Fisheries and Oceans Canada | Pêches et Océans Canada

PHOTO: ©T. Coolbaugh (OHMSETT)

Multi-Partner Research Initiative

Improving Oil Spill Response Technology in Canada

Fall 2021 Issue 2

In This Issue

What's new in 2021/22? 2

Atlantis whole-of-ecosystem model for the Salish Sea 3

Advancements in decanting technology 4

Analysis of dispersant effectiveness 5

Shoreline response decision support tool 6

Biodegradation in the Arctic 7

Science advice on dispersants 8

Researcher spotlight 9

Awards and recognitions 10

Canada

Greetings from the Director General, Ecosystem Sciences Directorate

The Multi-Partner Research Initiative (MPRI) is an inter-governmental program with Transport Canada, Fisheries and Oceans Canada (DFO), Natural Resources Canada, Environment and Climate Change Canada and the Canadian Coast Guard under Canada's Oceans Protection Plan. MPRI's aim is to advance oil spill response science in order to enhance Canada's capability to effectively respond to marine spills and protect the marine environment and its living resources. Over the past four years, it has supported over 40 research projects that support science-based decision making for future oil spill response operations in Canada and abroad. Moreover, MPRI has successfully built a national/international research network of expertise that includes academia, industry and governmental agencies, and has supported the training and mentorship of over 90 post-graduate students and post-docs. These contributions, along with the relationships its built with the end-users in the oil spill response community, are delivering on Canada's commitment to a stronger evidence base for oil spill response.

Finally, I wanted to congratulate the MPRI research teams for effectively adapting to the challenges of the past year and a half. Despite restrictions to access to research facilities and to travel for fieldwork and workshops, they managed to keep their projects on track, not only achieving but in many cases exceeding their project milestones.

Well Done!!! ***Bernard Vigneault***

What's New in 2021/22 ?

New Projects

We are pleased to announce the funding of 10 new MPRI projects for fiscal year 2021/22, seven of which are funded under a competitive DFO "Open Call " process. Totaling over $3 million, these projects led by research teams from Canada, USA and Europe include conduct of mesocosm-scale in-situ burning and dispersant tests, the development of novel spill treating agents, 3-D models for oil fate and trajectory; advances in innovative remotely operated vehicle and remote sensing technologies; improvements in toxicity test protocols and our understanding of oil emulsification at sea. More details will be provided in subsequent newsletters.

Synthesis and Legacy Program

A Synthesis and Legacy Program has been launched to highlight advances in knowledge, technology, and expertise under the MPRI network over the last five years and its impact on oil spill response capacity and capability in Canada and worldwide. This initiative involves scientists, oil spill responders and decision-makers to synthesize and reflect on the research findings/achievements and lessons learned from the program. It will also provide a forum to discuss knowledge gaps, the prioritization of future research priorities and the transfer and dissemination of findings to end users. In addition to the coordination of scientific publications in the peer-reviewed literature , the program will include an International conference hosted by MPRI in March 2022.

Figure: Distribution of MPRI researchers in 14 countries

Building a Tool to Understand the Impacts of Contaminants & Contaminant Management in the Salish Sea

by Sara Mynott, University of Victoria

MPRI is supporting an international team of researchers from CSIRO (Australia), University of British Columbia and University of Victoria who are working with regulators in British Columbia to expand the scope of the Atlantis model for use by oil responders to predict the impact of oil spills and various response strategies on the health of the Salish Sea ecosystem.

Atlantis is a whole-of-ecosystem model, developed by CSIRO, which has been adopted around the world to assess the impact of human activity on the marine environment. The model incorporates all features of the marine and coastal environment, pulling in current flows and environmental conditions from fine-scale water flow models, and explicitly representing the marine food web that is shaped by those conditions.

By modelling the spread of contaminants, both in the environment and through the food web, Atlantis can represent the lethal effects of an oil spill, as well as longer-term impacts on population growth and reproduction.

By simulating hypothetical scenarios, Atlantis can be used to explore both intervention and response options ahead of an event, and help with strategic planning. For example, the model can be used to see how different kinds of oil spills – based on the volume and kind of material spilt, its location and the season in which it occurs – and response options could play out ahead of time.

