GENICE

Microbial Genomics for Oil Spill Preparedness In Canada’s Arctic Marine Environment


Principal investigator

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Areas of contribution

Oceanic processes
Modelling and forecasting
Polar-lower latitude linkages
Education
Observations
Sea ice processes
Data assimilation
Data archiving
Outreach
Policy-relevant / cultural aspects
Economic aspects
Societal and/or behavioural aspects
Summary

Reduced sea ice cover and ice-free summers have led to increases of 166% in shipping through the Northwest Passage since 2004. Increased activity brings increased risks of accidental releases of diesel or bunker fuel and other transportation related contaminants. Furthermore, significant oil reserves are estimated to exist in the Arctic, yet recent decisions by major oil producers signal that drilling in the Canadian Arctic is at least a decade away. This “hiatus” in offshore petroleum exploration and production offers scientists an important window of opportunity to develop emergency preparedness plans, and this opportunity must not be squandered. GENICE will use microbial genomics to generate credible, science-based knowledge on the potential for bioremediation – the biodegradation of oil by naturally occurring microorganisms. Marine microbial communities are nature’s ‘first responders’ in the event of a marine oil spill, yet little is known about this potential mitigation approach in the cold ice-laden Arctic marine environment. The project will achieve key deliverables of (1) new baselines using microbial genomics, (2) bioremediation viability case studies and demonstrations for Arctic marine habitats, and (3) a new approach to dynamic mapping of risks and mitigation potential using microbial genomic biomarkers. These outcomes will interface economic policy development and learning around emergency preparedness and oil spill response in Canada’s Arctic waters. Ongoing engagement and interactive exchange of knowledge between scientists and different end-user groups will include residents of potentially affected northern communities, different levels of government including regulatory agencies, non-governmental and indigenous organizations, and the private sector.

Description

The Canadian Arctic is experiencing extraordinary changes according to both environmental and socioeconomic indicators. Reduced sea ice cover and ice-free summers have led to a tripling in vessel traffic since 1990. With this increased activity also comes greater risk of accidental spills of fuel and other transportation-related contaminants. Climate change has also focused attention on Arctic oil exploration and attendant fears of an oil spill. Significant oil reserves are estimated to exist in the Arctic, yet recent decisions by major oil producers including Shell, ExxonMobil, Chevron signal that drilling in the Canadian Arctic is at least a decade away. GENICE will introduce genomics approaches to deliver a new understanding of Arctic marine microbial communities – the first responders to marine oil spills in Canada’s northern waters. This way, the potential for bioremediation will be assessed, addressing the urgent need for oil spill mitigation technology related to Arctic shipping, to seize the window of opportunity to develop science-informed policy before any Arctic oil production commences.

The risk and impact of accidental marine oil spills was brought into focus by the Gulf of Mexico Deepwater Horizon (DWH) blowout and oil spill in 2010. More recently, the smaller 2015 Marathassa oil spill in English Bay, Vancouver, highlighted the concern and confusion associated with these events, and raised questions about preparedness in Canada. This is of great concern, especially with the prospect of a larger, more serious incident in the cold, dark, inaccessible regions of the Arctic and along transport routes adjacent to Canada’s northern communities. In the aftermath of DWH and other oil spills, scientists have observed a rapid mobilization of naturally present microorganisms catalyzing bioremediation, mitigating negative impacts of the spill. The ability of microbial communities to biodegrade crude oil is generally well known, but the reliability of bioremediation as a mitigation technology under permanently cold conditions such as those in the Arctic marine environment, especially when sea ice is present, has not been adequately investigated and must not be taken for granted.
GENICE will combine cutting edge genomics with analytical chemistry (petroleomics) and sea ice geophysics to characterize the Arctic marine microbiome and rates of biodegradation for a range of pollutants at in situ temperatures (down to −2°C). Sea ice, seawater and sediments will be collected during fieldwork conducted from various platforms including Canada’s scientific icebreaker CCGS Amundsen. A special focus on sea ice will capitalize on the new Churchill Marine Observatory (CMO) controlled oil-in-sea ice testing under realistic marine conditions.

With these combined approaches we will be able to achieve key deliverables, identified together with northern communities, government departments and private sector end-users: (1) to incorporate microbial diversity into novel baseline metrics for environmental effects monitoring, (2) to demonstrate the efficacy of bioremediation technologies in cold sub-zero Arctic conditions, (3) to provide genomic biomarker screening technology for creating vulnerability maps for regions of concern, and (4) to provide end-users with a Best Practices document with GENICE findings and recommendations. The project will primarily focus on the Hudson Bay region, a region of intense and increasing shipping in close proximity to many Arctic communities in multiple provinces and territories, and a region that is considered a bellwether for future conditions anticipated for the rest of the Arctic.

