

Destabilized microbial networks with distinct performances of abundant and rare biospheres in maintaining networks under increasing salinity stress

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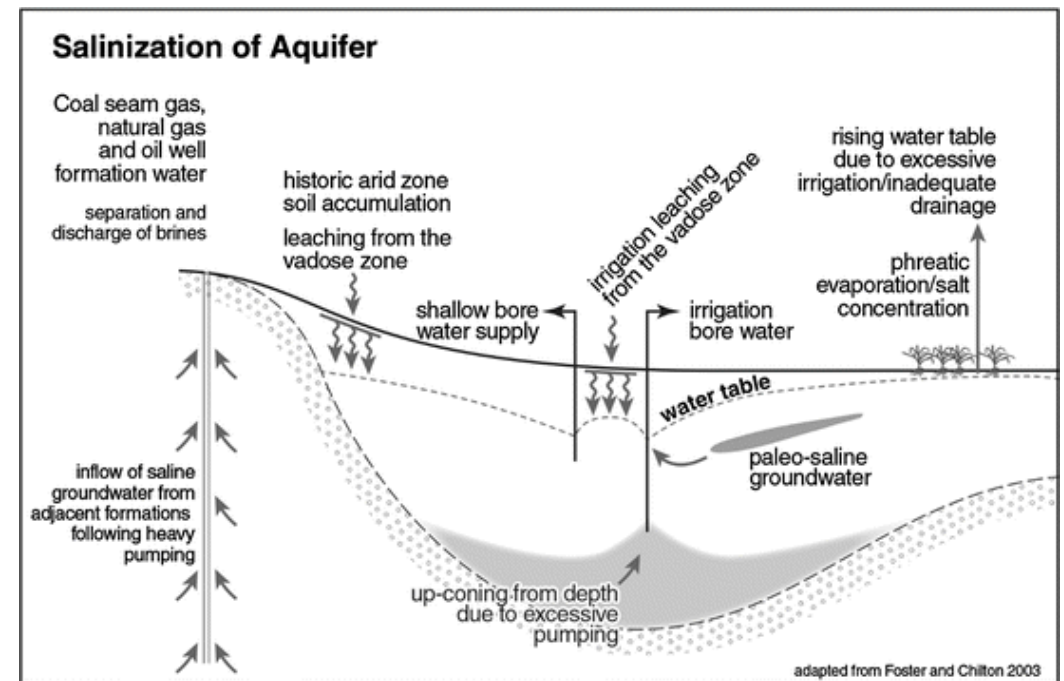
