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March 31, 2022
Jamal Shirley
Nunavut Research Institute
Iqaluit, NT
X0A 0H0

Re: **Nunavut Research License renewal for NRI # 02 033 21R-M - Annual Summary of 2021 Field Season and Proposed 2022 Research Activities – Axel Heiberg Island**

Dear Jamal,

I hope you and the Nunavut Research Institute (NRI) staff are all doing well! Please find enclosed the *Annual Summary Report* describing my 2021 research activities in Nunavut. We were fortunate to be able to conduct field work in 2021, given that our 2020 season was cancelled due to the Covid-19 pandemic. This annual summary serves as part of my application to renew my multi-year Nunavut Research License 02 035 19R-M for our upcoming 2022 field season.

Please be advised that I am in the process of having the Inuktitut translation completed. I will forward that translation to your office as soon as it is available.

I have successfully applied to the Polar Continental Shelf Program for field work at the McGill Arctic Research Station on Axel Heiberg Island for approximately 14 days between July 1 and July 31, 2022. The researchers on this trip will be Lyle Whyte, Brady O'Connor, Scott Sugden, Louis-Jacques Bourdages, and possibly a fifth student or research assistant who I have not yet hired.

If further information is required or if you have any questions, please do not hesitate to contact me.

Sincerely,

Lyle Whyte
Professor

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2021 Annual Summary of Research Activities for NRI Permit 02 033 21R-M

Commented [SS1]: Lyle - The "Annual Summary" guidelines provided by the Nunavut Research Institute request a summary between 500-1,000 words, and their instructions do not mention a description of proposed research for the following season. I have therefore expanded the summary of last years' work to meet NRI expectations and added the "proposed 2022 research" separately.

My research program examines microbial ecology in unique Canadian High Arctic ecosystems, including permafrost, glaciers, cryptoendoliths, and hypersaline springs and sediments. Over the past 20 years, this research has contributed significantly to our knowledge of the diversity, abundance, and ecological role of microorganisms in polar regions. Our research program centers on three objectives: (1) studying microbial life at sub-zero temperatures to understand the low-temperature limits of life on Earth; (2) determining the current and future role of arctic microorganisms in global biogeochemical cycles, with an emphasis on potential climate change feedbacks; and (3) using extreme, cold-temperature environments as analogs for investigating the potential for life on other planets such as Mars.

In August 2021, we sent four team members to the McGill Arctic Research Station (MARS) on Axel Heiberg Island. Our team consisted of one post-doctoral fellow (Miguel Ángel Fernández-Martínez), two PhD students (Elisse Magnuson and Brady O'Connor), and one MSc student (Louis-Jacques Bourdages). The trip was delayed in both Iqaluit and Resolute Bay, which limited our research activities to four days. Nevertheless, the team was able to advance three projects that are crucial to our ongoing arctic microbiology research.

First, Fernandez, O'Connor, and Bourdages field-tested the latest model of our biosignature detection platform using samples collected with a new robotic ice drill. The overall objective of this project is to produce a low-mass, low-energy, integrated, automated platform for detecting biosignatures and performing field-based DNA sequencing in remote locations and on future planetary science missions. Our current system consists of multiple devices including a microbial activity microassay (μMAMA), an automated nucleic acid extraction device (MagLysis; developed by Bourdages), and a Nanopore MinION sequencer. In 2021, we identified limitations in our drilling and detection platforms, and we are refining these systems for testing in 2022.

Second, Magnuson performed an *in-situ* experiment at Gypsum Hill spring using bio-orthogonal non-canonical amino acid tagging (BONCAT), and she also collected samples for laboratory analyses. The Gypsum Hill spring, along with other similar springs near MARS, releases cold, hypersaline water and therefore represents an extreme environment for life on Earth and a potential source for novel microorganisms. Much of our past and planned future work focuses on detecting, identifying, and characterizing the unique species that inhabit these extreme environments. The BONCAT technique allows us to distinguish metabolically active microbes from dead or dormant cells, which can often be a challenge in field microbiology studies.

Finally, the team collected various soil, ice, permafrost, and water samples needed for our ongoing laboratory-based studies of biosignature detection, spring microbial ecosystems, and general arctic microbiology. For example, we have successfully isolated approximately 76 arctic bacterial strains, 17 of which were novel and 10 of which produced novel antibiotics. These strains show promising antibiotic activity against human and plant pathogens, and we hope to continue identifying promising strains from sites near MARS.

In addition to completing a successful 2021 field season, we also published ~6 scientific articles in the last year describing results from our ongoing work in Nunavut.

Proposed 2022 Research

We have successfully applied to the Polar Continental Shelf Program to support a two-week field season in July 2022 with Lyle Whyte, Brady O'Connor, Louis-Jacques Bourdages, Scott Sugden (new PhD student), and a possible fifth student or research assistant. Our main objective is to continue detecting and characterizing microbial activity in extreme environments, and we will pursue this objective by advancing the four key projects outlined below.

First, O'Connor and Bourdages will field-test our recently improved biosignature detection platform, including the latest prototypes of our drill, DNA extraction machine, and microbial activity microassay. We will test samples from the Gypsum Hill, Lost Hammer, and Colour Peak hypersaline springs, and we will use our results to continue improving these devices.

Second, O'Connor will explore whether glacial ice supports metabolically active microbes by collecting 1 m cores of glacial surface ice from the White and Thompson glaciers (near MARS). These samples will be used to evaluate whether similar icy environments on Mars, Europa, and Enceladus might be habitable to microorganisms.

Third, Sugden will begin a project to explore microbial activity in soils exposed after glacier retreat. As glaciers recede, the soils left behind are populated by microorganisms that begin cycling nutrients through the system. Sugden will perform *in situ* analyses and collect samples to track soil carbon flows and determine whether deglaciated soils will become carbon sources or sinks.

Finally, we will continue detecting, identifying, and characterizing the unique microbial species that live in these extreme environments and screening them for novel antibiotics. The field team will collect soil and ice samples from the areas around MARS, as well as water and sediment samples from hypersaline springs. These samples will be brought back to our lab for analysis.