These four deliverables will contribute to diverse social and economic benefits. Engaging with multiple end-user groups will deliver new tools for informing policy and strategies for oil spill preparedness and response. Genomics will provide useful information for planning of safe ship corridor networks, remove the uncertainty of the costs associated with potential spills, and enhance environmental baselines needed by regulatory agencies. Northern communities and organizations, in partnership with the GE3LS team, will enhance Canadians’ understanding of bioremediation. Policies and strategies informed by genomics research will enable an improved capacity for environmental protection through safer shipping and oil exploration in the Arctic.

The GENICE application was submitted to Genome Canada in April 2016 and was successful. The ~$10 million (CAD) project is beginning in 2017 with $5m in cash for research at the University of Calgary, the University of Manitoba, and McGill University. In kind contributions from various sources make up the other $5m, and include a portion of the investment in the Churchill Marine Observatory as well as activities at collaborating institutions around the world including the Georgia Institute of Technology (US), Sintef (Norway), Newcastle University (UK) and Aarhus University (Denmark). The project is structured around six activities, namely: (1) Project Management; (2) Field Sampling; (3) Genomics Methodologies; (4) Sea Ice Environments; (5) Benthic Environments; (6) Economic, Social and Legal aspects.

A range of end users supporting the project provided letters of support (>40) that were submitted with the application. End users include major oil companies (ExxonMobil and Shell), environmental consulting companies (Stantec), various federal government departments (e.g. Environment and Climate Change Canada; Department of Fisheries & Oceans, Canadian Coast Guard, etc), Canada’s federal energy regulator the National Energy Board, and northern communities (e.g. Churchill, Manitoba). A meeting in December 2016 in Winnipeg convened these stakeholders so that the GENICE science team could kick off activities by soliciting feedback and input from these end users. This feedback is being used to shape the scientific approach and sampling plan.

**Timeline**

2016-10-01 - 2020-09-30
User relevant aspects

GENICE started in Dec 2016 with a Knowledge Exchange workshop where various end users met in Winnipeg with the GENICE scientists. These workshops will occur regularly during the 4 year project, and are a centrepiece of all Genome Canada projects as "GE3LS" i.e. "Genomics and its Ethical, Environmental, Economic, Legal and Social aspects" (https://www.genomecanada.ca/en/programs/ge3ls-research):

GE3LS will integrate genomics knowledge into the complex milieu of economic policy development and learning around emergency preparedness and oil spill response in Canada. Ongoing engagement and interactive exchange of knowledge among scientists and end-user groups will involve residents of affected Arctic communities, different levels of government including regulatory agencies, non-governmental and Indigenous organizations, and private sector entities. GENICE scientists, working together with GE3LS experts in anthropology, policy, law, economics and learning theory, will play a major role in this project’s interactions with end users. Scientists will work with GE3LS researchers to translate and communicate science and deliverables effectively and maintain ongoing engagement with end users via GE3LS activities. Overarching objectives of Activity 6 are:

1. Characterize the economic, legal and political landscapes associated with the management of and response to oil spills in the Arctic;

2. Work with key contacts in end user groups to develop a transformative engagement strategy for exchanging and utilizing scientific, indigenous and end-user knowledge categories;

3. Develop and implement knowledge mobilization workshops to encourage and enable exchange of ideas between researchers and end users to facilitate measurable actions;

4. Determine learning outcomes and establish end-user engagement processes specifically suited to facilitating the incorporation of genomics information and data into decision-making processes relevant to oil spill preparedness and response in Arctic waters.

Regional emphasis

Northern hemisphere: Yes
Southern hemisphere: No

Key project deliverables

(1) to incorporate microbial diversity into novel baseline metrics for environmental effects monitoring;

(2) to demonstrate the efficacy of bioremediation technologies in cold sub-zero Arctic conditions;

(3) to provide genomic biomarker screening technology for creating vulnerability maps for regions of concern;
Data management

The following measures will ensure free and open access to data and results generated during the GENICE project:

Arctic Connect is an interactive web portal hosted by the Arctic Institute of North America at the University of Calgary (http://arcticconnect.org)

Collection and storage of genomics data will be enabled by guidelines and recommendations conceived by committees within the research community, such as the Genomics Standards Consortium (GSC) (http://gensc.org/) and the Environmental Ontologies Project (ENVO) (https://bioportal.bioontology.org/ontologies/ENVO). In a large effort the GSC and the public sequence data archives NCBI (National Center for Biotechnology Information) and ENA (European Nucleotide Archive) have together implemented standards that enable and require researchers to outfit sequence data with contextual data.

Is data provided to WMO Global Telecommunication System

No