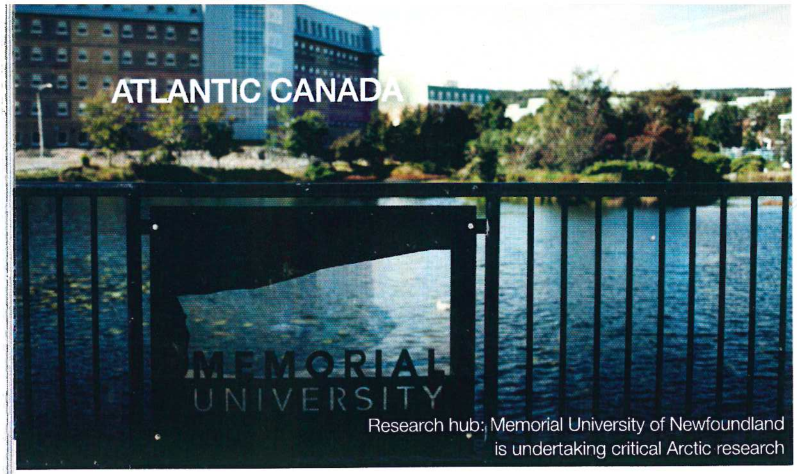

Research hub: Memorial University of Newfoundland is undertaking critical Arctic research


Memorial University project team in Helsinki.
Left to right: Dr. Faisal Khan, Doug Smith, Faisal Fahd, Mawuli Afenyo

Assessing and minimising risk: OIL SPILLS AND SHIPPING

An exploration into the work of Memorial University of Newfoundland in St. John's, one of Canada's premier learning institutions, and a hotbed of research for the shipping, technology and oil industries in the Arctic region. By Andrew Safer

The combination of accelerated melting of polar ice, prospects for increased shipping, and the potential for oil spills are galvanising researchers in Canada and Finland to address knowledge gaps regarding transits in ice-covered waters.

Mawuli Afenyo and Doug Smith at Memorial University of Newfoundland in St. John's and Maisa Nevalainen at the University of Helsinki, Finland are PhD candidates focused on these issues through an international research initiative spearheaded by the Joint Research Center of Excellence for Arctic Shipping and Operations based at Aalto University (Finland). The five-year project, that began in 2013, includes thirteen PhD and two Master's degree students at five universities in Finland, Norway, Germany, and Canada: (1) Aalto University (Aalto U), Helsinki, Finland; (2) University of Helsinki (UH), Helsinki, Finland; (3) Norwegian University of Science and Technology (NUST), Trondheim, Norway;(4) Technical University of Hamburg (TUH), Hamburg, Germany; and (5) Memorial University of Newfoundland (MUN), St. John's, Canada. The research projects are supported by £1.7 million from Lloyd's Register Foundation.

Mawuli Afenyo, who has a Master's degree in Petroleum Engineering and an MBA in Green Energy, is conducting his research at Memorial University in St. John's, Newfoundland. He is developing models to determine the dispersion pattern of oil post-spill in icy waters. He is developing a 'multimedia' model that will predict the concentration of pollutants in the air, water, ice, and sediment. The values obtained could be compared with the accepted threshold values for pollutants in a particular jurisdiction. "Government agencies can decide if it's really risky, or if it's okay," he says. Afenyo notes that there are complex and simultaneous processes that occur immediately following a spill including evaporation, sinking, biodegradation, and emulsification. "The oil can spread on the ice, you can have it on-snow, and it can be encapsulated in ice. The oil can go below the ice as well," he says, adding that due to a lack of field experiments, there is little real-world data to indicate how oil actually behaves in ice. He is following the lead of Norwegians who have done some numerical modeling of oil in ice conditions. The aim is for responders to use his models to determine the physiochemical properties of the oil to aid in a response effort. Afenyo notes that there is little known about encapsulation - the process whereby oil becomes trapped in ice - and its eventual release into the water. Noting that encapsulation is missing in most oil spill models, he will be investigating this process to understand its mechanisms. Afenyo will be presenting a paper on his ongoing work at the Arctic Technology Conference in St. John's in October 2016.

