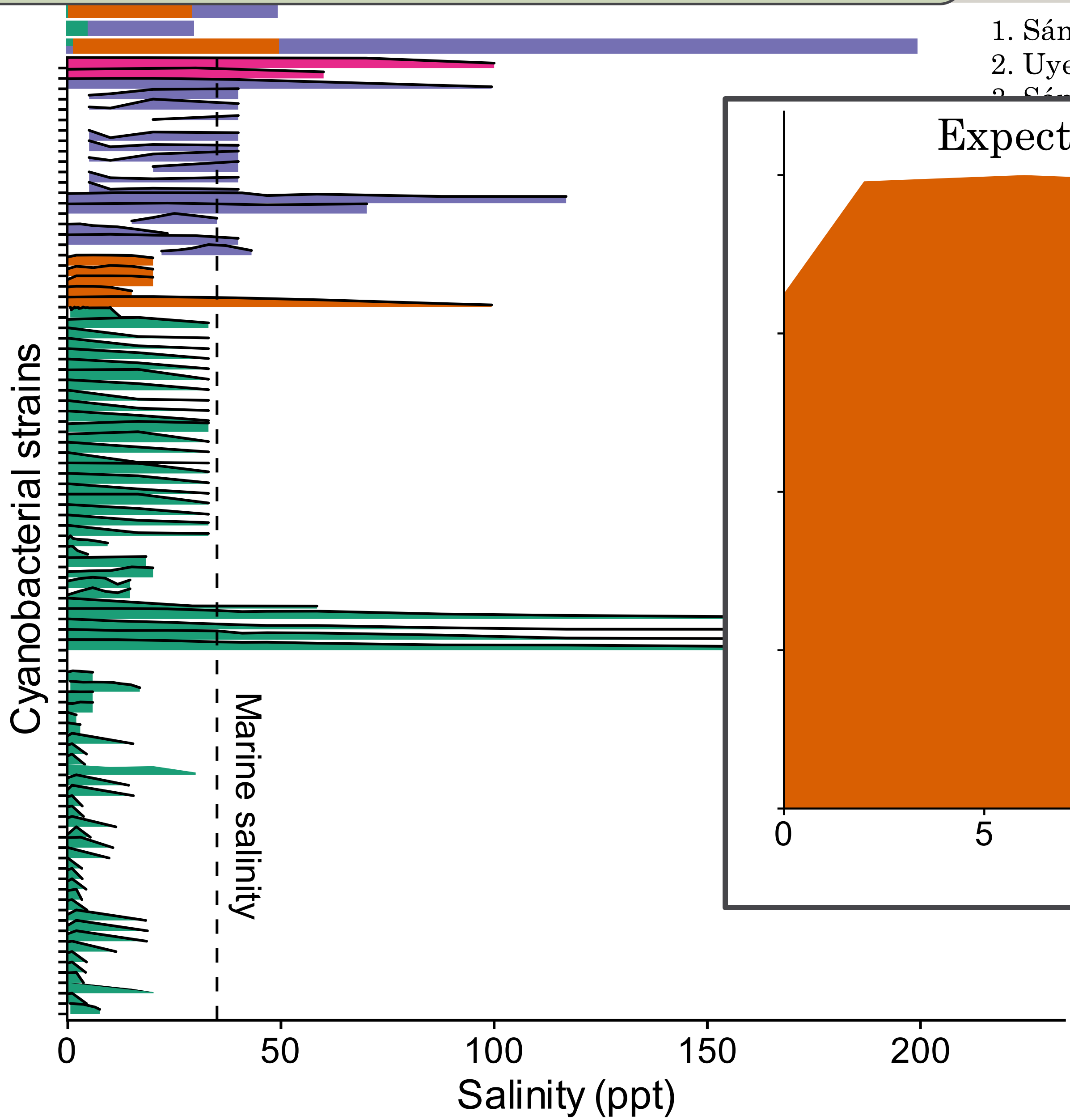


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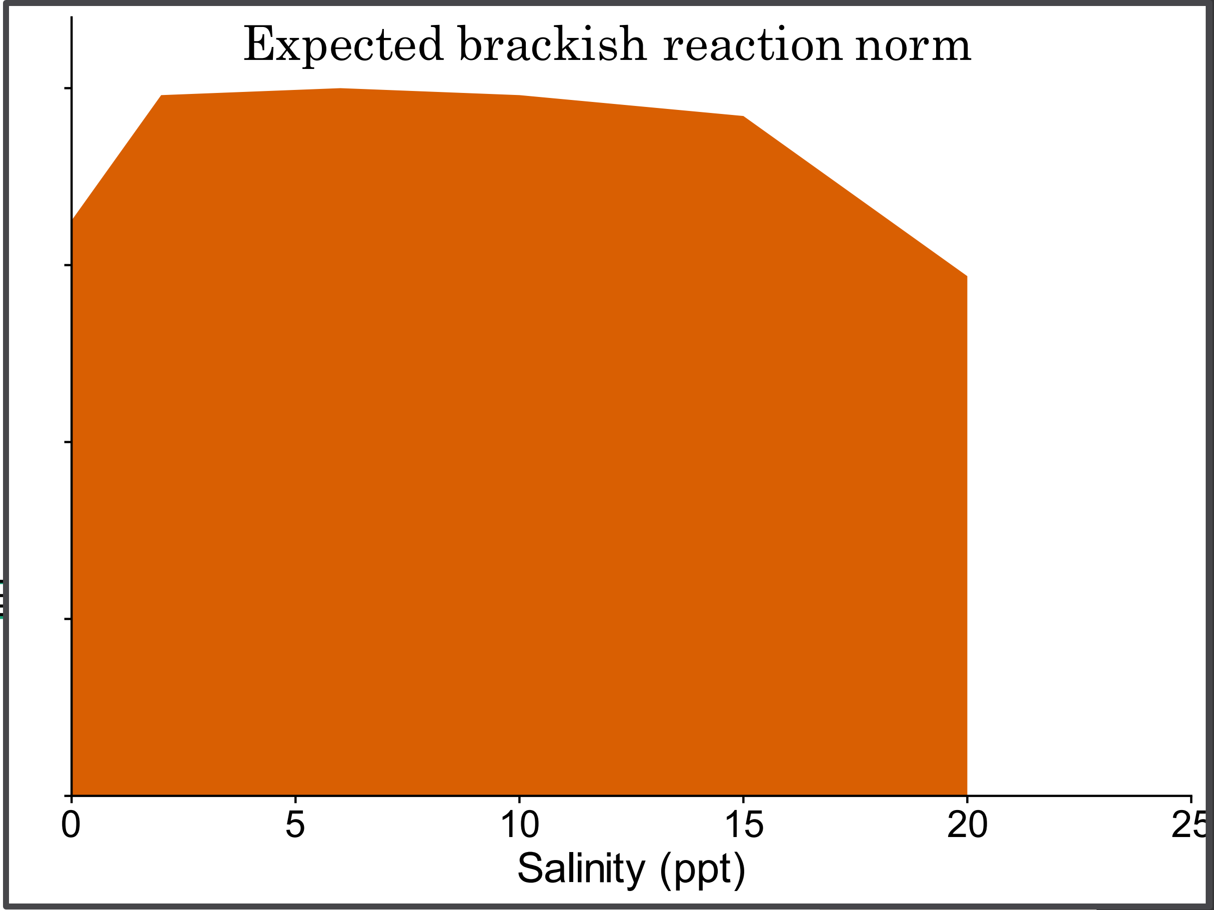