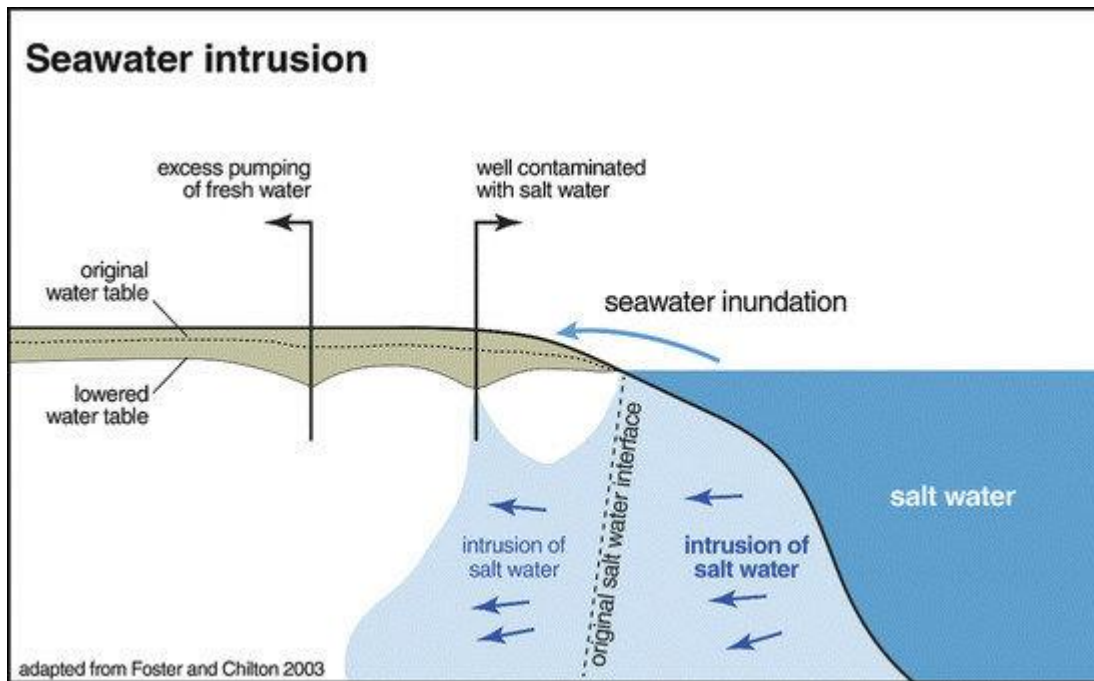
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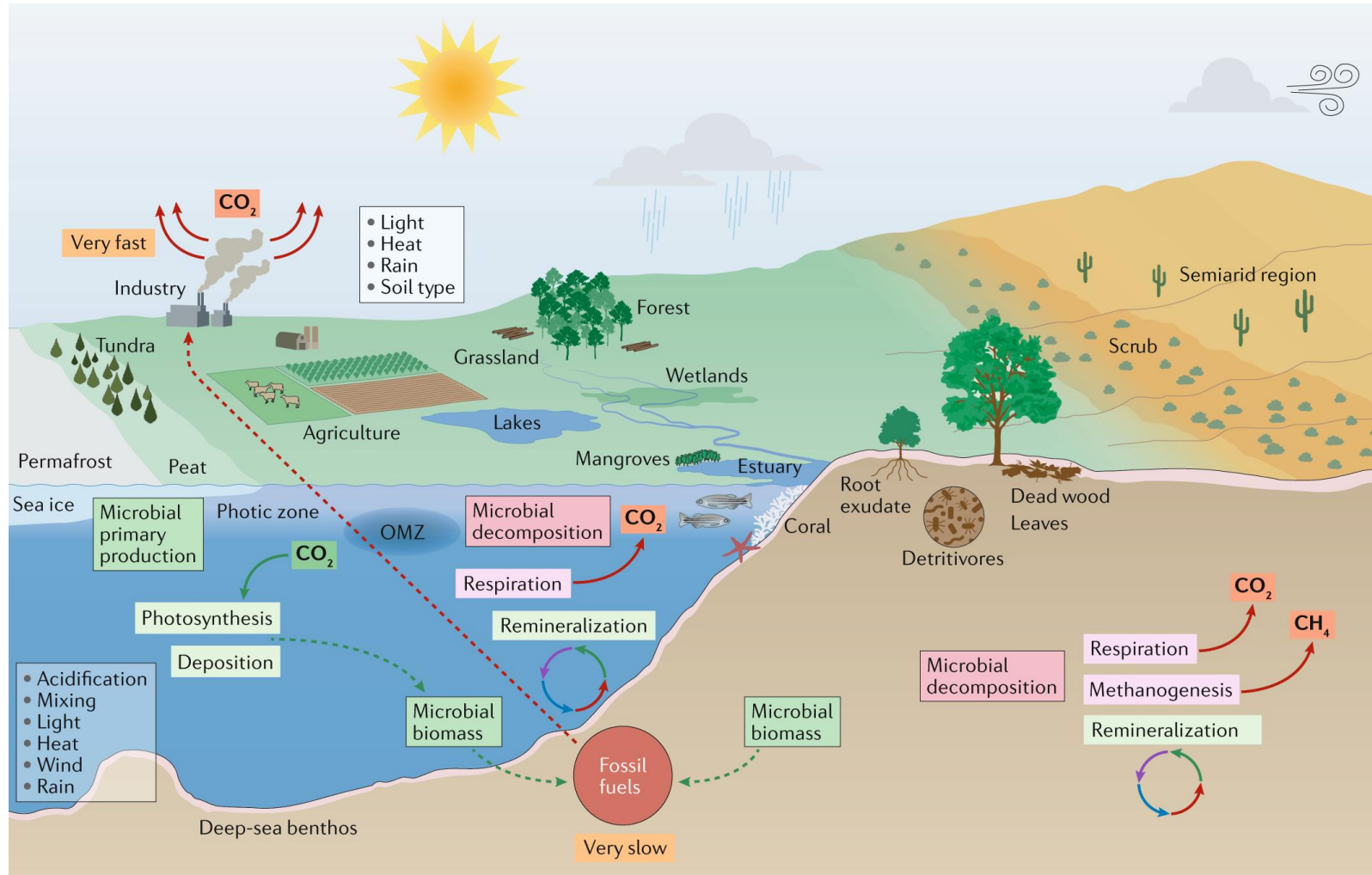
Increasing environmental stress in the aquatic ecosystem

