**INTRODUCTION**

Due to the vast taxonomic and functional diversity within most microbial communities, microbiomes have an incredible ability to change, adapt to, and recover from a wide variety of environmental changes. While the microbiome’s higher-order taxonomic composition is often partially linked to its functional potential, the fine-scale individual membership of the communities can be irrelevant to its overall functioning due to functional redundancy. Furthermore, this functional redundancy between taxa ensures that the functional potential of the microbiome persists even after a major community re-arrangement following a major perturbation {Louca, 2016 #8590;Nie, 2016 #8591}.

While many previous studies looked at gradual adaptations of communities in response to gradually changing environmental conditions, few studies looked at more acute perturbations in natural environments. The resilience and adaptations of microbiomes to acute perturbations such as temperature changes or antibiotic administration have been demonstrated in controlled environments {Jurburg, 2017 #8583;Raymond, 2016 #8584;Lozupone, 2012 #8582}, however due to compounding environmental factors such studies are much more difficult to perform in uncontrolled environmental conditions.

The northern Atacama Desert is one of the harshest places on Earth, with an average annual precipitation of less than 1mm. Despite this, poly-extremophilic microbiota have evolved to exist in these extreme conditions by relying on the protection of various minerals. One such endolithic (inside rock) community is harbored within halites – salt rock nodule formations found on the surface of salt salars. A unique property of halite microbiomes that make them a compelling system for measuring responses to environmental stressors is their isolated nature. Encased in rocks, halite communities receive very little biomass exchange, and have limited nutrient input beyond atmospheric gasses {Crits-Christoph, 2016 #8776;Finstad, 2017 #8580;Robinson, 2015 #6954}. As such, each halite nodule represents a near-closed system, allows us to track microbial community changes without unintended external factors compounding the results.

Because of salt’s deliquescent properties, these halophiles are able to survive by receiving water almost exclusively from the humidity in the air {Davila, 2015 #8777;Finstad, 2017 #8580;Crits-Christoph, 2016 #8776}. Additionally, the major taxonomic components of this community are *Halobacteria* and *Bacteroidetes* – two hyper-halophilic salt-in strategists. This unique adaptation allows them to keep sodium ions out with an internal osmotic pressure resulting from actively importing potassium ions, which are less damaging to the cell {Mongodin, 2005 #3877;Crits-Christoph, 2016 #8776;Monard, 2016 #8592}. This is energetically favorable to actively pumping out sodium {Oren, 1999 #2147}, but required the cell’s proteome to be have an extremely low isoelectric point (pI) to be able to function at high potassium concentrations {Oren, 2013 #8589;Paul, 2008 #7985;Mongodin, 2005 #8581}.

The highly specialized nature of the halite microbial communities can make them more vulnerable to change compared to habitat generalists {Monard, 2016 #8592}, particularly to sudden changes in water availability. Because the nodules are primarily comprised of porous salt {Davila, 2013 #6726}, a major rain could at temporarily alter the internal conditions and create a major osmotic shock to the microbial communities. The rain that northern Atacama received in August 2015 was its first major precipitation event in 13 years. Combined with the isolated nature of halite microbiomes, this gave us a perfect opportunity to track the response of an environmental microbiome to a major natural perturbation. Our longitudinal study not only captured the microbiome’s immediate adaptations, but also its recovery in the subsequent year, revealing two strikingly different community adaptation strategies.

**What is the paper about?**

1. There are two types of community shifts:
   1. Gradual shifts via changes in relative abundances of major taxonomic groups
   2. Rapid shifts via changes in abundances of major taxonomic groups, and rearrangement within those groups.
2. Microbiomes are overall resilient at the taxonomic and functional scales
3. Individual community composition can be permanently rearranged by rapid perturbations