Scientific and Operational Objectives for FMARS-10

Flashline Mars Arctic Research Station, Devon Island, Nunavut, Canada
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This document contains the scientific and operational objectives that I intend to accomplish during this field season at the Flashline Mars Arctic Research Station (FMARS) under the auspices of the Mars Society. I have been selected to be the crew's biologist, the Health & Safety Officer, and the Executive Officer for this field season. Therefore, I divide my goals for the rotation based on the roles I will be fulfilling.

<u>Biology</u>

In 2003, the National Research Council highlighted the emerging role of genomic technology in the study of polar habitats. The NRC also pointed out that the converse statement was also true: the study of polar habitats is expected to contribute greatly to the understanding of the genomics and systems biology of our planet. I am uniquely poised to exploit this upcoming synergy between two previously disparate fields. I propose to carry out biological studies that will incorporate traditional ecological techniques with the cutting-edge technology of genomics and molecular biology.

Biodiversity studies have been the core of the majority of research studies carried out in Devon Island. In particular, Charles Cockell and colleagues have examined the diversity present in populations of microbes, plants, nematodes, and fungi in select sub-environments of the Haughton Impact Crater (for example, Cockell et al, *AAAR* 2001, Fike et al, *IJA* 2003, Cockell & Stokes, *Nature* 2004, Cockell et al, *IJA* 2003). These studies establish a baseline of known biodiversity in the polar region, making possible the examination of the changes over time wrought by environmental change.

The challenge provided by the Mars Society is to carry out these biodiversity studies under Mars Analog simulation conditions. Previous expeditions have accomplished these goals, and I intend to model my methodology after theirs. Furthermore, a proposal for a Mars Analog Microbial Observatory has been circulated (S.R. Robles, personal communication). The National Science Foundation funds the establishment and maintenance of several centers around the country dedicated to the understanding of microbial ecology and its applications to academia, industry, government, and education. Since the Mars Society operates several sites around the world, studies can be made not only of the individual analog sites, but between them as well. Unified methodologies must be in place to carry out these studies in a scientifically rigorous fashion.

The goals of the biology portion of my proposal are identical to those of the FMARS program: to develop biological methodologies appropriate for Mars exploration; to examine the biological richness of the area surrounding FMARS; to catalog this information in a manner that is both accessible to and usable by remote scientists and future crews; and to disseminate these findings and experiences to the general public through the internet and classroom settings.

I. Remote Science Team interoperability: interfacing with off-site scientists

The Remote Science Team (RST) of the Mars Society has previously run an experiment testing the efficiency with which crewmembers of different missions can replicate the sampling of previous crews. Tiffany Vora, a member of Crew 11 (Jan. 2003) at the Mars Desert Research Station in Hanksville, Utah, had compiled a database of her sampled locations. This database included GPS coordinates, a written description of the site, and photographs of the sample. Under the auspices of RST members Stacy Sklar and Shannon Hinsa, this database was relayed to Dr. Shannon Rupert Robles on-site in Utah (Jan. 2004). SRR used TV's data to attempt to locate, resample, and analyze biological samples investigated by Crew 11 a year earlier. SRR's final report included her conclusions on the experiment as well as recommendations for a systematic methodology for sampling. It is the hope of the RST and the ground crews that such a methodology can be developed at the Flashline Mars Arctic Research Station this year to promote continuity of research from year to year and among crews.

The following methodology should be implemented this year for all biological and geological samples obtained by the FMARS-10 crew. Next field season's FMARS crew will be in a position to test the revised methodology for efficiency of site relocation and resampling.

<u>General:</u>
GPS Coordinates;

<u>Large-scale:</u>
Written description of area surrounding site, including any notes on approach and distance/size descriptors of the region (including distance from a previously sampled site);
Photograph of site on large-scale, including a size reference (preferably a person, to keep with the large-scale approach): this photo should include distinct visual references.

<u>Small-scale:</u>
Written description of sample site, including:

Size/distance descriptors (see above);

Presence of moisture;

Direction the site faces;

Presence of sunlight;

Presence/direction of wind;

Soil/rock characteristics;

Photograph of the sampling site on a small-scale, including a size reference (such as a rock hammer, or forceps).

Work-up:
Written description of sample, including:

Soil/rock characteristics;

Salient features, including putative biological entities;
Photograph of sample under magnification, including a notation of the objective used;
Discussion of sample's geological and biological properties.