- By 2100, sea level will possibly have risen by 0.63–1.01 m relative to the 1995–2014 average.
- Seawater intrusion poses serious negative impacts on both above- and below-ground water bodies in coastal areas .
- Changes in precipitation and evaporation due to climate warming, as well as human activities including the use of road deicing salts, mining operations and agricultural practices, are threatening global freshwater resources with salinization.



Greene R. et al., 2016
Kaushal, S. S. et al., 2018
Jeppesen, E. et al., 2020
IPCC, 2021
Hintz, W. D. et al., 2022

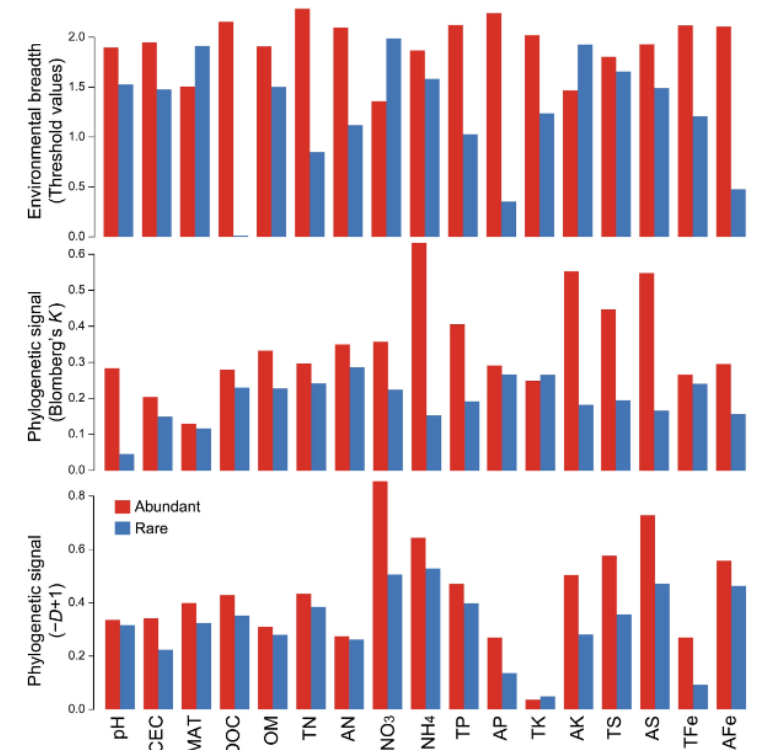
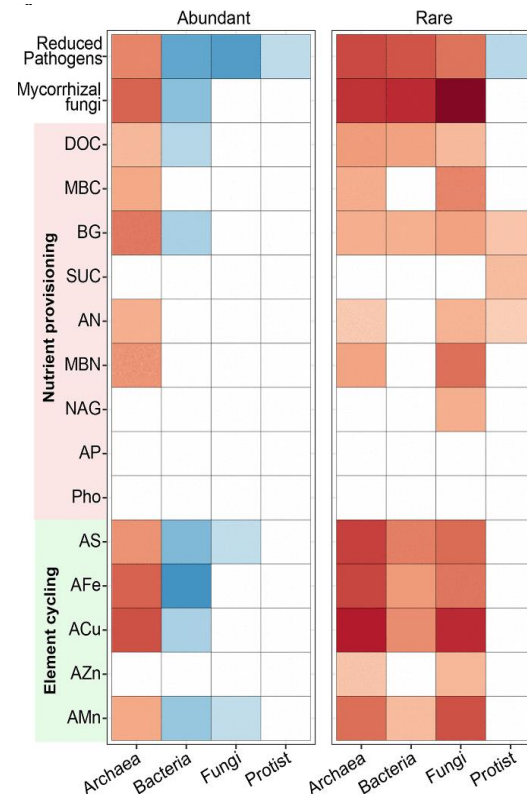
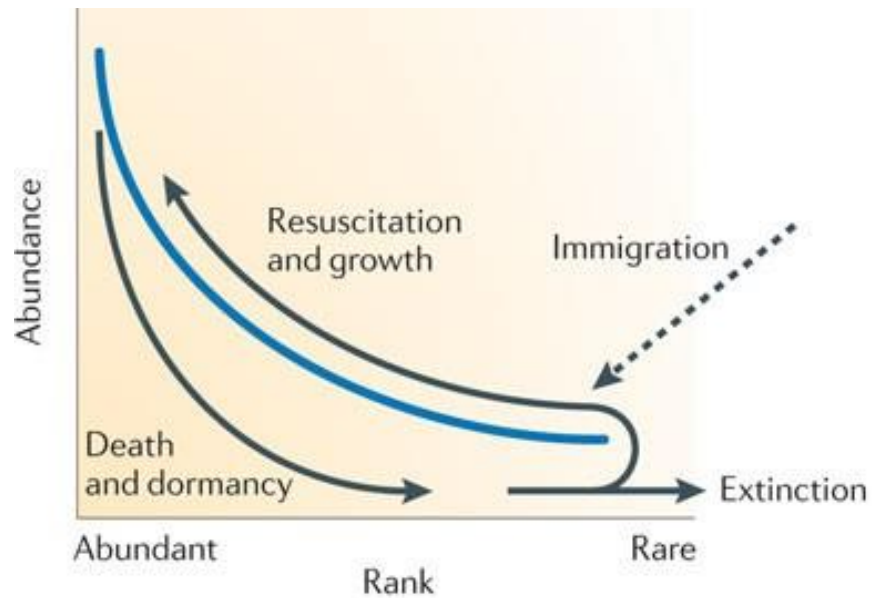
The importance of studying microbial responses to environmental change



- The microbiome, which controls the functioning of ecosystems, is sensitive to disturbances in environmental conditions.
- The impact of global changes largely depends on the responses of the microbiome.
- The intricate associations between microorganisms contribute to community dynamics and influence the functioning and stability of ecosystems.

Abundant and rare microbial biospheres

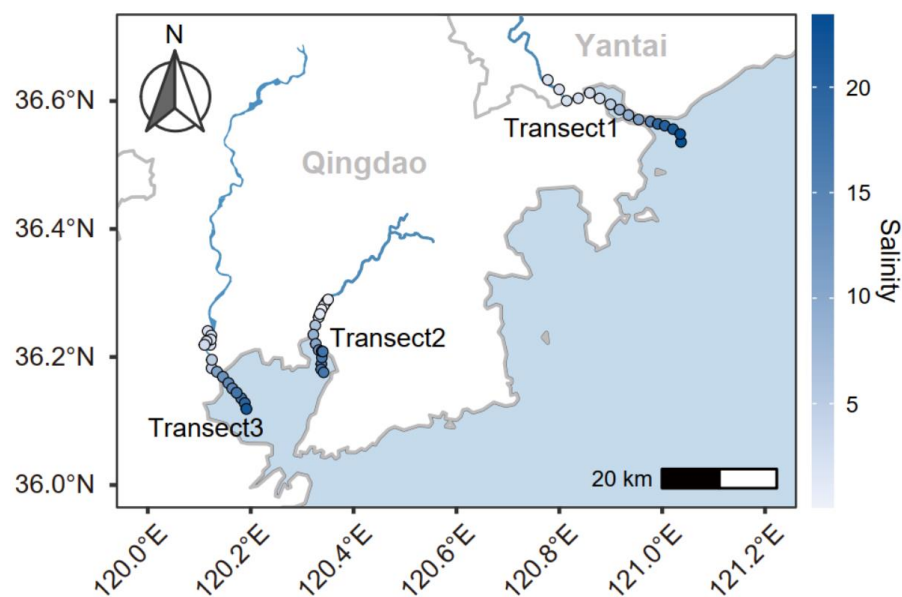
- The abundant biosphere contributes most of the microbial biomass, while the rare biosphere may act as a “seed bank” enabling certain species to become dominant in a particular environment.
- Abundant and rare biospheres show different biogeographical patterns, but both are recognized as important drivers of the functioning of ecosystems.



