RUI:MO:Collaborative Research: An Integrated Study of Eukaryotic, Prokaryotic and Viral Diversity and Dynamics in an Acidic, Hot Lake

PROJECT SUMMARY

In recent years, the study of microbial biogeography and diversity patterns has garnered attention from ecologists and microbiologists interested in testing macroecological paradigms in microbial systems. This project combines expertise in prokaryotic, viral, and eukaryotic biology from three institutions to propose a microbial observatory at **Boiling Springs Lake (BSL)** – a stable, acidic (pH 2.2), hydrothermal (52˚C), 13,000m^2 lake in Lassen Volcanic National Park, CA. BSL is a high sulfate, low chloride, low metal system in a relatively accessible, yet pristine location. BSL offers a unique opportunity to investigate a single hot spring containing stable and unstable habitats that appear to be unconstrained by dispersal limitations within and between these habitats. We can then test the hypothesis that prokaryotic beta diversity varies with scale in heterogeneous habitats, but not in homogenous habitats within this large lake. Prokaryotes in BSL sediments include numerous Bacterial and Archaeal genera, but appear to be dominated by three distinct phylotypes of Archaea that share less than 85% rRNA sequence identity with known organisms, and a Bacterial phylotype that shares ~ 88% rRNA sequence identity with *Desulfotomaculum*. Algae (especially Cyanidiales) and fungi appear to dominate the planktonic eukaryotic community. Virus-like particles are present at approximately 10^3 ml^{-1}, much lower than in other environments, but consistent with what has been observed in acidic waters elsewhere (Ortmann et. al. 2006, Breitbart and Rohwer, pers. comm.). Additionally, geothermal inputs (up to 95˚C) at one end of the lake create gradients of pH, temperature, and geochemistry, and provide additional habitats for microbial consortia.

Following investigation of lake bathymetry and physical structure (using a remotely operated vehicle designed and operated by undergraduate engineering students), we propose to sample two thermally distinct regions of BSL, at various temporal and spatial scales throughout the project duration, for biological and chemical analyses to assess variation in the measured parameters. Standard methods will be modified for BSL to determine productivity (primary and heterotrophic), and the relative contributions of chemosynthesis and photosynthesis to primary production. Culture-independent and culture-dependent approaches will be used to identify the primary producers and to determine the abundance, distribution, and diversity of prokaryotes, eukaryotes and viruses.

Intellectual merit – This interdisciplinary study will address the following critical questions:

(a) What is the physical and chemical structure of the lake, and how does it vary temporally and spatially?

(b) Who are the prokaryotes, eukaryotes, and viruses present in two thermally distinct regions of the lake? How do these populations change over temporal and spatial scales?

(c) What is the relative contribution of primary production by chemosynthesis vs. photosynthesis, and who are the potential primary producers in the lake?

(d) Do prokaryotic taxa area relationships obey a positive power law relationship ($S \propto A^Z$) in extreme environments as has been shown in high diversity, non-extreme environments? Do these spatial diversity relationships (e.g. β-diversity) differ in heterogeneous vs. homogenous habitats within the same hot spring?

Broader implications - A major goal of this RUI-MO proposal is to introduce undergraduates from three institutions to microbial ecology and train them in scientific research. During the proposed funding period, we will integrate this work into 5 classes impacting > 700 undergraduate students, and an additional ca. 100 undergraduates will be directly involved in BSL-related research projects. Our project will also contribute to graduate and high school student training.

We will convene yearly LVNP symposia involving PIs, students, park personnel and community members, and produce a web-based database of our results for the science community and public. In addition, we will involve students in producing a color booklet for LVNP visitors, highlighting the structure, chemistry, and biology of this unique lake, and giving the public a deeper appreciation of the microbial world.