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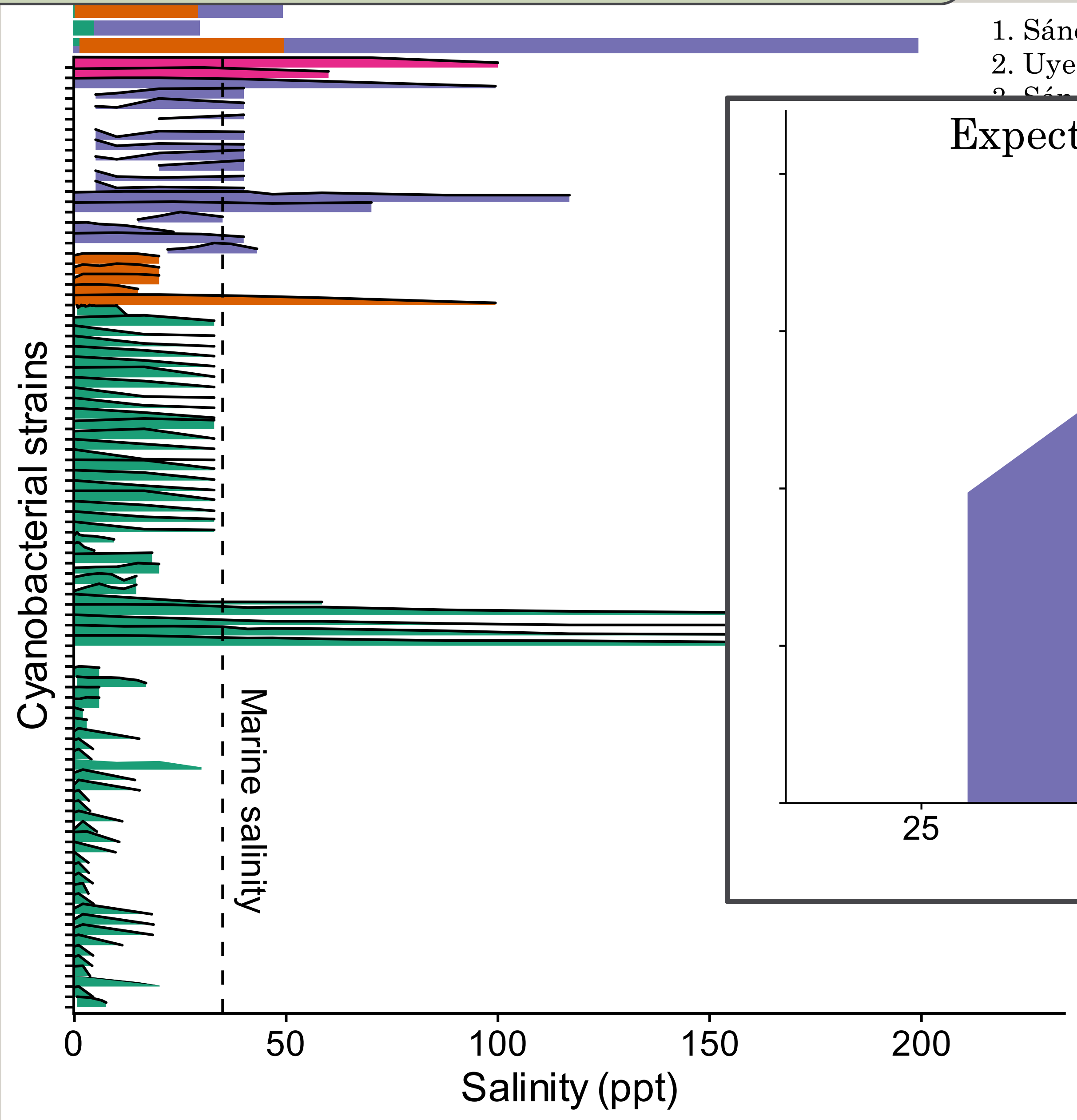



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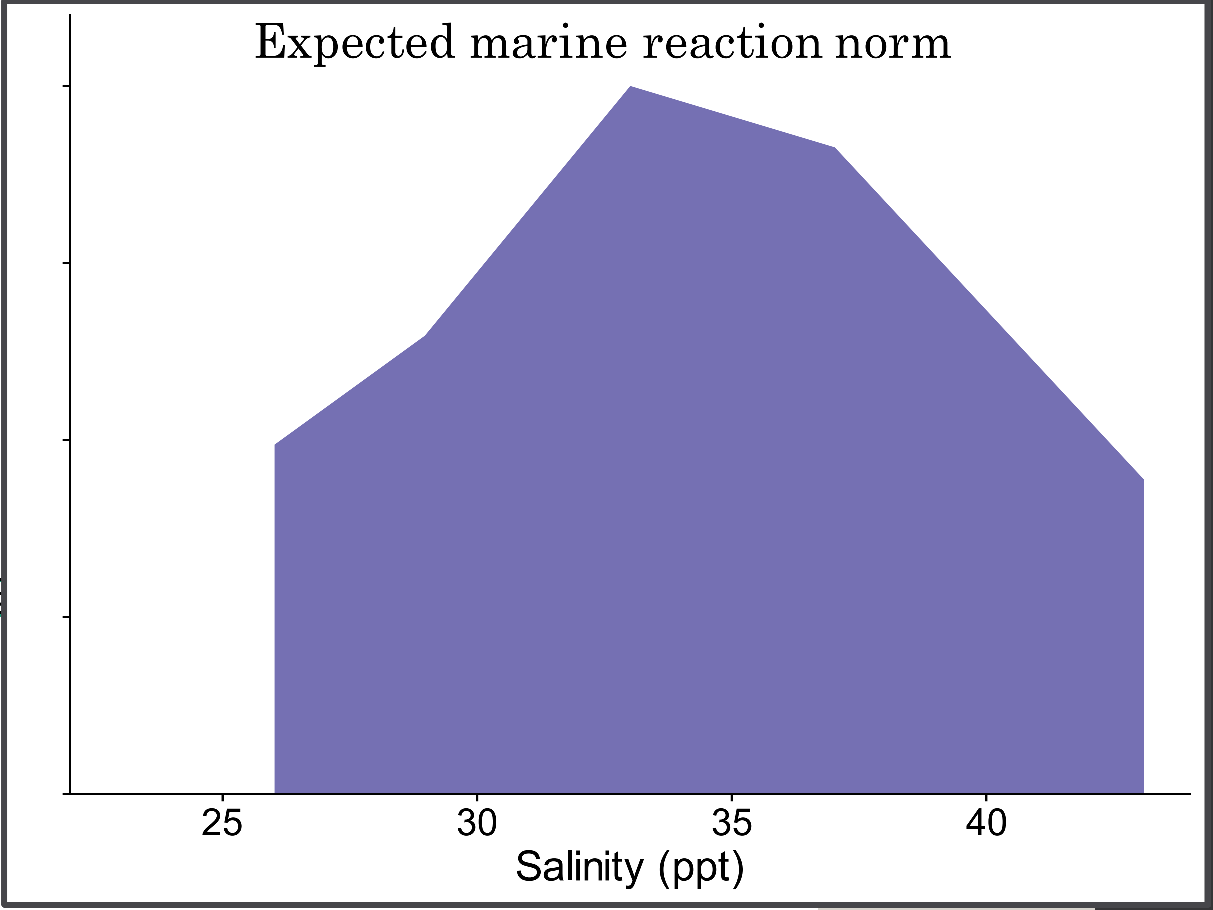