Key scientific questions and experimental design of this study

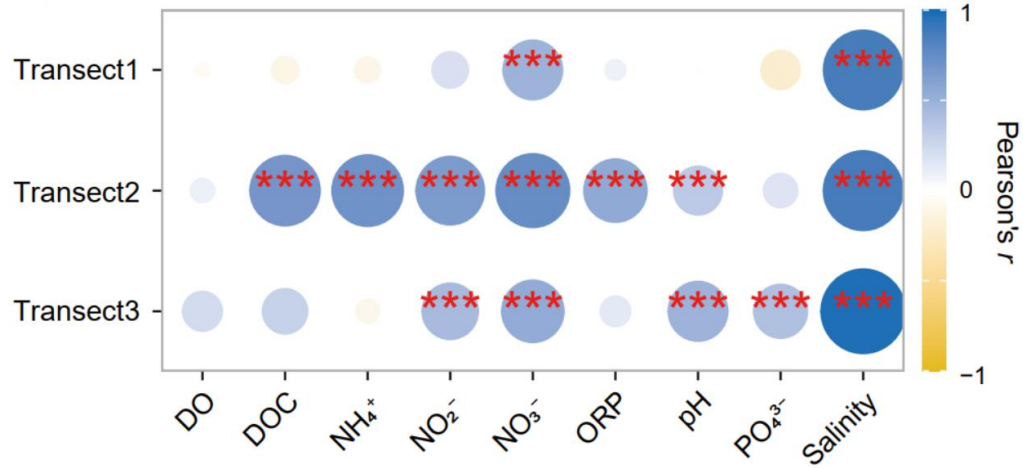


- How does the diversity, structure, and ecological network of the aquatic microbiome respond to increasing salinity stress?
- How do abundant and rare biospheres perform in maintaining ecological networks under increasing stress?

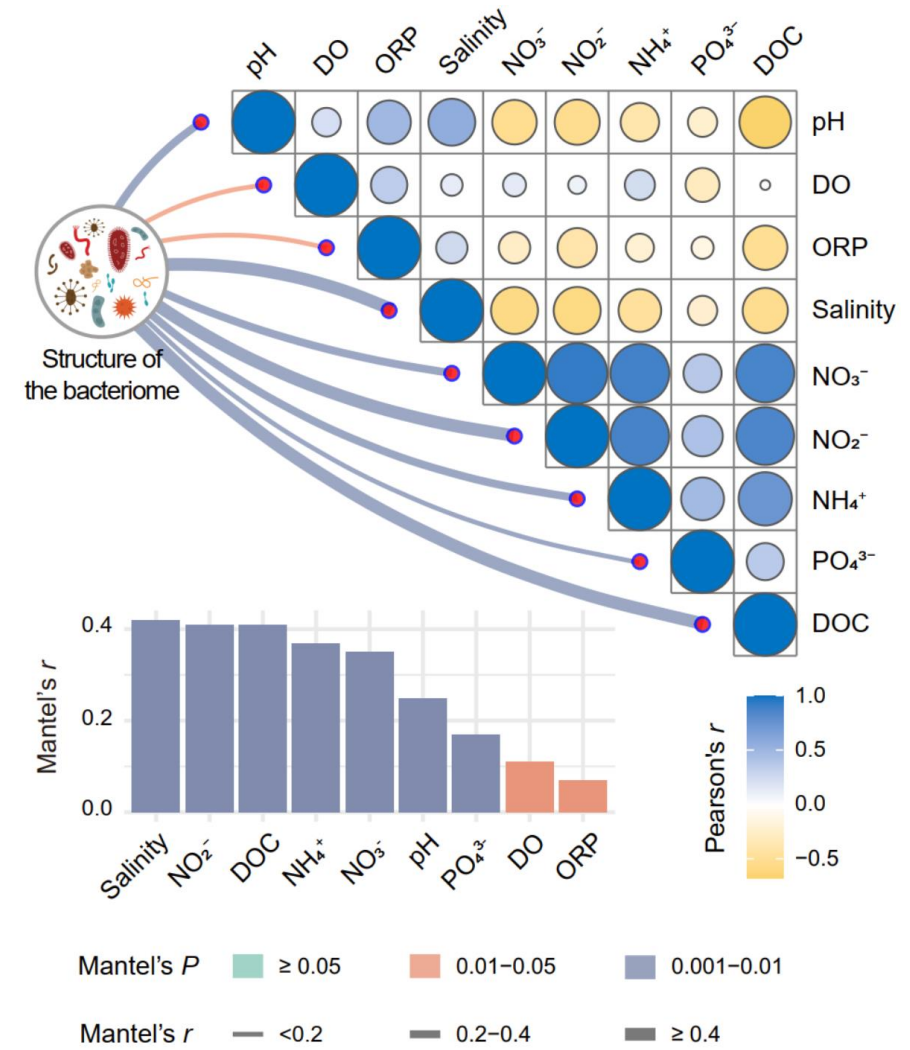


- Water samples were collected from three freshwater-to-seawater transects, which provide a natural and strong gradient of environmental stress and are ideal for studying microbial ecological patterns under environmental disturbances.
- The physicochemical properties and microbial information of the samples were determined.

