PHOTO: Fisheries and Oceans Canada

Multi-Partner Research Initiative

Improving Oil Spill Response Technology in Canada

In This Issue

Greetings from our Senior Science Advisor

Since our inception in 2017, the Multi-Partner Research Initiative (MPRI) has established a world-class network of expertise on oil spill response science. To date, over $35 million in grants and contributions have been awarded by Fisheries and Oceans Canada (DFO) to 40 projects and partnerships involving over 240 re-searchers from 60 institutions and 12 countries.

I am very excited to present our first MPRI Newsletter. This periodic newsletter will provide highlights on MPRI projects, researchers and outcomes, and other matters related to oil spill science in Canada. The first issue provides an overview of the MPRI and its program (focus) areas.

What is the Multi-Partner Research Initiative (MPRI)

MPRI is an oil spill research program under Canada's Oceans Protection Plan under the leadership of DFO.

Its governance includes a Steering Committee comprised of representatives from Environment and Climate Change Canada (ECCC), Canadian Coast Guard, Natural Resources Canada and Transport Canada; an Advisory Committee with key clients and stakeholders that includes representatives from the Provinces and Territories, Indigenous Groups, private sector industries, regulators, operational oil spill response organizations, and academia; and Technical Advisory Committees at the project level.

The goal of MPRI is to build a research network that brings together the best scientific expertise in oil spill research, both nationally and internationally, to advance scientific knowledge to support decision making on oil spill response and remediation strategies and to enhance Canada's response "toolkit".

Program Areas focus on the following Alternative Response Measures (ARMs): (i) spill treating agents, (ii) insitu burning, (iii) oil translocation, and (iv) decanting, as well as (v) natural attenuation, and (vi) key 'cross-cutting' topics, such as oil detection and characterization, and toxicity and risk assessment.

Locations of MPRI Researchers. Multi-colour circles indicate the number of researchers per location

Program Area: **Spill Treating Agents (STAs)**

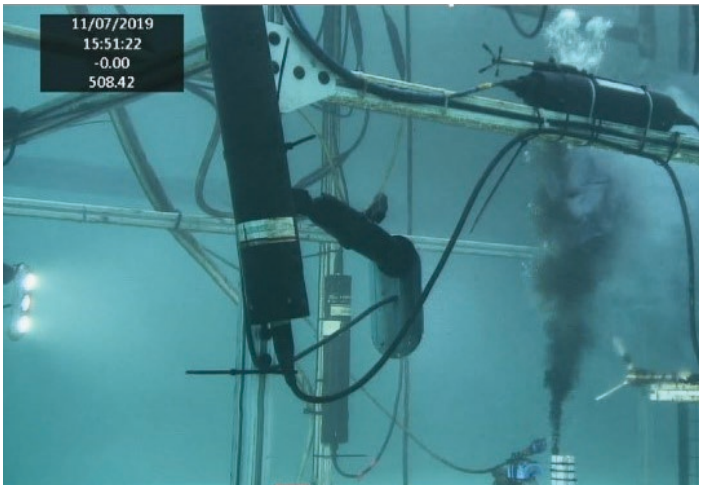
STAs are chemicals that interact with oil to alter its physical and chemical characteristics and behaviour in a manner that facilitates response and clean-up operations.

STAs include products such as dispersants, surface washing agents and herders. While STAs have been successfully implemented as a spill response option in other parts of the world, we continue to examine their effectiveness and environmental safety under Canadian marine conditions. Currently, only two STAs (one dispersant and one surface washing agent) are approved for use in Canada and only on a case-by-case basis.

MPRI has invested over $7.3 million in funding into 11 projects involving more than 25 institutions to understand and advance STA technologies and techniques; and to provide information in support of decision-making.

Projects led by labs at Memorial University and Johns Hopkins University are being conducted to evaluate the effectiveness of several chemical dispersant formulations for treating a range of crude oils (from condensate to viscous waxy-crudes) and their products (e.g., Bunker C, marine diesel, diluted bitumen, low-sulphur fuel oils) under various conditions.

A project led by the New Jersey Institute of Technology is collecting data and developing predictive models on the application and effects of subsea dispersant injection (SSDI) in response to a subsurface oil release at site-specific locations (e.g., off the coast of Newfoundland).