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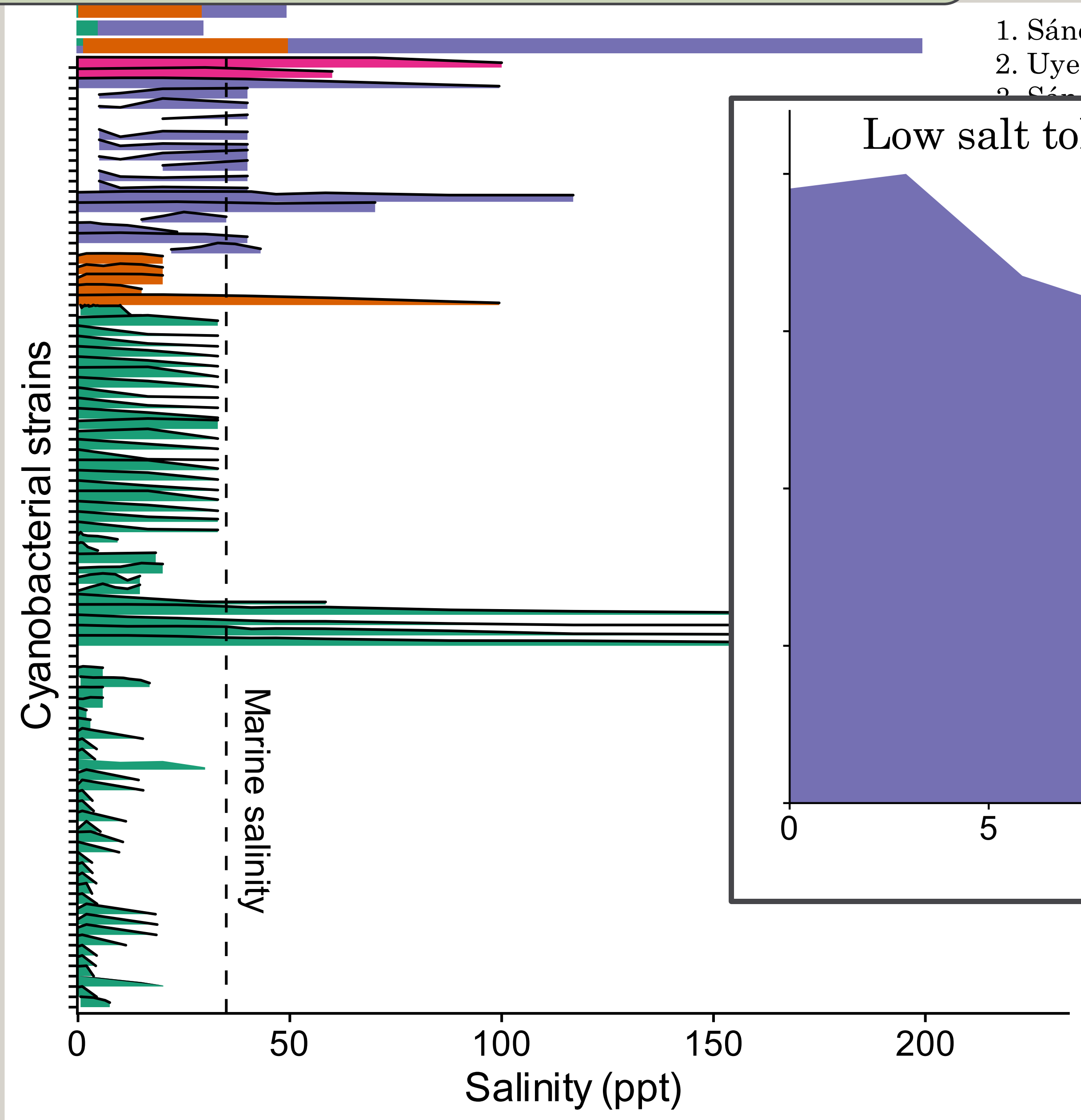


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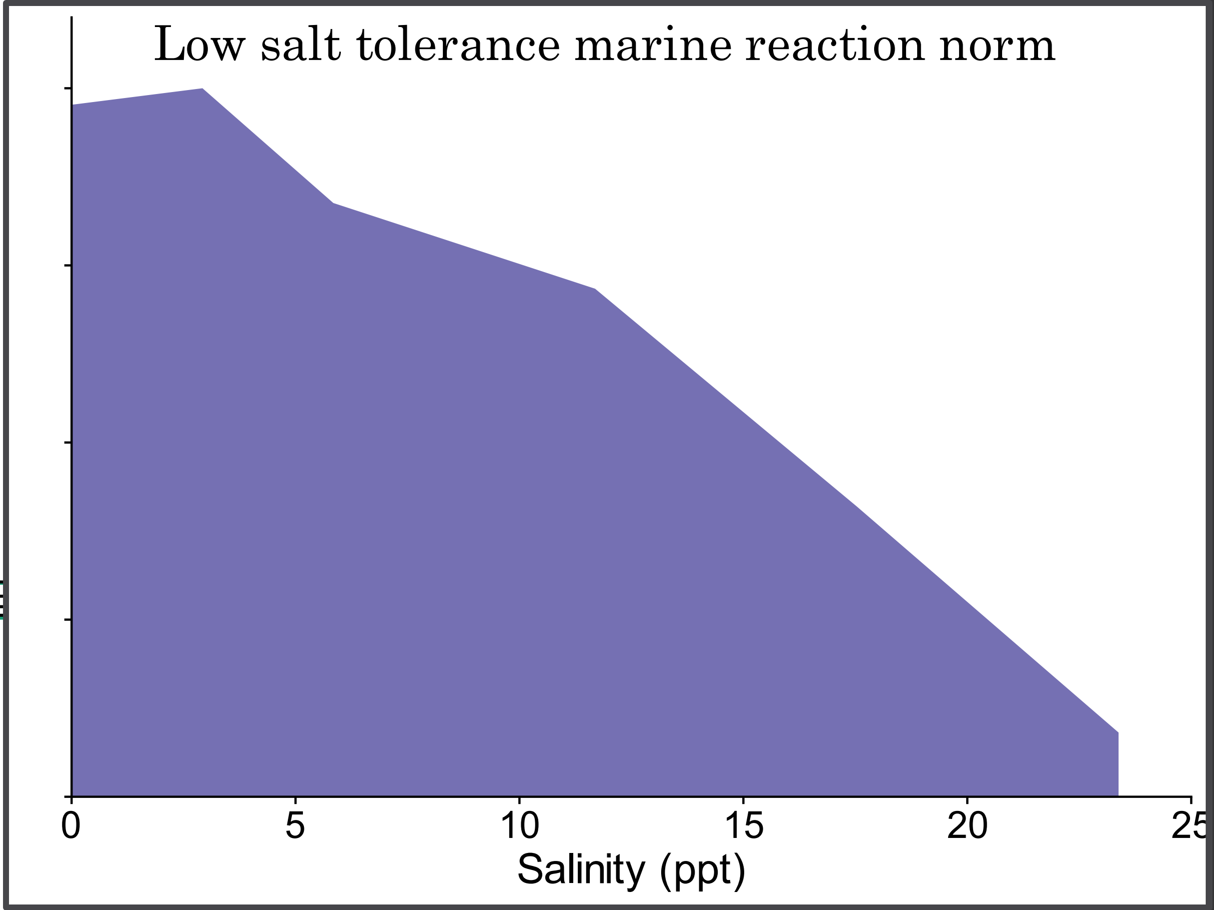