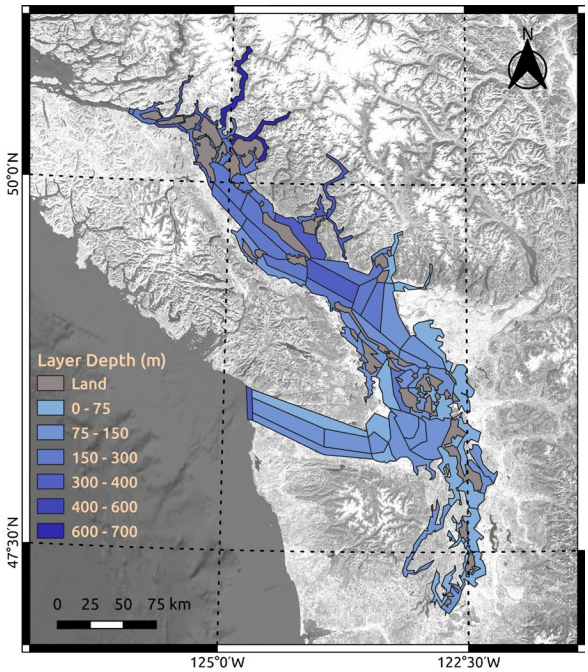

Figure: Region covered by the Salish Sea Atlantis model (© CSIRO)

This information can help managers to determine which actions will be most effective in minimizing regional environmental and socio-economic impacts. For more information about the Salish Sea Atlantis model and how it could support oil spill management, please visit the Atlantis website.

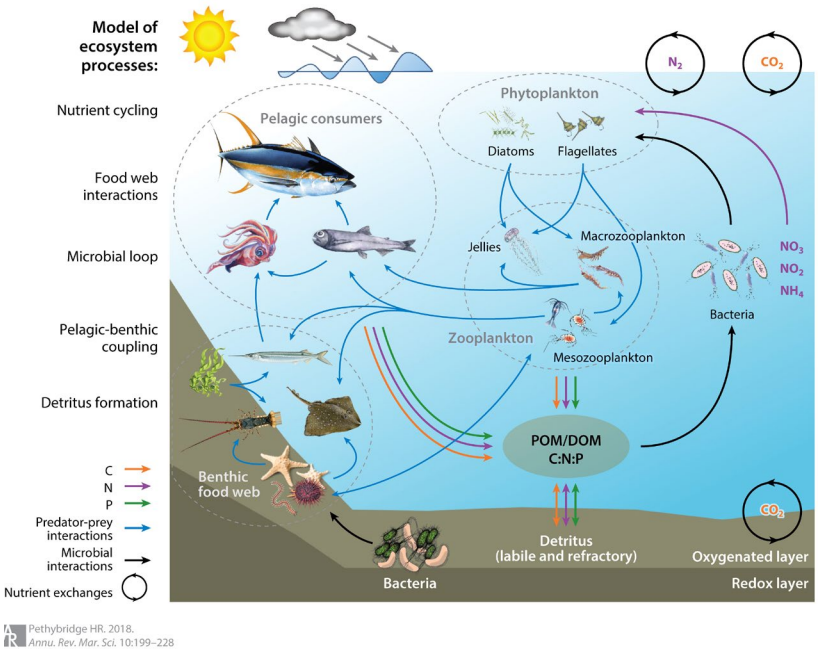

Figure: Representation of main ecological processes and food-webs included in an Atlantis ecosystem model. © Pethybridge et al. 2018 with selected illustrations by T. Saxby (IAN image library) and K. Lance.