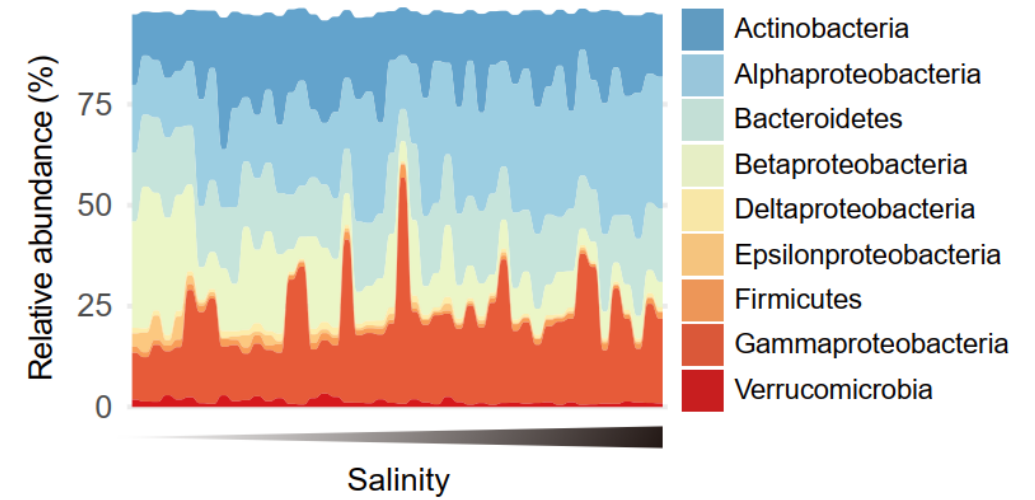
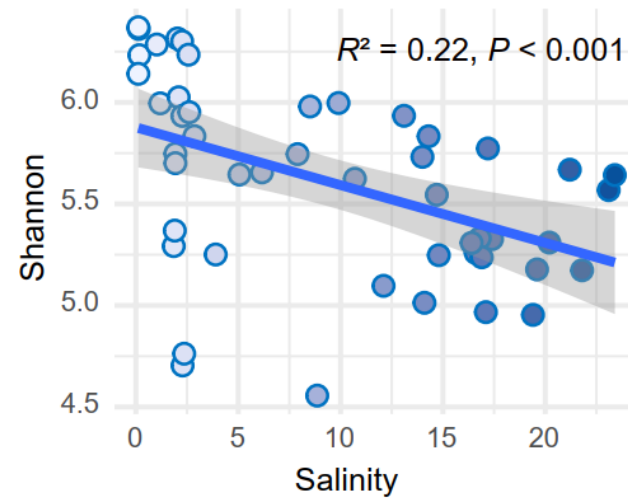
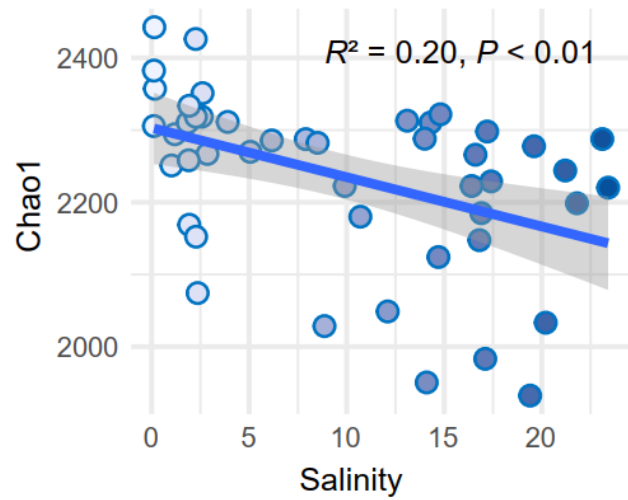
Salinity is the most important driver of the freshwater-to-seawater microbiome



- Salinity was positively correlated with geographical distance, with the largest correlation coefficient.
- Salinity was the strongest correlate of the structure of the bacteriome, with the largest Mantel's r value.