Subsea oil, gas and dispersant release experiment (M. Boufadel, NJIT)

SINTEF Oceans (Norway) is leading work into the development and evaluation of a novel less-toxic, more biodegradable bio-based dispersant. This institution is also leading research on the use of artificial energy (e.g., propeller wash, water flushing) to expand the "window-of opportunity" for use of dispersants in calm conditions with little natural wave turbulence.

The Woods Hole Oceanographic Institute (US) is leading a project to evaluate the significance of photooxidation on the weathering of oil and effectiveness of chemical herders to contract and thicken surface oil slicks to facilitate in-situ burning and physical removal using booming and skimming operations.

Contraction and thickening of oil with application of chemical herder (C. Ward, WHOI)

Inter-tidal beach sediment sampling, for subsequent laboratory-scale testing, Quebec (S. Beauregard, F. Bedard, Concordia University)

Program Area: **Oil Translocation**

Oil spilled in the marine environment frequently reaches coastal and shoreline habitats.

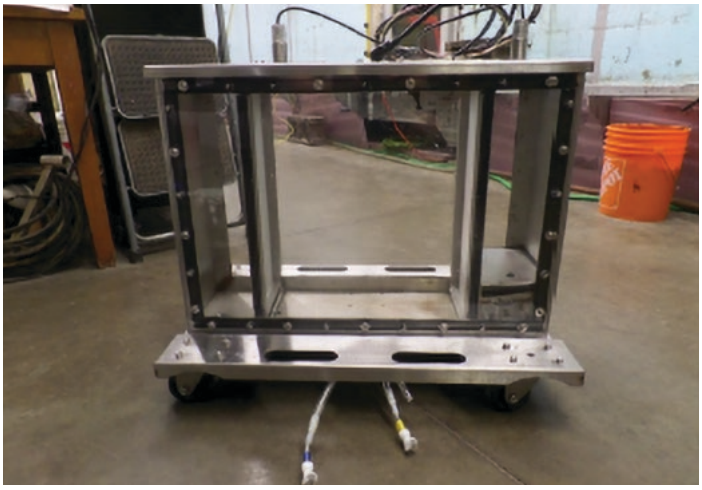
Once oil reaches the shoreline, active clean-up operations may be necessary to reduce environmental risk and accelerate recovery of the environment. Oil translocation includes techniques that facilitate the physical movement of oil on a shoreline to areas where it can be more easily recovered (example: oil can be moved into coastal waters to be collected via booming and skimming) and/or where the rate of natural biodegradation is enhanced.

MPRI has awarded over $5.2 million in funding to projects involving researchers from over 10 institutions that work to better understand and predict the fate of oil on shorelines and support decision-making on shoreline treatment strategies.

One of the primary objectives of this program area is advancing knowledge on the pathways and processes that contribute to the movement and natural biodegradation of oil on shorelines, particularly the role of fine grained sediment in the formation of oil particle aggregates Using this understanding, researchers from academia and the private sector are working on developing techniques to enhance these processes.

Another spill response strategy currently being explored is the application of surface washing agents (SWAs), which are substances that are applied to shorelines to enhance the separation and removal of oil that is adhered to solid surfaces, such as beach sediments. Like dispersants, there is concern over the potential environ-mental impacts associated with the use of these chemicals and their approved use is currently limited in Canada. To enable this as a potential tool in Canada's response "tool box", research led by Concordia University is evaluating the efficacy of new and current SWAs and investigating novel 'green' SWAs derived from sustainable biomass sources.

One of the major outputs of this program area will be the development of an "oil spill shoreline response decision tool" to help evaluate the potential consequences of shoreline treatment options on Canadian coasts. This decision tool will be geographically-, seasonally- and environmentally-based to support its potential application across Canadian coastline types at all times of the year.



Tank used for laboratory-scale testing of beach sediment samples (C. An, Concordia University)

PHOTO: Maksym Ivashchenko, Unsplash

Program Area: **In-Situ Burning (ISB)**

ISB is the controlled burning of oil on the water's surface. While ISB has the capability to remove large volumes of oil under ideal conditions, it currently has several limitations. For example, once oil is released in open water, it gradually spreads out and weathers, making it difficult to ignite and sustain burning. Moreover, ISB produces potentially toxic burn residues and atmospheric emissions from unburned oil and incomplete combustion. However, with the emergence of new technologies and operational protocols, this response option could become a valuable tool in Canada's response "tool kit". The goal of MPRI research in this program area is to investigate the effectiveness of current and new ISB technologies to remove spilled oil under Canadian conditions.