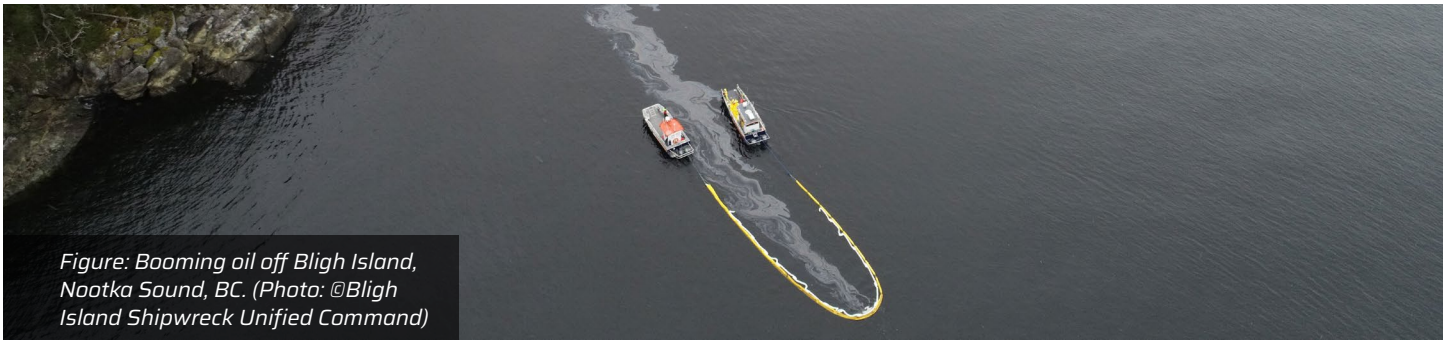

Figure: Booming oil off Bligh Island, Nootka Sound, BC. (Photo: ©Bligh Island Shipwreck Unified Command)

Decanting of Oily Wastewater by Nanobubble Gas Flotation Technology- A Field-scale Operation

by Debjani Mukherjee & Jianbing Li, University of Northern British Columbia (UNBC)

The removal of oil spilled at sea by booming (to contain) and skimming (to recover) is one of the primary spill response measures used in Canada. Unfortunately, skimmers typically pick-up a mixture of both oil and water which significantly constrains the response capacity due to limited temporary storage space on response vessels. Effectiveness of the operation can be greatly enhanced by decanting (separation of the oil from water) with disposal of the decanted water at sea, thus reducing the volume of waste and transit time to shore for disposal.

Under the MPRI, nanobubble gas flotation technology is being investigated as an alternative technique to conventional methods for decanting, such as gravity separation, to treat oily wastewater during field operation. The advantages of this emerging technology include higher oil removal efficiency, better effluent quality and smaller physical footprint on board vessels. It works on the principle of the density difference between water and oil droplets. In this process, oil droplets become attached to induced gas bubbles which rise to the top of the separator where they are skimmed off.

Led by Dr. Jianbing Li of UNBC, an operational-scale field trial will be conducted of a mobile nanobubble gas flotation unit developed in Canada by K-Line Trailers Ltd. The study will be conducted in collaboration with scientists from Memorial and Dalhousie Universities and members of the oil spill response community, including the Canadian Coast Guard, Environment and Climate Change Canada and Western Canada Marine Response Corporation, in January 2022 at the Canadian Coast Guard base in Richmond, B.C.

The mobile unit consists of complex liquid processor, nitrogen gas cylinder for generating nanobubbles in a saturated fluid stream, pumps and electronic controls. The maximum throughput of the unit is 66 m^3/h. The oil-water emulsions similar to that expected from booming and skimming operations will be pumped continuously as an influent to the mobile system and the emulsion will be separated in the separator under the effect of nanobubble gas flotation. The floated bubble-oil droplets will be skimmed off from the top of the separator and the decanted water will be pumped to a storage tank through the effluent. To reduce the amount of wastewater generated, a recirculating system is being designed by mixing the effluent (decanted water) from the storage tank with test oil to synthesize the influent for further experimental runs.

A number of experimental and operation parameters will be examined to evaluate the efficiency of this system to treat the oil-water mixture, such as the oil type (crude oils and low-sulfur fuel oils), oil concentration, emulsion composition, size of nanobubbles and retention time. The concentrations of hydrocarbons and their transformed products will be analyzed in the decanted/treated water and in the recovered oil. Complimentary methodologies, such as adding demulsifier and integrating with other processes like centrifuging, that may further enhance the overall effectiveness of the system will also be investigated. The results of this trial will help determine if, and under what circumstances, this type of technology may provide an effective in-situ (on-water) treatment for oily wastewater, and thus improve the overall efficiency of oil spill response operations in Canada.