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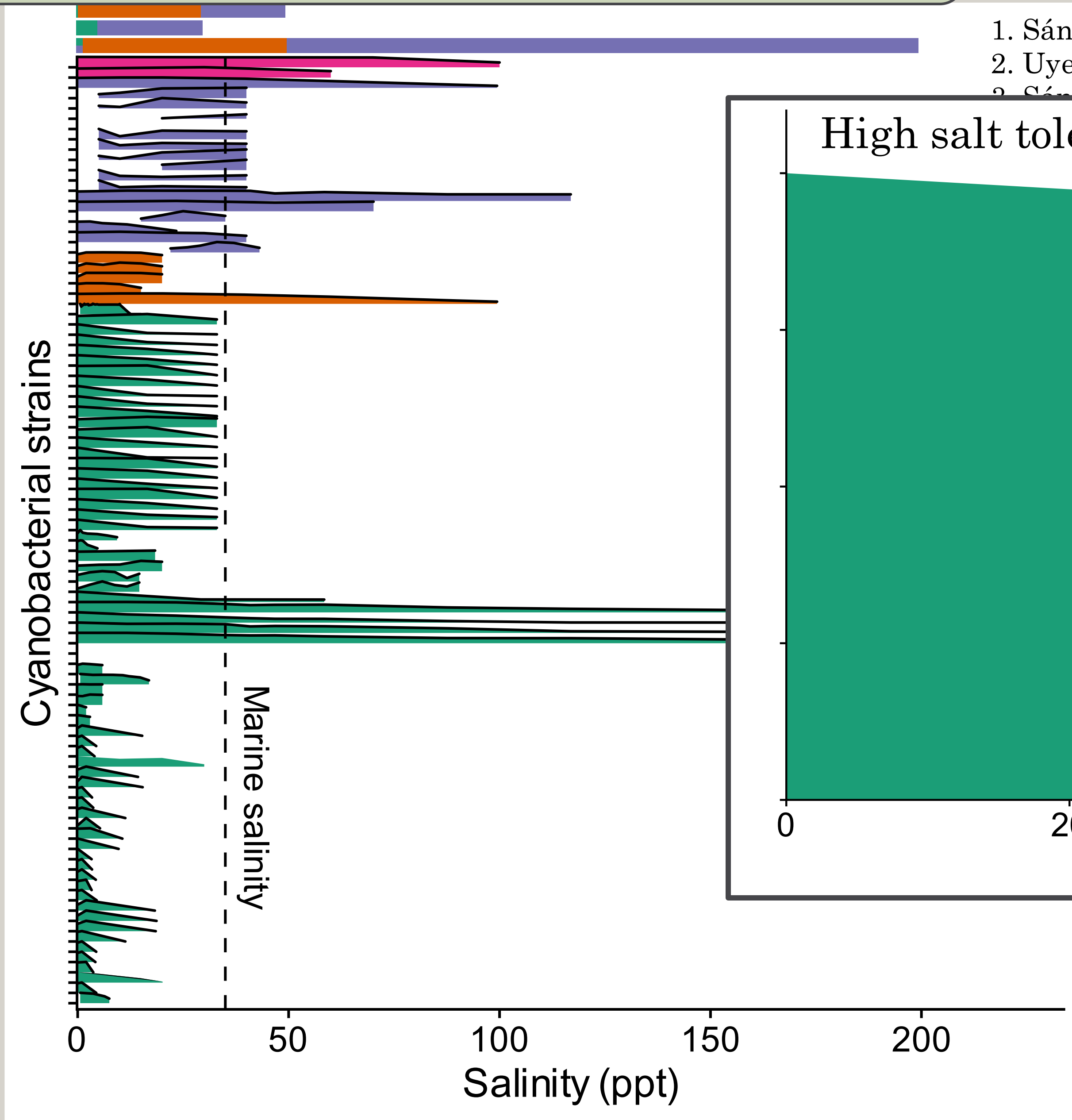


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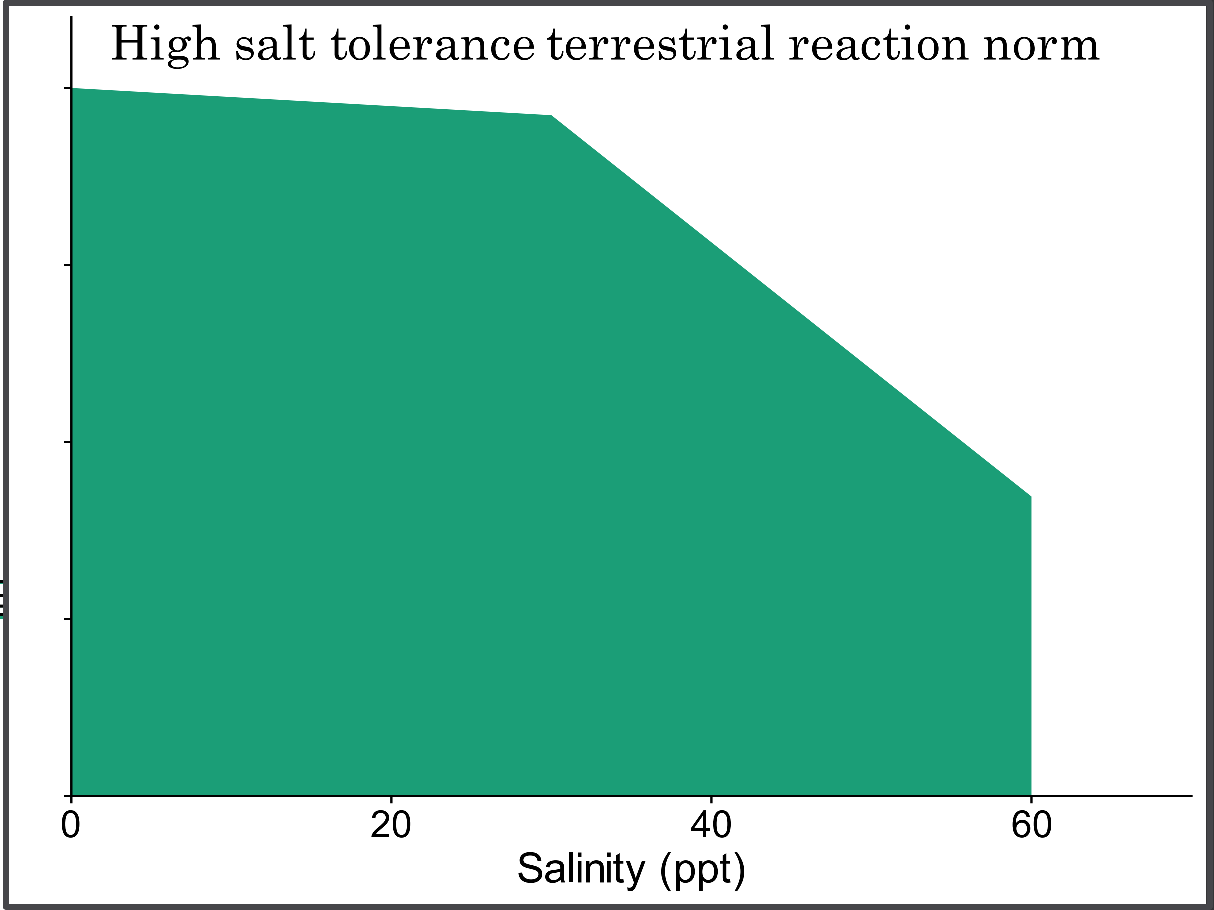

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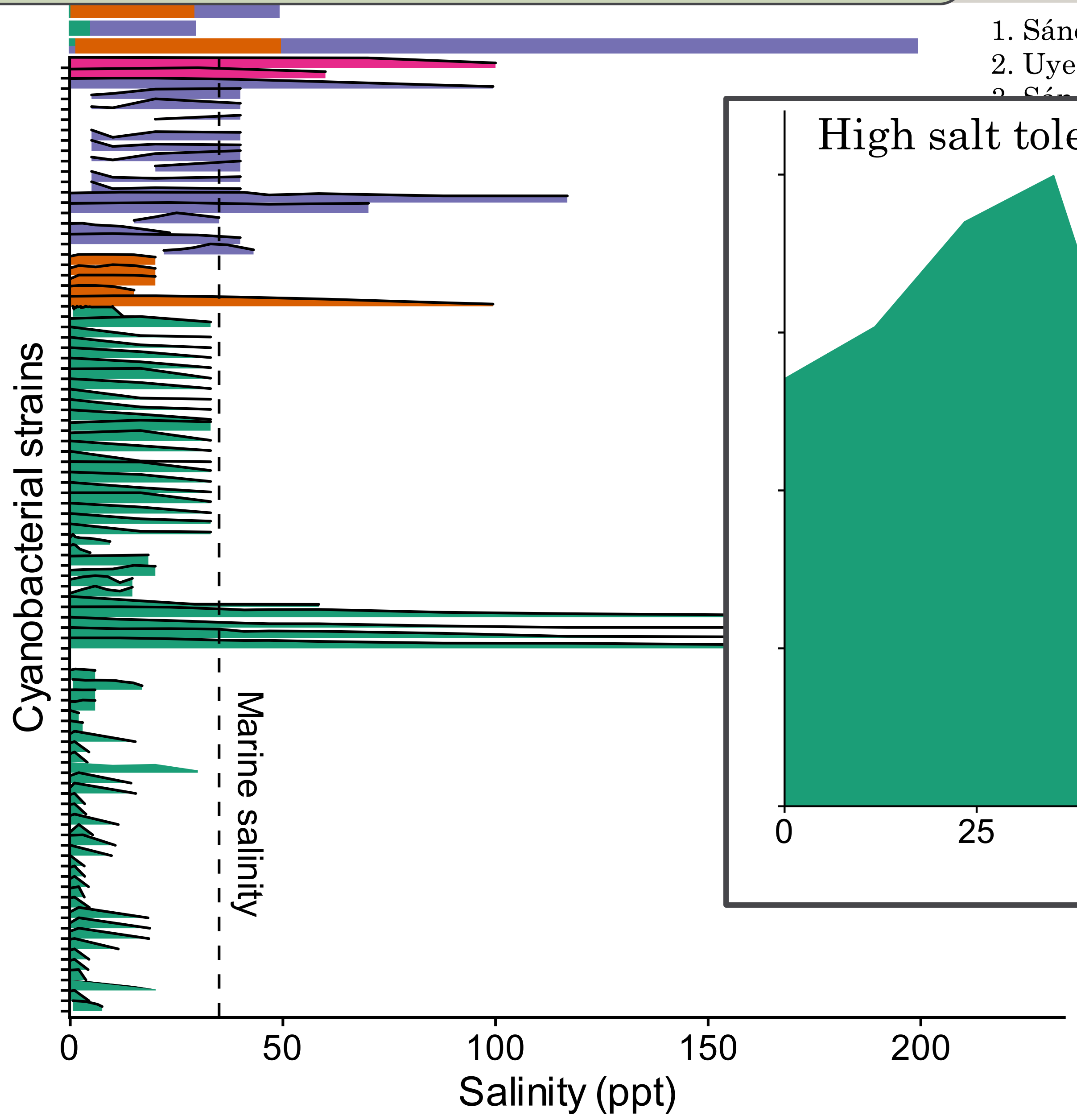