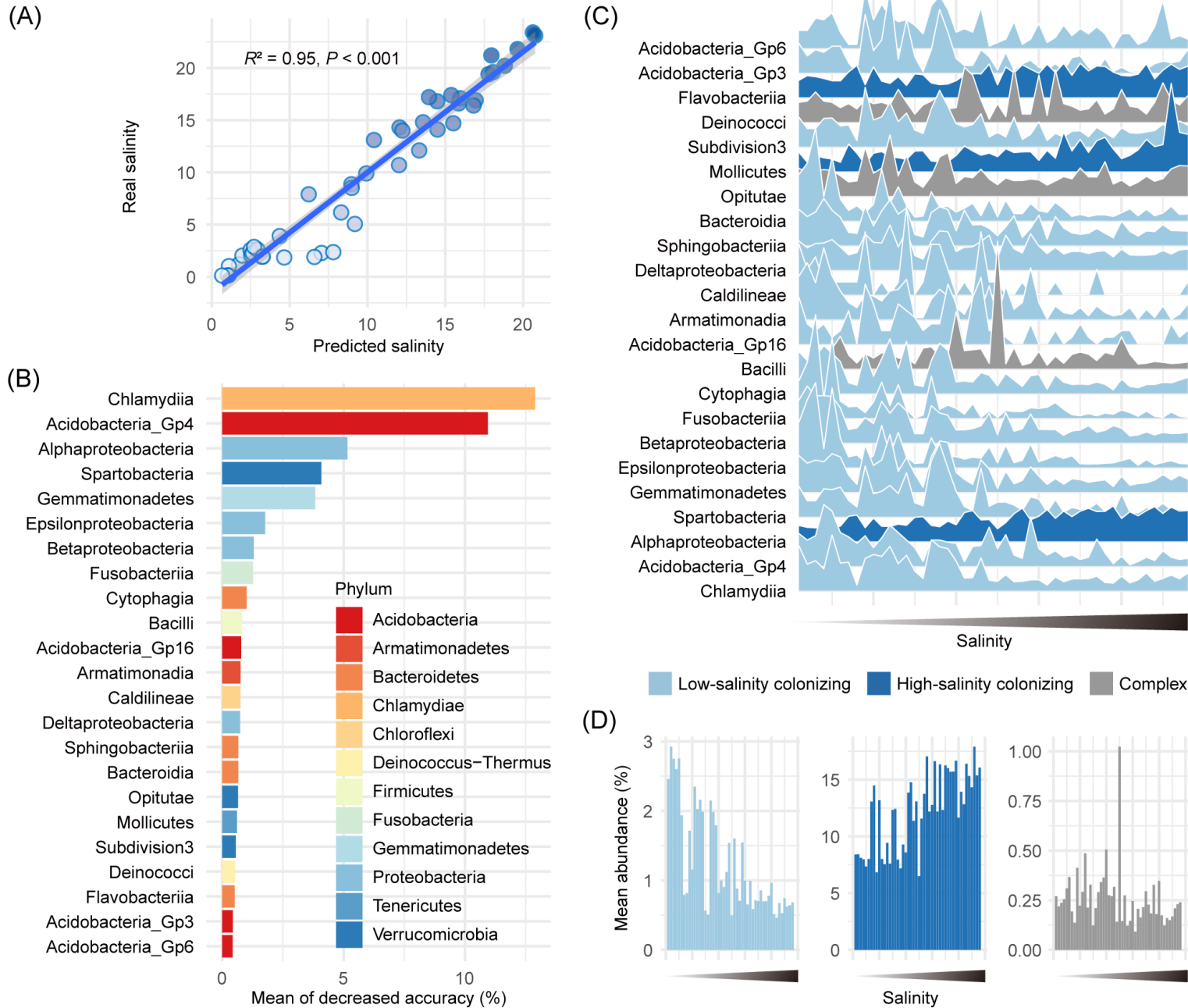


Decreased diversity and altered community structure



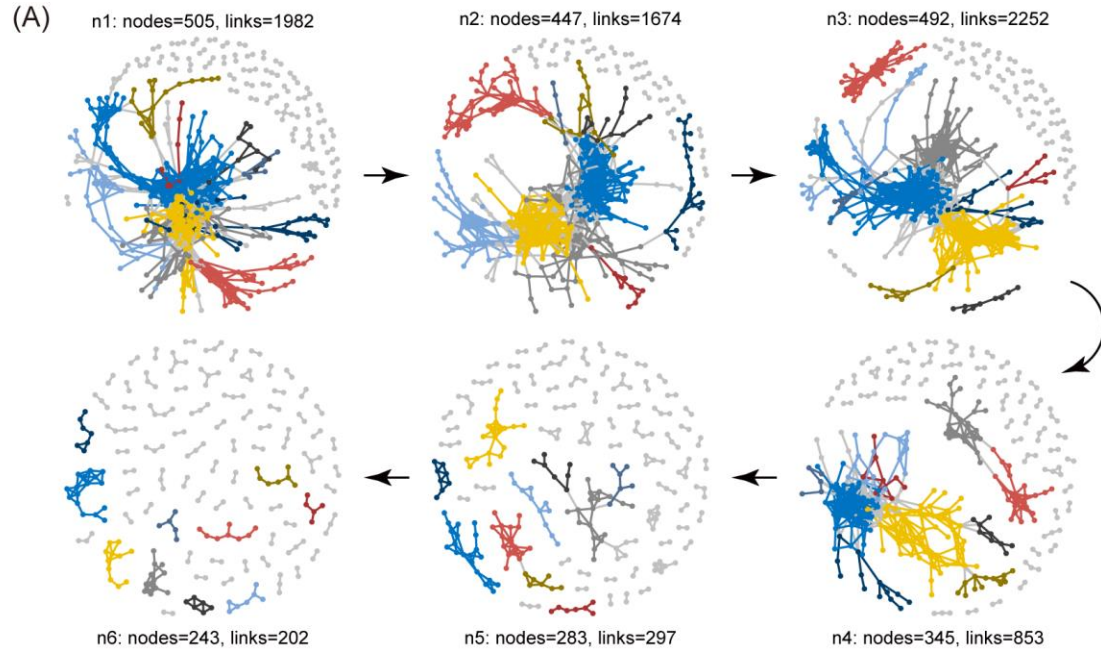
With the increasing stress, the microbial diversity reduced significantly and the taxonomic structure experienced a strong succession.