MPRI has awarded over $4.3 million in funding to 6 projects involving more than 25 institutions to understand and advance ISB technologies and techniques and to provide information in support of decision-making on their use in Canada.

In-situ burn test of crude oil in laboratory (D. Cooper, SL Ross)

In-situ burn with simulated boom (P. Panetta & R. Byrn, Applied Research Associates)

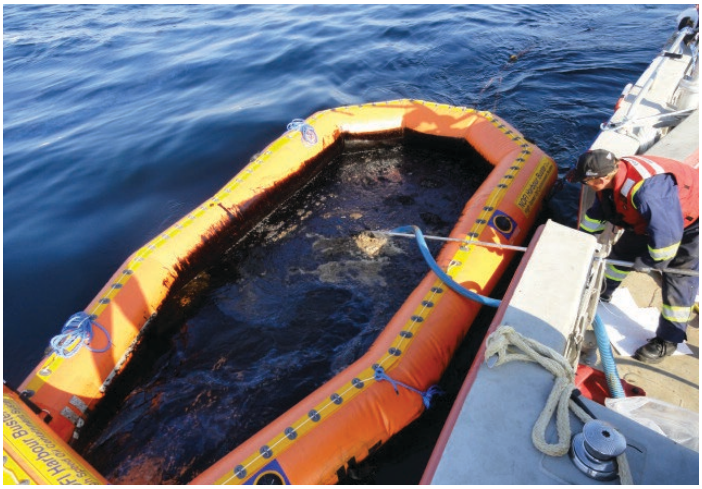
Both containment booms (floating barriers) and chemical herding agents can be used to contract, thicken and contain oil slicks so that they are more easy to ignite and burn. Under the direction of the University of Manitoba, small-scale experiments are being conducted to test the efficacy of ISB using fire-resistant containment booms and chemical herding agents for different types of spilled conventional and unconventional oils. The US EPA is leading a study to assess the toxicity of in-situ burn residues compared to non-burned oil. SINTEF Oceans (Norway) is developing and validating methods for characterizing the chemical composition of burn residues remaining after ISB in order to understand the efficiency and effects of burning oil spilled at sea. The University of Manitoba has also conducted a review of the state of knowledge on ISB, as well as the public's perception on the use of ISB as a response technique in Canadian waters.

Program Area: **Decanting and Oily Water Management**

Conventional mechanical oil spill clean-up operations, such as booming and skimming, will typically generate large volumes of oily wastewater that can range from 10 to 40 times more than that of the actual oil spilled. Under current Canadian regulations, the mixture of oil and water recovered is considered a deleterious substance and thus once onboard a ship it cannot be readily discharged back in the sea. Instead it must be transported to shore for disposal. This process significantly reduces the effectiveness of oil spill response operations at sea and increases the volume of hazardous waste to be treated on shore.