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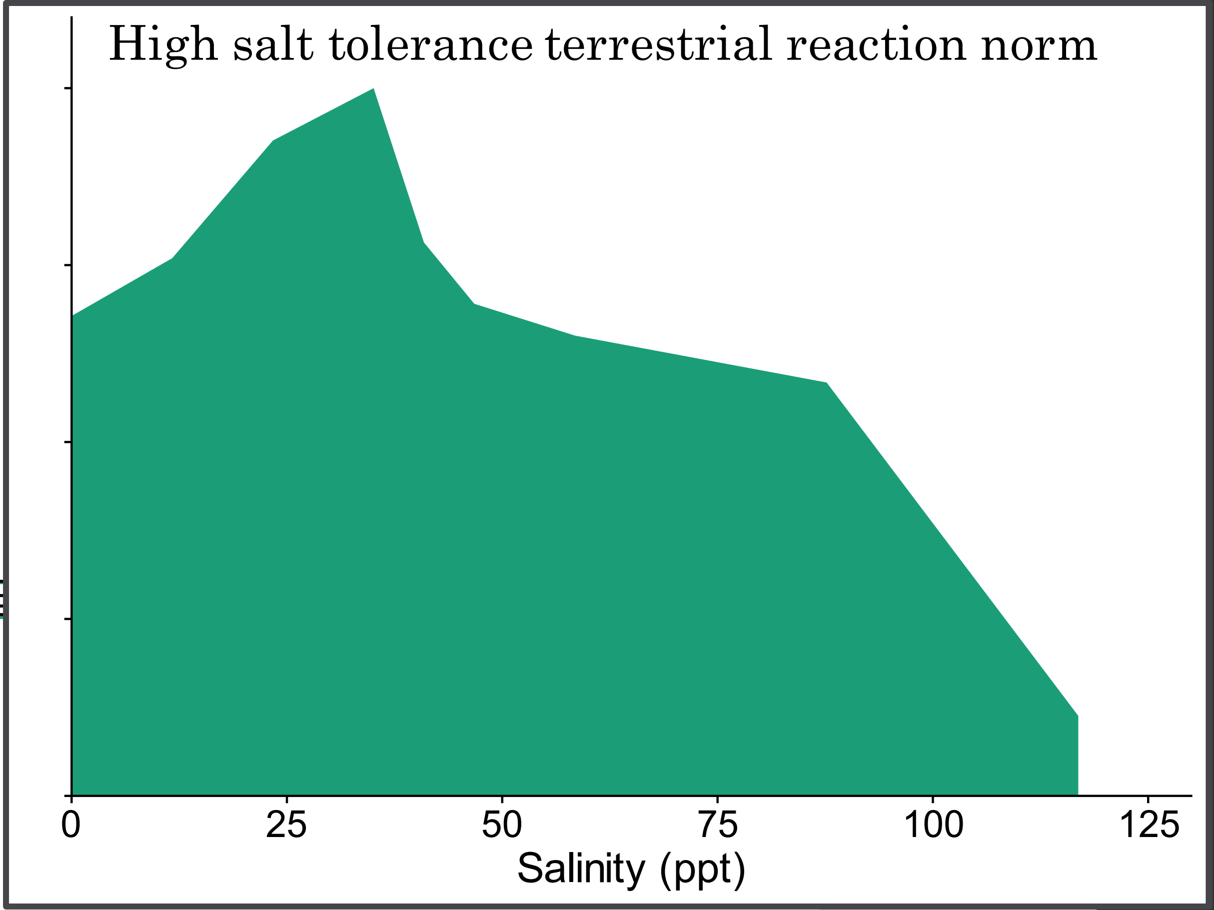

# Research answers

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Sometimes but not always

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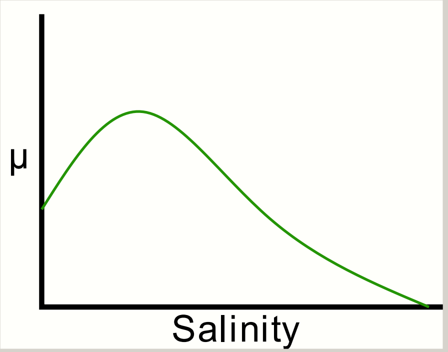
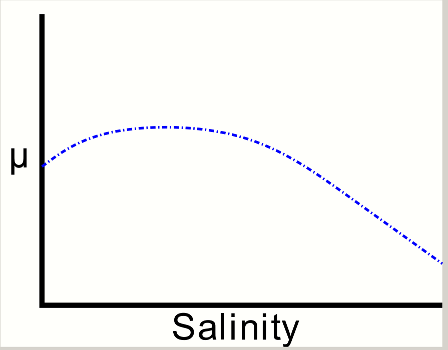
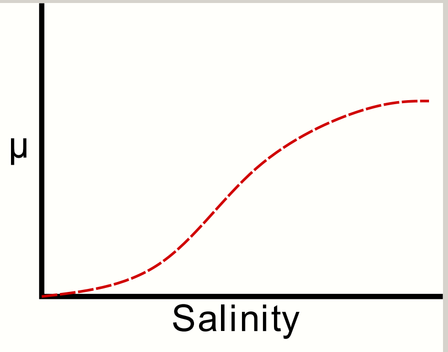
Sometimes but not always

No

# Future question: Can we identify molecular mechanisms behind the different response shapes?



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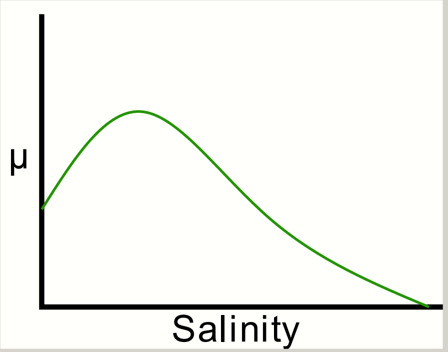