Salinity-discriminant biomarker taxa

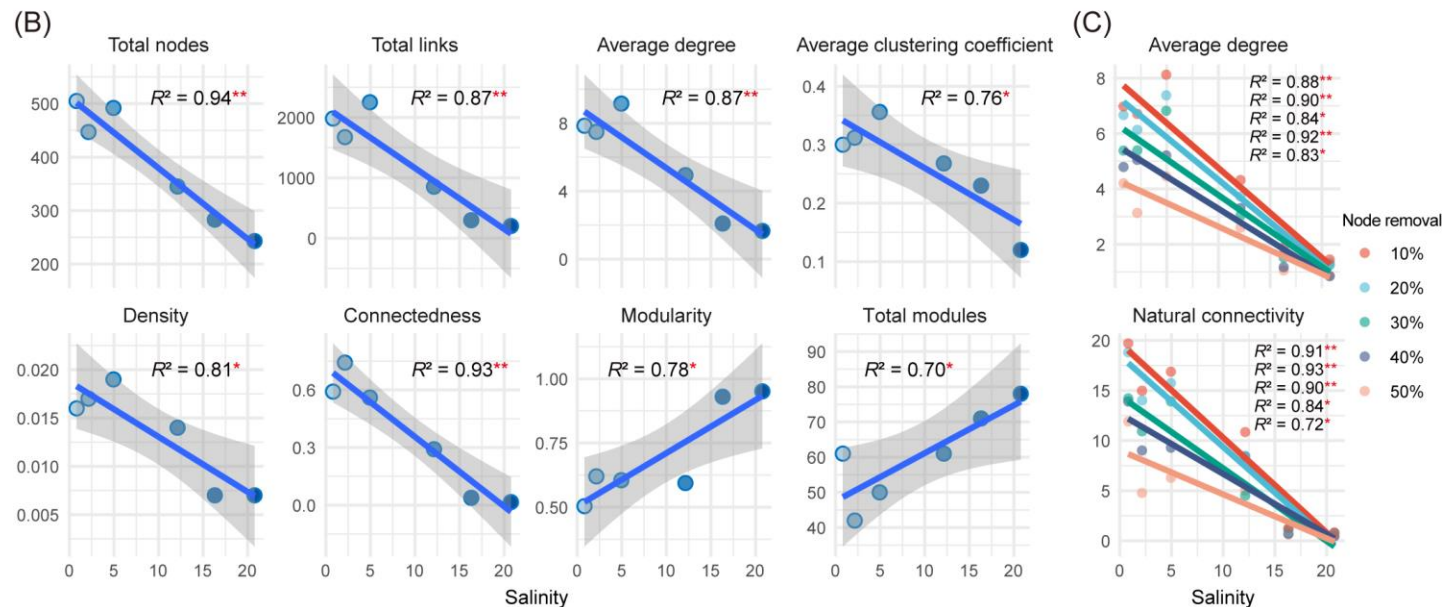


Using a Random Forest model, we identified a group of biomarker taxa to link microbial taxa to salinity. The identified biomarkers included 23 salinity-discriminant classes and could be used as an indicator of salinity fluctuations in the aquatic ecosystem.

Destabilized microbial ecological networks



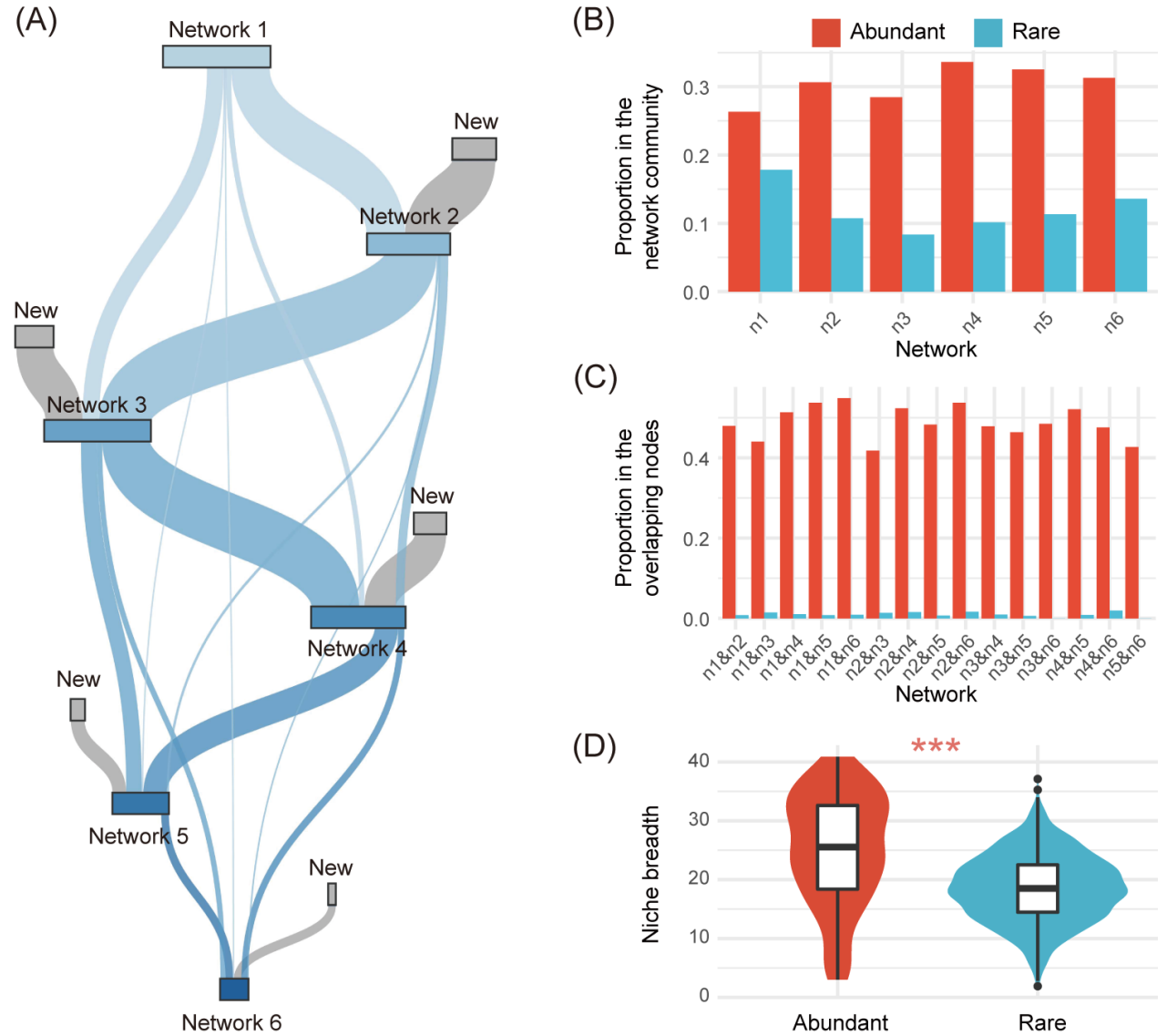
- The size (total number of nodes), total number of links, average degree, average clustering coefficient, density, and connectedness of ecological networks decreased significantly with the increasing stress.