Figure: Mobile nanobubble gas flotation unit (Photo: ©S.M. Nasiruddin, UNBC)

Figure: Helen Zhang (PI), Min Yang (PhD) and Zhiwen Zhu (PDF) conducting oil spill response experiments at the Ohmsett Facility, New Jersey in November 2019. (Photo: ©M. Boufadel)

Comprehensive Analysis of Technical Effectiveness for Using Dispersants for Marine Oil Spills in Canadian Waters

by Dr. Helen Zhang, Memorial University

Dr. Baiyu Helen Zhang led a research team with internationally recognized expertise associated with Memorial University, CEDRE, New Jersey Institute of Technology, SINTEF Ocean, and McGill University to conduct a systematic analysis of the effectiveness of selected dispersants in treating oils transported and shipped in Canadian waters. The research activities aim to provide scientific evidence and technical advice on the potential application of dispersants in Canadian waters in an effective and reliable manner.

The cutting-edge research activities involved several national/international class facilities (e.g., NRPOP, CEDRE, OHMSETT, SINTEF, and NRC) with key research outputs including: (i) a comprehensive review on the use of dispersants as an oil spill response technique with up-to-date status and future prospectives; (ii) prediction of oil droplet size distribution with dispersants under various operational conditions through design-of-experiment and parallel optimization modelling; (iii) investigation of interactions between microplastics and oil dispersion in the marine environment and behaviors of microplastics-oil-dispersant agglomerates at different sea layers; (iv) identification of the key oil weathering tracers by tracking oil biomarkers during dispersed oil weathering and a forensics-based integrated analytical strategy established for evaluating behaviors of dispersed oils; (v) introduction of machine learning to oil fingerprinting analysis by developing a data-driven binary classification framework; (vi) metagenomic profiling of oil degrading communities obtained for assessing the diversity and adaption of microbes during biodegradation of chemically/naturally dispersed oil for in-depth understanding of sophisticated microbial response to marine oil spill dispersion; (vii) development of magnetic nanoparticles decorated bacteria (MNPB) using oil-degrading and biosurfactant-producing species and identification of a novel access-dispersion-recovery strategy for enhanced heavy crude oil mitigation; and (vii) generation of fish waste based bio-dispersants and systematic evaluation of associated dispersion effectiveness.

Figure: Xing Song (PDF) presenting his findings in PEOPLE 2019 conference (Photo ©J. Ling)

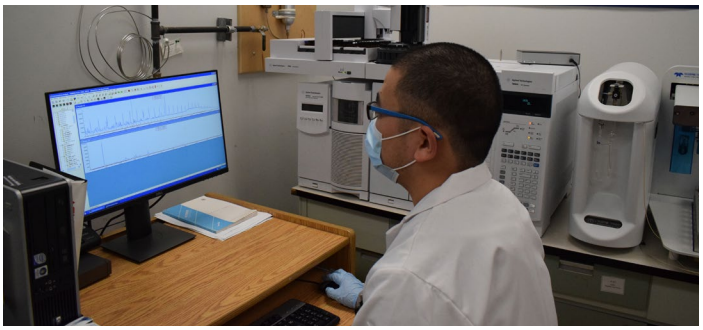

Figure: Yiqi Cao (PhD) working on oil fingerprinting using GC-MS at Memorial NRPOP lab in 2021 (Photo: ©J. Ling)

The project has trained three PhD students and five postdoctoral fellows. To date, the team has generated 20 refereed journal papers, 2 book chapters and 33 publications in international/national conferences/symposiums/workshops.

Oiled Shoreline Response Program Decision Support Tool

by Ed Owens, Owens Coastal Consultants, Elliot Taylor, Polaris Applied Sciences & Chunjiang An, Concordia University

One project in the MPRI is the development of an Oiled Shoreline Response Program (SRP) Decision Support Tool as an aid to oil spill preparedness, planning, and response activities, both as part of preparedness and at the time of an incident (see design components in figure below). There are many science-based components of the decision-making process regarding feasibility and the appropriateness of treatment and cleanup techniques for different shoreline types and for different oiling conditions and that address the potential consequences of the viable options.

A key objective of the Decision Support Tool is to present this information in a manner that can be easily used by planners, managers, operations personnel, and the public to better understand how and why a decision has been developed. The project is a joint endeavor between Concordia University in Montreal, Owens Coastal Consultants, and Polaris Applied Sciences who have been brought together under the umbrella of the MPRI, one aim of which is to develop partnerships and relationships between industry and academia.

The SRP Decision Support Tool is intended to be a dynamic, interactive, multi-layered, geographic-based, seasonal simulation model for shoreline oil spill response decision analyses.