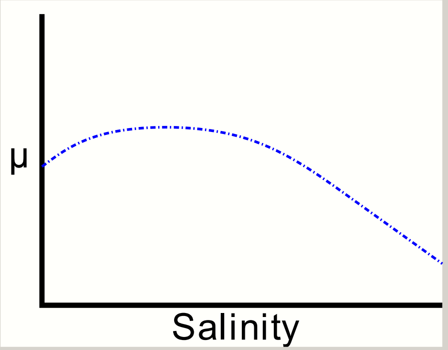


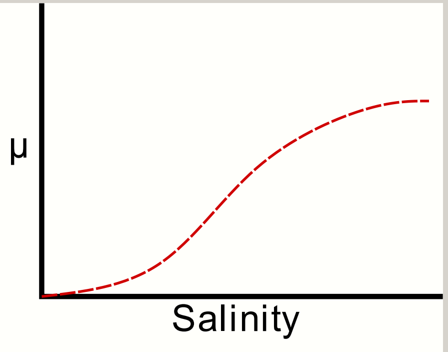


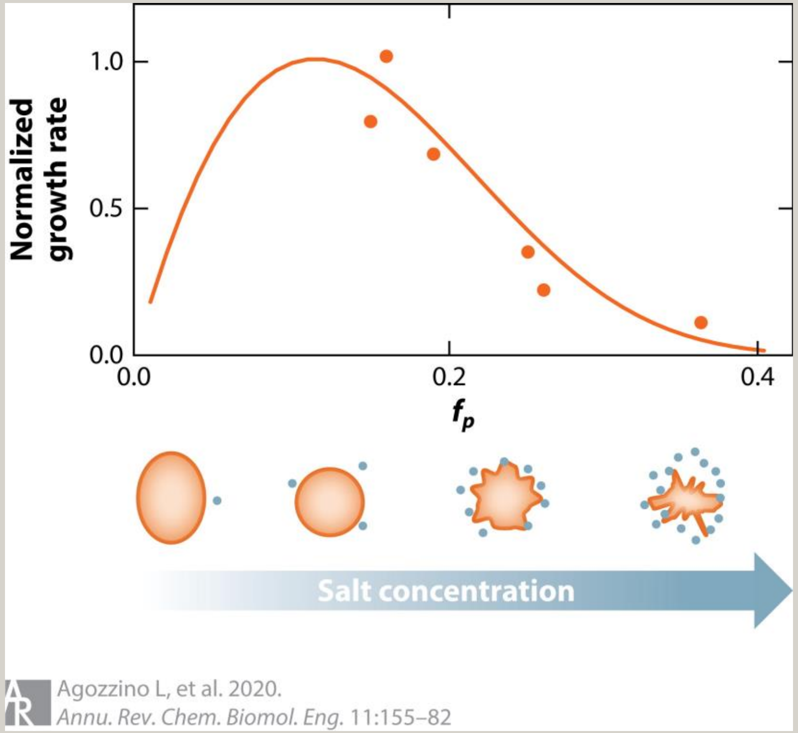

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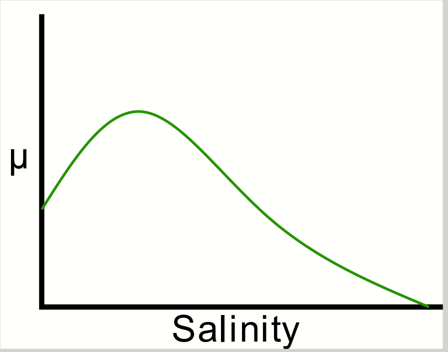
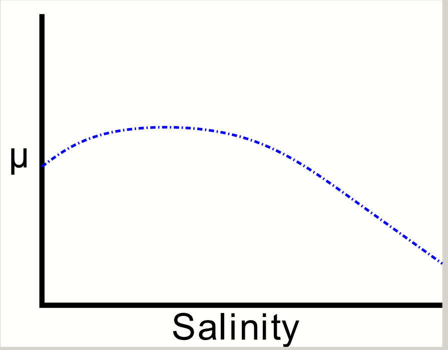
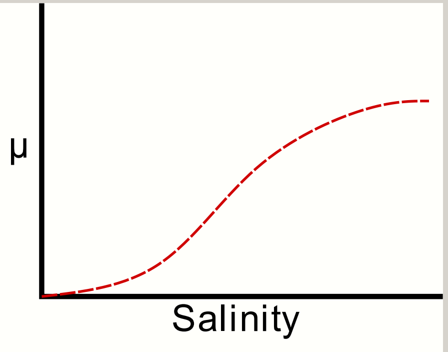
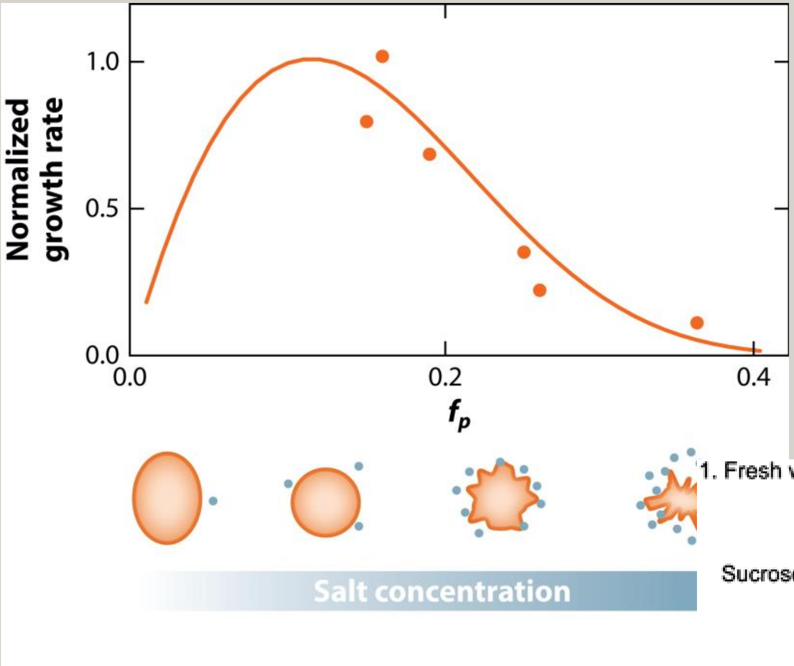
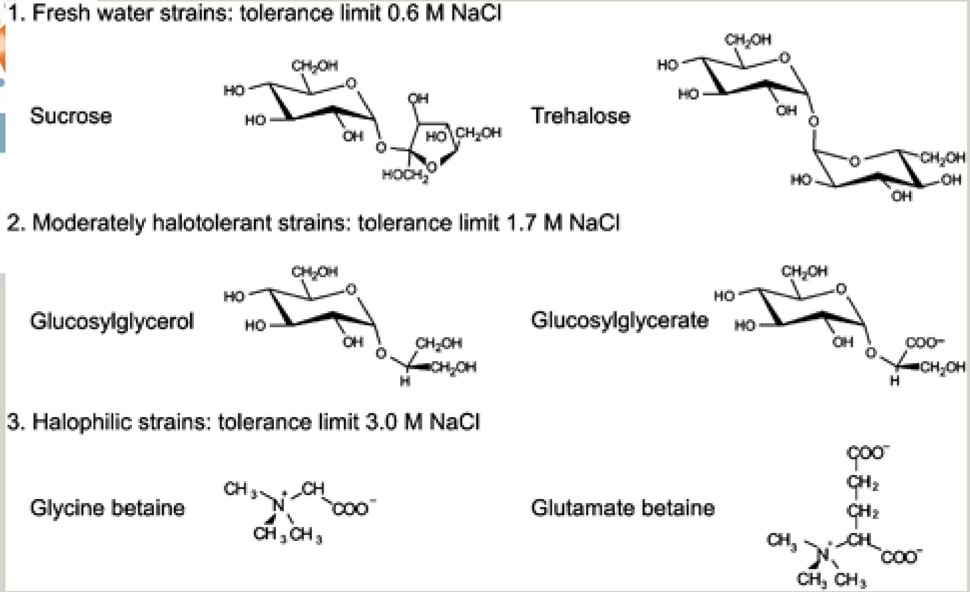