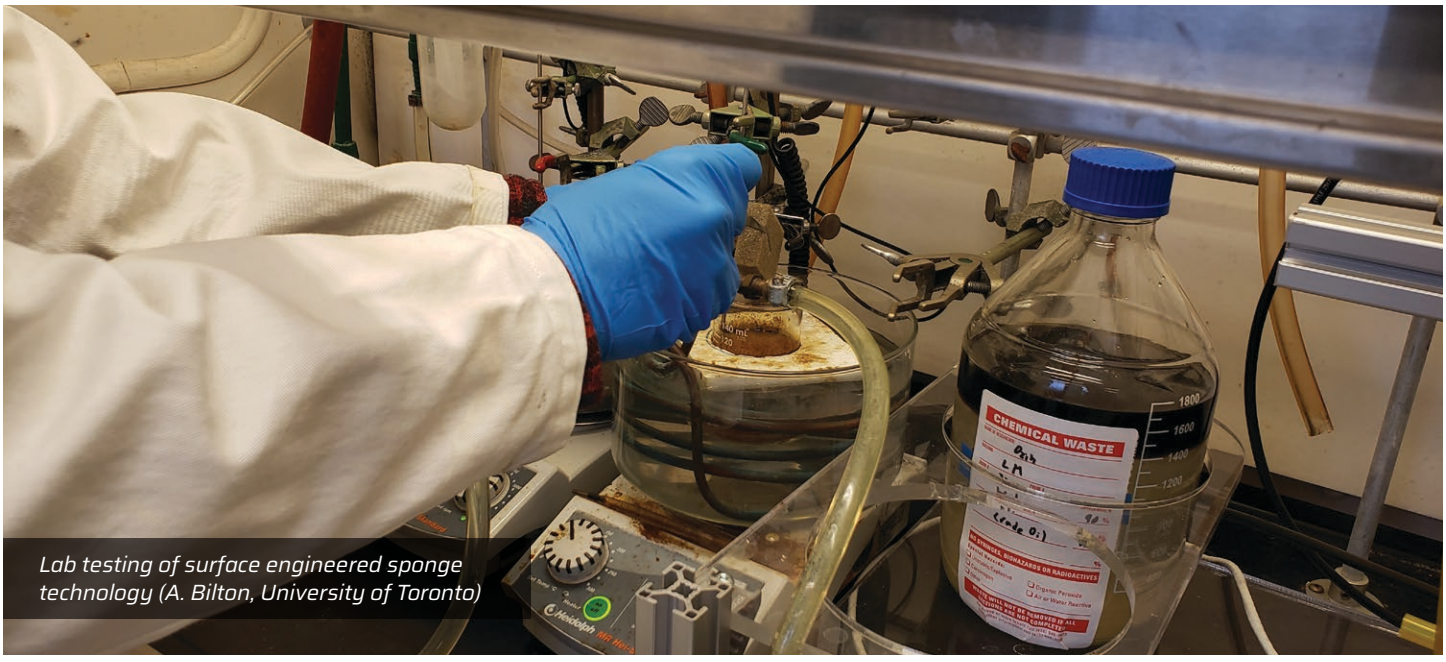
MPRI has granted over $3.6 million in funding to two multi-faceted projects involving more than 6 institutions to advance decanting (oil-water separation) technologies and wastewater treatment options at sea. Current re-search focuses on:

- Evaluation and improvement of existing decanting systems that can be used for oil spill response at sea
- Design of an integrated oily waste management system framework
- Analysis of the ecotoxicity and biodegradation potential of treated water resulting from various decanting systems/ technologies
- Development and evaluation of novel adsorption technologies to remove polycyclic aromatic hydro-carbons from oily waste-water, including Carbon-Based Hydrophobic Technology, Organic Polymer-Based Functionalized Materials, and Surface Engineered Sponges Treatment System



Skimming oil (Canadian Coast Guard)

- Moving beyond the laboratory, MPRI is supporting a collaboration between researchers and spill response organizations (e.g. Canadian Coast Guard) to test the performance of different decanting systems and technologies on real response vessels under real sea conditions. This initiative will give researchers and responders the opportunity to identify and resolve practical operational scale considerations not evident under laboratory conditions.



Lab testing of surface engineered sponge technology (A. Bilton, University of Toronto)

In-situ microcosm study of natural attenuation of oil in Arctic beach sediment (I. Altshuler, McGill)

Program Area: **Natural Attenuation**

Active oil spill response strategies are not 100% effective and in many cases are not deployed at all due to cost and logistical limitations.

Natural attenuation involves a number of processes that impact the fate of oil spilled into the environment, including evaporation, dissolution, dispersion, photooxidation, and biodegradation.

Biodegradation is a particularly important process be-cause it results in the permanent removal of oil components through the action of microorganisms, mainly bacteria, that are able to use many of the compounds present in oil as a food source.

The risk of oil spills in the Canadian Arctic is rising due to increases in marine vessel traffic associated with development and a longer open water season for the North-west Passage due to climate change. There is now a need for a greater understanding of the abilities of cold water microbes to degrade oil compounds under the extreme conditions found in the Arctic. As such, MPRI is supporting a number of research projects examining biodegradation processes in Arctic conditions, including two studies led by the University of Manitoba. One used chemical and molecular analyses and biofilm profiling and imaging to understand the abilities of cold water microbes to degrade oil compounds under extreme Arctic conditions. The other conducted microbial genomics and chemical oil profiling to distinguish between naturally occurring hydrocarbons and oil released from a spill and the presence of oil degrading microbes.