II. Transect monitoring of plant communities: baseline establishment and ongoing monitoring

In 2004, Shannon Rupert Robles conducted plant transects in conjunction with aquatic biodiversity studies. Each of these plant transects was carried out within 50m of the aquatic sampling location (personal communication). Cockell et al (*AAAR* 2001) systematically determined vascular plant and bryophyte cover for micro-oases located within Haughton crater. Both of these studies found a low degree of biodiversity in the regions sampled. These plant transects will be extended to include data on two different communities in the region of the crater: those located on the original regolith of the area, and the others located on the impact breccia. Given the low biodiversity of the area, quantitative studies giving rise to statistically significant data should be possible within the limitations of time and simulation.

Methods: With the help of the field geologists, regions of distinct soil composition will be identified, and plant communities will be located. At least 3 1x1 meter plots will be defined haphazardly per region. All plants within the boundaries will be counted and identified, and at least one member of each species will be photographed *in situ*. If possible, the biodiversity of lichens and mosses should be assessed in the same manner. Written descriptions and proper site documentation (see Section I) will be carried out. Time permitting, I will return to the sites sampled during FMARS-9 (within 50m of the aquatic sampling sites) and perform transects similar to those performed previously. These data will be useful in determining the change in plant community structure over a period of one year.

III. Examination of microbial diversity, including public outreach

To promote the goal of establishing a microbial observatory at the Mars Analog sites, soil samples must be analyzed for microbial species diversity, and those organisms present must be identified. Both of these objectives are carried out through the techniques of molecular biology and genomics. Furthermore, the Department of Molecular Biology at Princeton University is interested in integrating the samples and experiences from FMARS into a new course introducing undergraduates to the advances in the studies of microbial populations.

Methods: Soil samples will be gathered at each transect site and 2 meters outside the periphery of the plant community. These samples will be kept as cool as possible for the duration of the rotation. Each sample will be gathered in duplicate: one sample will be examined at FMARS for gross soil features and identification of organisms visible under microscopy. The second sample will be archived for molecular work after departure. DNA will be extracted from each of the archived samples, and 16S rDNA will be amplified and sequenced to identify members of the microbial community. To quantify the number of microbes present in each soil sample, soil dilutions will be plated and colonies counted after incubation at 25°C for 72 hours (as in Cockell et al, *AAAR* 2001).
Outreach: Archived soil samples will be given to a class of undergraduate students at Princeton University (who are not necessarily biology majors!). The students will carry out the 16S rDNA diversity studies. I will further point out the astrobiological applications of such studies to future Mars missions, and engage the students in thinking about the search for life elsewhere. Photographs and field reports that I will accumulate at FMARS will be indispensable in creating excitement in the minds of these young researchers.

Health and Safety

The safety of the FMARS crew is of paramount importance. I am a nationally certified Emergency Medical Technician, and I am interested in adapting New Jersey EMS protocols to the FMARS station. These protocols will increase the safety of working under simulation conditions, and will themselves be an examination into the efficacy of first aid and health monitoring during a Mars mission.

I. **Daily monitoring of vital signs and well-being**

Upon crew consent, each crewmember will have his heart rate and blood pressure recorded on a daily basis, along with a short description of the physical and mental health and exertion of the crewmember. The success of a crew is largely based on the health of its members, and by monitoring the health of a crew under simulation conditions, we can suggest means to keep Mars crews healthy. During my previous rotations in MDRS this was a popular topic of group conversation; I expect no less during FMARS-10.

II. **The telemedicine practice run: interfacing with the remote Flight Surgeon**

Tam Czarnik has laid out guidelines for the interfacing of crews with medical experts back home. As per those guidelines, on the first day of simulation, I will contact the Flight Surgeon via vtext.com, and expect a response. If no response is received within five minutes, the message will be repeated.

III. **Crew training and methodology brainstorming**

The crew of FMARS-10 has expressed interest in exploring the development of protocols for first aid and rescue under the extreme conditions of the simulation. Of course, if any real injuries occur, simulation will immediately be suspended. However, it will be useful for the crew to examine the materials at the Hab and discuss which of them are suitable for impromptu medical treatments. Additionally, all crewmembers should be trained in the basics of trauma management (bleeding, broken bones, etc). Again, these sessions are expected to precipitate group discussion and brainstorming.

IV. **Rescue simulations**

Simulations will be designed to explore three scenarios requiring the rescue of a crewmember:

1. Crewmember down near the Hab (transport via walking)
2. Crewmember down far from the Hab (transport via ATV)
3. Lost crew retrieval

Details of these simulations will be left to the group to discuss and design, and will be conducted if time permits. These simulations are intended to put into practice the elements discussed during the pursuit of the goals outlined in parts I, II, and III of this unit.

References

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