In order to run his models using Arctic data, Afenyo is collaborating with Maisa Nevalainen, a PhD candidate in Environmental Sciences at the University of Helsinki, Finland who is focused on the ecosystem impacts of an oil spill in the Russian Arctic. Afenyo's models showing where a pre-determined amount of oil would go following a spill will interact with Nevalainen's models, which will show impacts on animals, from predators at the apex of the food chain down to invertebrates. To gather the quantitative data, she will be interviewing subject matter experts, asking them about probabilities regarding acute impacts of oil on different animal groups in the Arctic, combining their accumulated knowledge, and adding historical and toxicological data. She is building ecotoxicological models that represent species for which toxicological data is available (such as invertebrates). Nevalainen and her colleagues have developed a framework for quantitative oil risk assessment in the Arctic. "To our knowledge," she says, "this is the first holistic picture of the ecological entities and their interactions that should be taken into account when analysing the risks to the Arctic environment posed by oil transportation." Nevalainen adds that they are using Bayesian theory for the risk assessment because Bayesian networks handle uncertainty explicitly, can aggregate low- to high-precision information from a variety of sources, and update easily when new information becomes available. Improved understanding of impacts on Arctic species will enable a more realistic assessment of risk. "We should understand better how big the risk is," she says. "Right now, environmental groups are saying the risk is enormous, and oil companies are

Photos: Memorial University of Newfoundland saying they are being safe, so no worries. I'm hoping to find some actual number in between those two." Afenyo and Nevalainen will be validating their models by using data that is available for the Kara Sea in the Arctic Ocean, north of Siberia.

Doug Smith, an Ocean and Naval Architectural Engineering PhD candidate at Memorial University, is taking a holistic approach to building a model that can be used to help prevent shipping accidents from occurring. Since accident information for Arctic shipping is scarce, rather than depending on historical data, he is developing models that use what is learned from successful operations - how work actually gets done - and variability that can impact overall operations. "Variability" refers to an event or circumstance that falls outside of the expectation of the idealised workflow, such as the variable ice conditions that must be dealt with regardless of the expected conditions. "A good communication structure within the organisation is a critical element with respect to safety," says Smith. He adds that operators should have the same mental model of the operation as the engineers and management. The key is to have a consistent and realistic mental model. "Then, things that are outside the norm raise flags for the operators," observes Smith. To build his model, Smith is using the functional resonance analysis method (FRAM), which incorporates an understanding of variability within the system, which is present in both successful operations and accidents. The model will include both variability and the adjustments that have been made to accommodate it successfully, and occasionally, unsuccessfully. He plans to collect information from captains, chief engineers, and others on board ships who have first-hand knowledge of shipping operations and variability, and what was done to keep operations safe.

Dr. Brian Veitch, professor of Ocean and Naval Architectural Engineering at Memorial University, supervises Smith's research. "Rather than focus exclusively on past accidents as a source of insight, we're trying to understand why shipping operations are almost always successful," he says. "That is, we're investigating who and what make an operation robust and resilient in the face of changing circumstances." He sees great value in taking a human factors approach to preventing shipping accidents. Recently, Afenyo took a flight to the University of Helsinki to collaborate with Nevalainen for three months. "They each have a piece of the puzzle," Dr. Veitch says, "and they're going to join them so they can do something bigger than the sum of the parts." They will be developing a risk assessment model for Arctic shipping and applying it to a case study in the Kara Sea. FE

Afenyo, Nevalainen, and Smith plan to publish the results of their work in scientific papers. Information regarding their findings will be available on the Research Center of Excellence for Arctic Shipping and Operations web site: www.cearctic.aalto.fi/en/