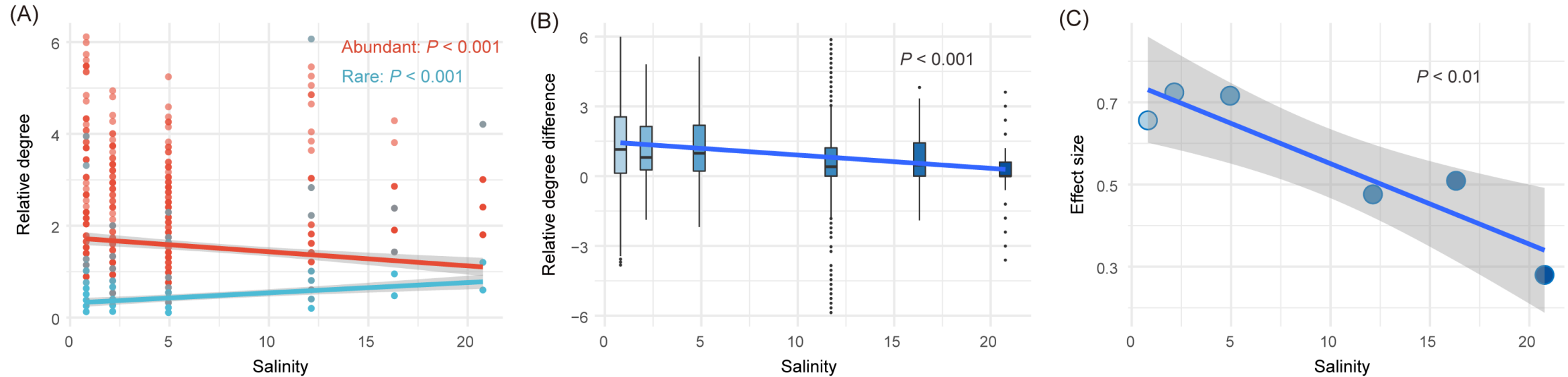
- The modularity of ecological networks increased during the transition.
- The stability of ecological networks diminished significantly with increasing salinity stress.

Robustness of abundant and rare biospheres in ecological networks

- The network community composition experienced sharp turnovers with increasing salinity.
- In terms of maintaining ecological networks, the rare biosphere was more sensitive in the face of increasing stress, while the abundant biosphere was more stable, which could be explained by the significantly broader niche breadth of the abundant biosphere than the rare biosphere.

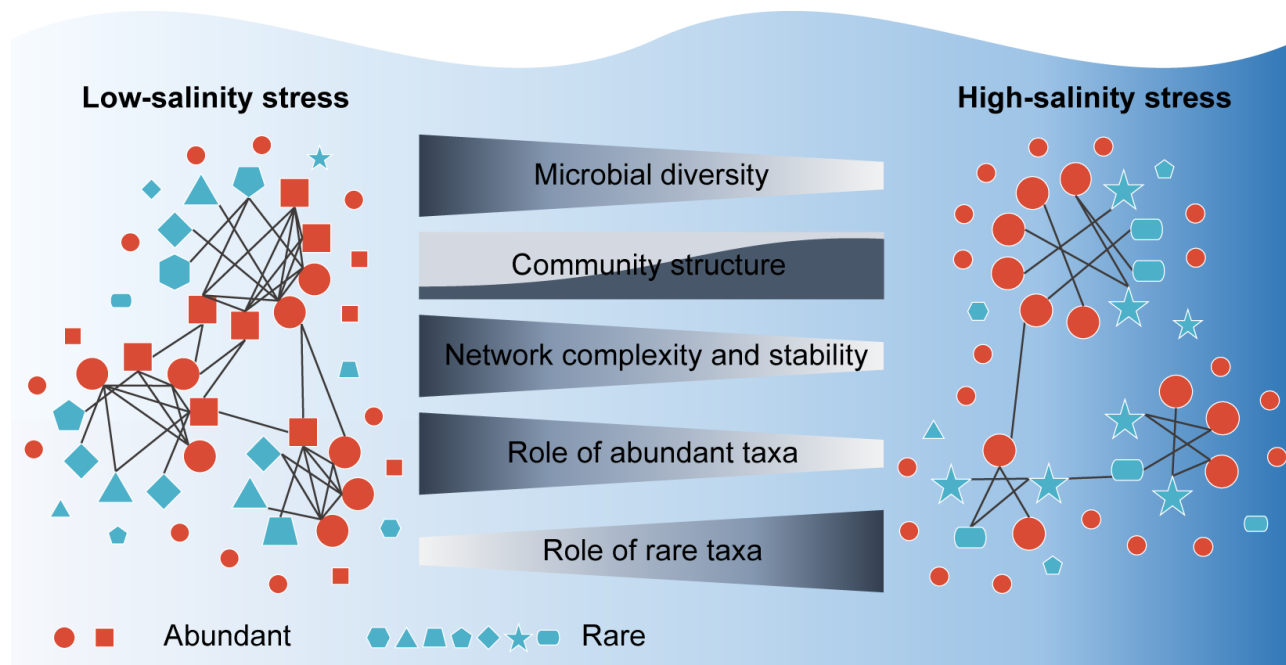


Trends in the role of abundant and rare biospheres in ecological networks



The abundant biosphere played a much more important role in stabilizing ecological networks than the rare biosphere in the low-stress environment, but the relative importance of the abundant biosphere decreased with increasing stress, while that of the rare biosphere increased.

Summary



With increasing salinity stress:

- the microbial diversity decreases and the community structure undergoes marked turnover;
- the complexity and stability of microbial ecological networks diminish;
- the abundant biosphere is more robust in maintaining ecological networks than the rare biosphere;
- the importance difference between the abundant and rare biospheres in maintaining networks narrows significantly.

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