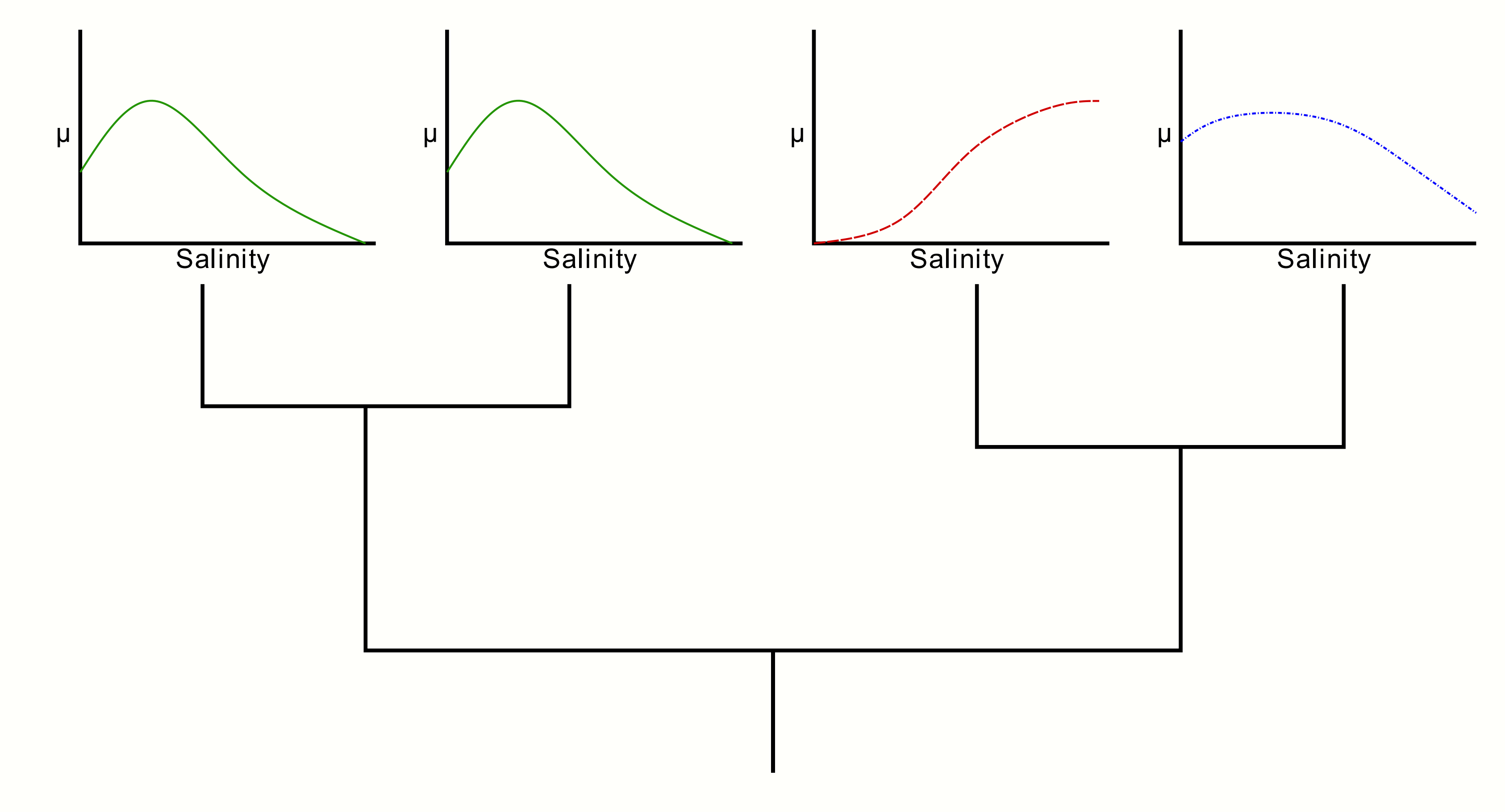




Agozzino L, et al. 2020.
*Annu. Rev. Chem. Biomol. Eng.* 11:155–82



# Future question: How do these reaction norms evolve?



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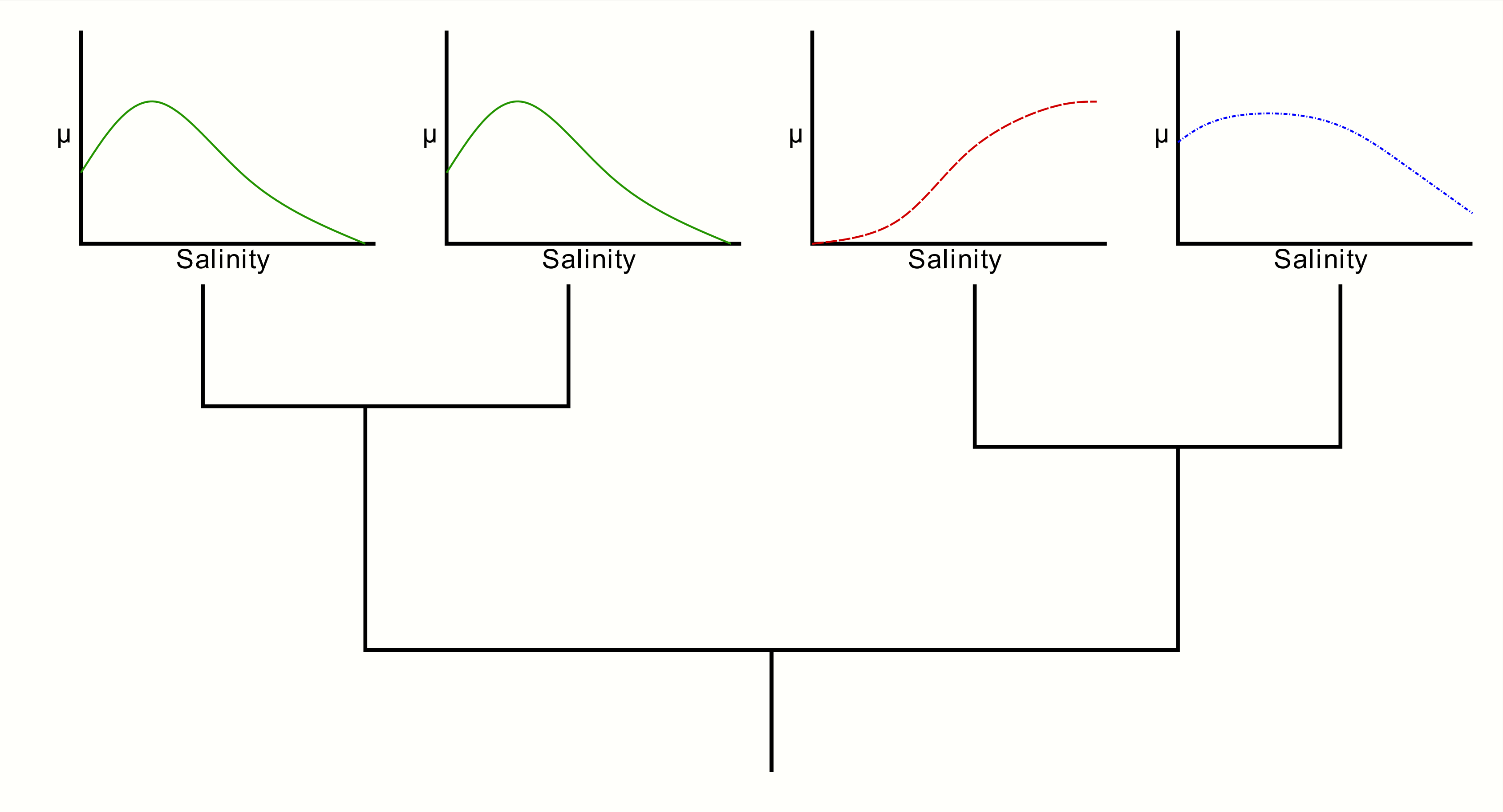
Ancestral state reconstruction