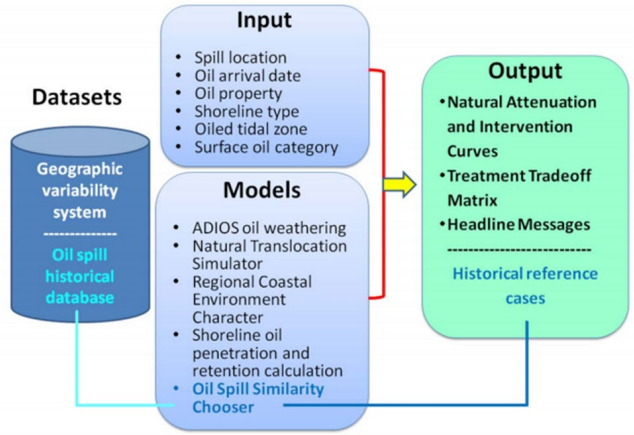

Figure: Decision support tool components and GIS data base

Strong progress has been made to develop the GIS database for the appropriate shoreline information for Canada and a demonstration input/output interface has been developed to illustrate the use of the tool. The Tool includes the ability to select historical case study information from shoreline oiling incidents in Canada and from oiled shoreline experiments to provide scientific information relevant to a specific scenario or a real-world incident response. This SRP Decision Support Tool can be applied to all temperate and polar shoreline environments and, with a few modifications, also to tropical regions.

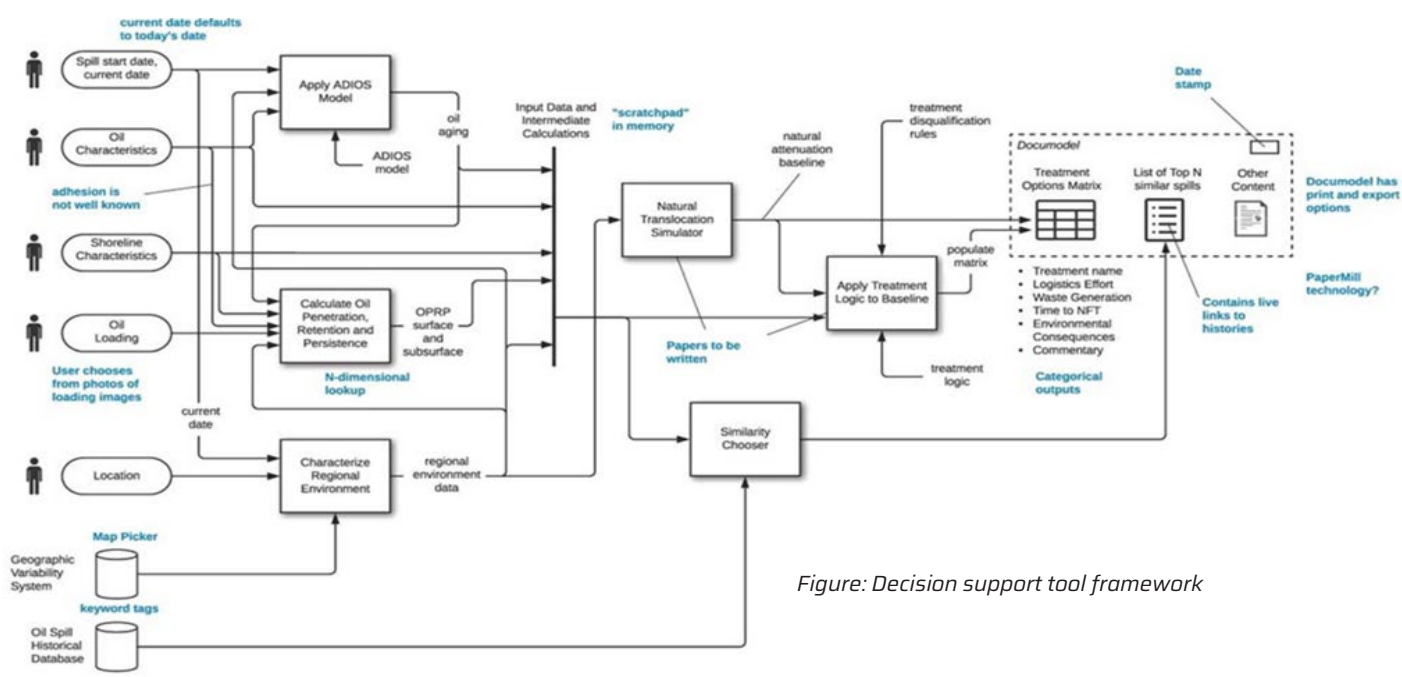

Figure: Decision support tool framework

Figure: Deploying in-situ microcosm in Nunavut (Photo: ©A. Tam, Department of National Defence)

Biodegradation and Bioremediation of Oil Spills in the Arctic

by Charles Greer, McGill University & National Research Council Canada

Concerns about climate change, increased shipping traffic in the Arctic and the increasing demand on oil resources is putting the Arctic environment at increasing risk of oil spills and their resulting impacts on the resource-based culture of Indigenous peoples in the north. Consulting with and engaging northern communities on what is important to preserve and maintain their environment to support their way of life is essential in developing any strategy to deal with future oil spills. Local communities in Arviat, Chesterfield Inlet and Resolute Bay in Nunavut are concerned about how some of these changing trends will impact their subsistence-based way of life, because a great deal of their hunting and fishing is along the coast. Since these coastal communities rely on transfers of fuel from ship to shore, there is growing interest in being prepared to address an oil spill should one occur.

Our research is exploring a new experimental system to evaluate the ability of marine microbes in the Arctic Ocean to be effective in oil spill remediation.

We have developed in situ microcosms to study the natural attenuation of oil in this ecosystem, under typical inclement conditions. In situ microcosms are comprised of oil coated natural matrices, like clay beads or river rocks, that are incubated under natural marine conditions in the north. In this way, we observed microbes in the seawater capable of degrading oil become enriched on the oil coated matrices, while the uncoated matrices tend to enrich a different microbial community. Through this, we can identify microbes in the marine environment that have the ability to degrade components present in oil and determine whether these particular environments have natural oil degrading populations that could become active and functional should an oil spill occur. By conducting this research in different northern areas, it will be possible to develop a microbial map of areas that have good oil-degrading populations and suitable nutrient conditions, as well as identify areas that may be more at risk. Results from the in situ microcosms are demonstrating that many of the bacteria enriched on oiled substrates are well-known oil-degrading bacteria that have been observed in other oceans around the world. In the Arctic, it is becoming clearer that some of these known oil-degrading bacteria are observed more frequently, indicating that they have adapted to the conditions present in the Arctic.

Figure: MPRI-funded researchers sampling ice cores with the help of community members in Chesterfield Inlet, NU. (Photo: ©C. Greer)

Although some find it surprising that microbes are efficient at degrading hydrocarbons in Arctic environments, data have shown that oil compounds are degraded even at sub-zero temperatures (-1°C), and at rates that are quite comparable to those seen in more temperate environments. This is an important observation that will influence future directions on Arctic research, especially when considering oil spill impacts in remote and poorly characterized environments.

National Peer Review Process on Dispersants

MPRI researchers contribute to science advice to support decision-making on Alternative Response Measures (ARMs).

DFO Science has recently completed a Canadian Science Advisory Secretariat (CSAS) peer review process on the State of Knowledge on Chemical Dispersants for Canadian Oil Spills. CSAS peer reviews are used by DFO to develop objective scientific advice for decision-making. The process involves inviting a group of internal and external experts to review and synthesize current knowledge and prepare consensus advice based on the available evidence.

The goal of the Dispersants science peer review meeting was to consolidate, assess and critically evaluate the current state of knowledge on dispersants as it applies to a Canadian context. Specific questions addressed included:

1. How does applying dispersants change the movement of oil and exposure to sensitive receptors (e.g., aquatic species, habitats, and other sensitive coastal or marine areas)?

2. What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short and long-term impacts on sensitive receptors?

3. What are the key considerations or recommendations for environmental monitoring after dispersant use?

4. What are the priority, outstanding science needs to support the regulatory regime and decision making for the use of dispersants in Canada?

The outcomes from this process are expected to be used to:

- Efficiently inform critical and time sensitive spill response decisions (such as net environmental benefit determinations);
- Provide consensus-based, scientific advice to inform and support the communication of spill response decisions;
- Support and inform the development of regulations, policies, standards and guidance for dispersant use; and
- Support various other Government of Canada initiatives related to spill response.