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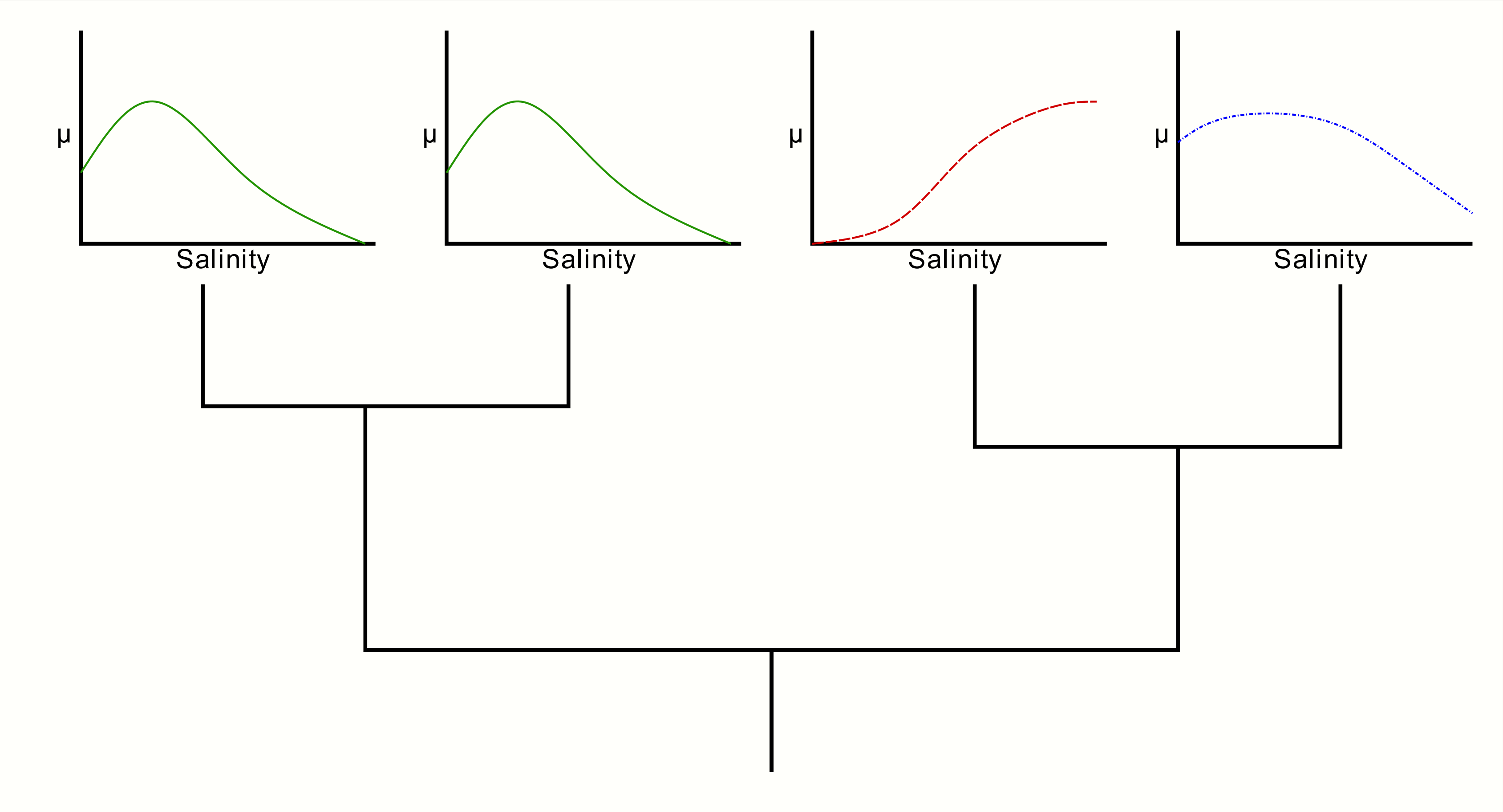
Experimental evolution



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- Friends and family

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- Department of Geological Sciences, University of Colorado Boulder
- Biological Sciences Initiative, University of Colorado Boulder

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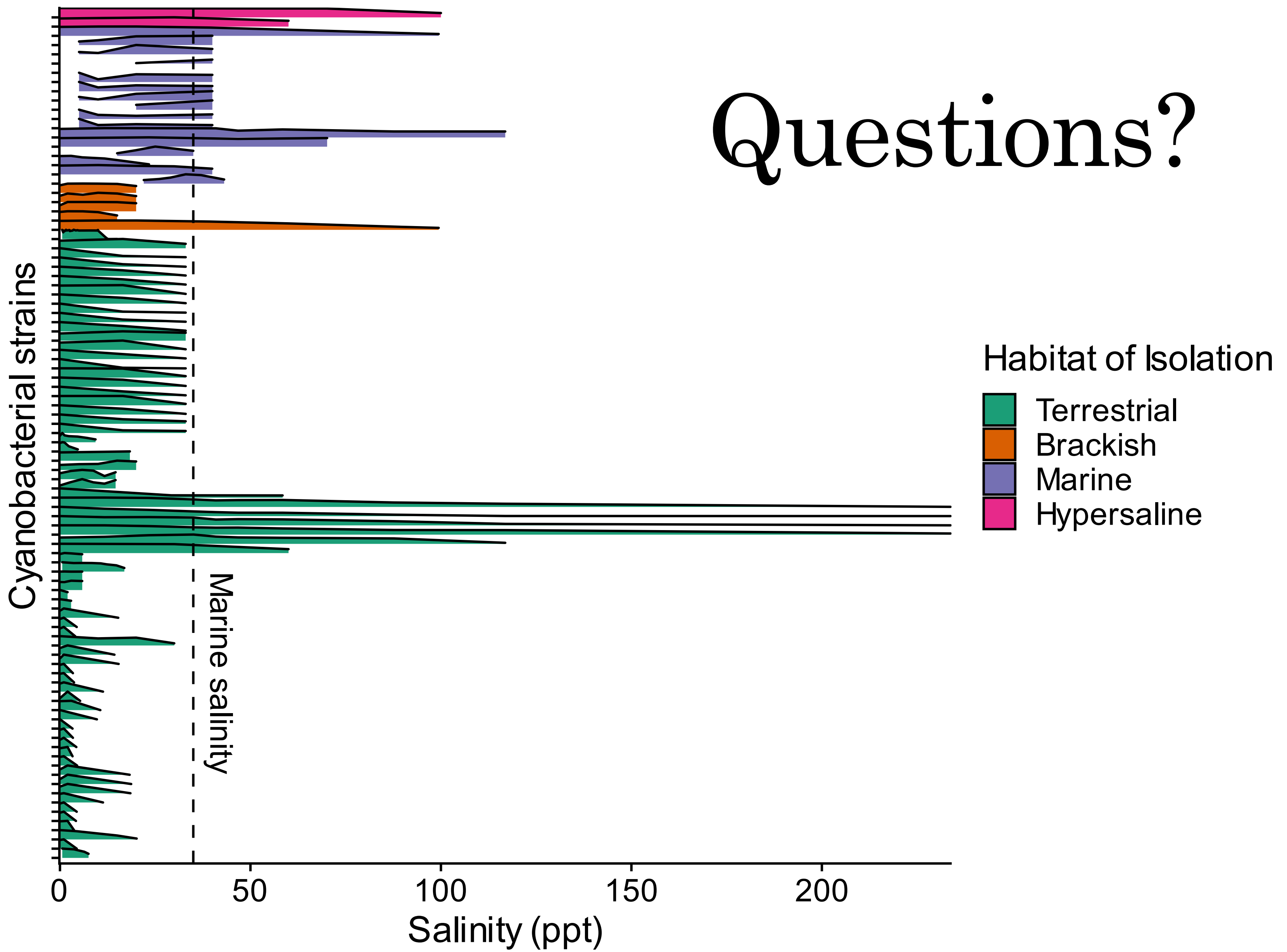
# Questions?

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