The Dispersants CSAS process involved over 40 Canadian and international experts from government, industry, and academia. MPRI team members served on the Steering Committee and several MPRI researchers participated in the peer review meetings held in March 2021. Outcomes of this process include a research document, a proceedings and a Science Advisory Report (to be posted on CSAS website, as they become available).

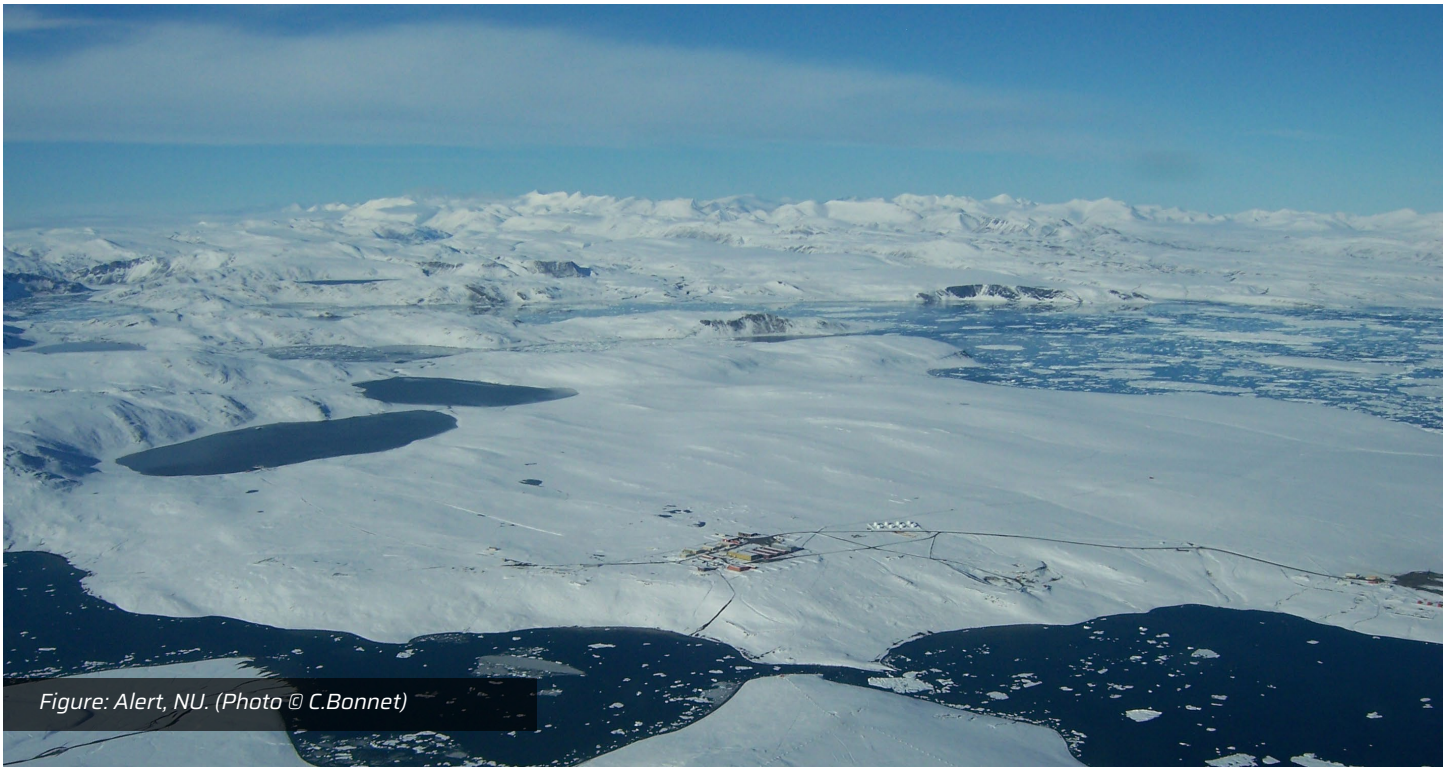

Figure: Alert, NU. (Photo © C.Bonnet)

Researcher Spotlight Interview with Allison Chua

PhD student in Oceanography at Dalhousie University under the direction of Dr. Douglas Wallace.

Q: Could you tell us about your current research and how it is connected to the MPRI?

A: My research focuses on the development and testing of novel underwater vehicle platforms and sensor packages that can be rapidly deployed to characterize the spatial and temporal evolution of unpredictable ocean phenomena, such as a marine oil spill and subsequent response efforts. The Autonomous Underwater Vehicles (AUVs) and Remotely-Operated Vehicles (ROVs) that I work on are based on small, open-source, and commercially-available platforms that allow modular integration of various payloads, making them very versatile instruments that can be used for a range of purposes including oil detection/monitoring and in-situ burn (ISB) residue collection.

Q: As a student, what has it been like being involved with the MPRI network?

A: I think that the MPRI network does an incredible job at connecting everyone involved in the entire oil spill research and response community, from academia to industry to government. The opportunities I've had to collaborate with researchers like Dr. Neil Bose (Memorial University) and Dr. Feiyue Wang (University of Manitoba) by itself have been invaluable, but the MPRI network has also given me the chance to conduct experiments with companies like ExxonMobil and government organizations in both Canada and the United States. As a student, participation in MPRI has been an invaluable experience, since the variety of unique opportunities to gain knowledge and experience in oil spill research would otherwise not have been available to me.

Q: What part of your research are you the most passionate about?

A: Underlying every aspect of my research are the principles of relevancy, practicality, and accessibility. I want my research to be a realistic answer to a real-world problem that can be implemented today, which is one of the reasons that I think it fits well within the MPRI. I believe in the academic process of repeated testing, publications, and peer-review, but seeing my work make a positive contribution, whether it is delineating oil spill boundaries for cleanup or assessing the environmental health risk to fish species, is more important to me than any number of publications.

Q: How has this experience influenced your future academic/career goals?

A: Participating in MPRI has shown me how much more is possible when interdisciplinary teams of various backgrounds with unique perspectives come together to achieve common goals. As a PhD student in Oceanography who came from industry with a background in Mechanical Engineering, my research background is slightly unorthodox, and I owe a great deal to Dr. Ken Lee's (MPRI) encouragement and support. Through this experience, I have a better understanding of the strengths and weaknesses in my skillset and therefore the type of working environment that best fits me, regardless of the direction in which my future career lies.

Figure: ROV surfing a wave as it maps oil and dispersant. (Photo: © T. Coolbaugh, OHMSETT.)

Upcoming Events

International Oil Spill Science Conference

March 21-25, 2022 (Halifax, NS, with virtual option)

The conference will feature presentations and panel discussions on the results of MPRI-funded research projects as well as other major national/international studies relating to MPRI's program areas. **The deadline to submit an abstract is January 7, 2022.** Please visit the ***Conference website*** for more information!

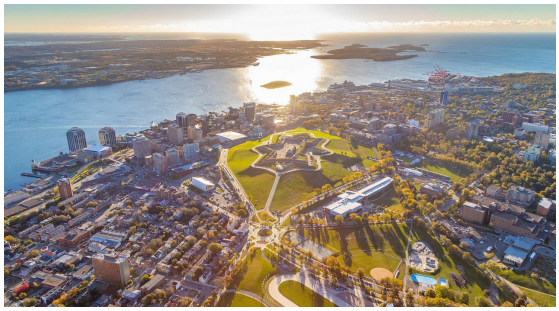

Figure: Halifax Harbour

Awards & Recognitions

Dr. Baiyu Helen Zhang, Memorial University

Awarded the ***2020 Memorial University President's Award for Outstanding Research***. This award recognizes young researchers at Memorial University who have made outstanding contributions to their scholarly disciplines.

Dr. Bing Chen, Memorial University

Named a ***Fellow of the Canadian Society for Civil Engineering and a Fellow of the Engineering Institute of Canada***.

Dr. Chunjiang An, Concordia University

Awarded ***Concordia University Research Chair in Spill Response and Remediation.***

Dr. Feiyue Wang, University of Manitoba

Awarded the ***Chemical Institute of Canada's Environment Division Research and Development Dima Award***. Presented for distinguished contributions to research and/or development in the fields of environmental chemistry or environmental chemical engineering, while working in Canada.

More information

Resources
www.dfo-mpo.gc.ca/science/partnerships-partenariats/research-recherche/mpri-irmp/index-eng.html

Email
DFO.OPP.MPRI-PPO.IRMP.MPO@dfo-mpo.gc.ca