MPRI researchers sampling ice cores with the help of two community members in Chesterfield Inlet, NU (G. Hostetler, University of Manitoba)

To address concerns over the fate and effects of unrecovered oil spilled within Canada's Atlantic, Pacific and Arctic Ocean territorial waters, MPRI is supporting a number of studies led by McGill University and Natural Research Council of Canada with research partners from Europe and the engagement of Inuit community members to determine the potential rates of natural oil biodegradation at various marine and coastal locations across Canada using "in-situ microcosms" and genomic analysis. MPRI has also supported a collaboration between Canadian (led by Memorial University) and Chinese re-searchers to investigate the biodegradation of spilled diluted bitumen (dilbit) over time and study microbial activities that occur during biodegradation.

Program Area: **Cross-Cutting Research**

MPRI supports cross-cutting research initiatives that are relevant to the understanding and advancement of ARMs.

Oil characterization, detection and mapping

To ensure continuity and enable comparison of results of chemical analysis between different projects, and to train future experts in the field, MPRI is leading a national hydrocarbon laboratory inter-calibration exercise (HICE) with ECCC that will compare and calibrate the chemical analytical capabilities and results from labs across the country.

MPRI is also supporting the development of a Canadian academic "centre of excellence", based out of University of Manitoba, for the chemical characterization of petroleum oil, its weathered and degraded products, and the products generated from spill response techniques. This team is providing analytical support and "standard analytical protocols" to all MPRI projects, as required.

Other cross-cutting studies in this area include:

- Investigation of low sulphur fuel oils (SINTEF, Nor-way)
- Comparison of recent advances in estimating and measuring oil slick thickness to improve data for modelling oil fate and transport (led by NOAA)
- Enhancement of oil databases that are compatible with existing models (led by NOAA)
- Development of in-situ sensors and Autonomous Underwater Vehicles (AUV) for use in oil spill reconnaissance in open and iced waters (CSIRO Australia, Memorial University and Dalhousie University)
- Development of software tools to facilitate access, analysis and interpretation of data derived from Shoreline Cleanup and Assessment Techniques (SCAT) for responders (led by NOAA).

Risk assessment models

MPRI is funding two projects developing risk assessment models in support of Net Environmental Benefit Analysis (NEBA). The first, led by CSIRO involves refinement of the "Atlantis Ecosystem Model" to factor in oil spill response data. Application of this predictive holistic ecosystem-based model would provide insights on the dispersion of oil, contaminants, nutrients and species, the impacts of spills and cleanup operations on fish, habitats and other aquatic organisms, and how those effects influence the rest of the system (e.g. fisheries and other users). The second, led by Dalhousie University, involves the coupling of high resolution circulation model with an oil-spill trajectory model to aid in the assessment of future risks and environmental impacts of oil spills in the Arctic.

Article continued on page 11

AUV Trial (R. Blenkinsop, Memorial University)

Research Spotlight Interview with Zhikun Chen

PhD student at Concordia University. Since 2018, Zhikun has been involved in research in the Oil Translocation Program Area under the direction of Dr. Chunjiang An.

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

A: My current research is funded by MPRI. Spilled oil in the marine environment frequently reaches the coastal zone where active cleanup strategies may become necessary if the rates of natural weathering and attenuation of the stranded oil are considered inadequate. The application of surface washing agents (SWAs) is an operational technique that enhances the separation and removal of oil that is adhered to solid surfaces. The project I participated in is about the evaluation, improvement and development of washing agent-aided shoreline treatment tool sets, which is led by Dr. Chunjiang An at Concordia University. I am also trying to develop novel "green" surface washing agents to efficiently clean-up the shoreline affected by oil spills and reduce the potential secondary environmental impacts caused by using toxic chemicals.

Q: Can you tell us a little bit more about this novel "green" surface washing agent you are developing?

A: I'm investigating a new green surface washing agent (SWA) based on nanocellulose a low-toxicity material derived from sustainable biomass sources. That's an exciting area of research which involves the use of nano materials and advanced characterization methods, such as synchrotron-assisted analysis. This new SWA can enhance the removal of stranded oil by affecting the interfacial properties among water, oil and substrates. The results of my analysis also demonstrated that it has no negative impact on marine and intertidal ecosystems. A pa-per about this study has been peer-reviewed and published in the Journal of Hazardous Materials.

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

A: MPRI is a great platform which brings together the best scientific expertise in oil spill research, both nationally and internationally, to work as an integrated team. For myself, I have benefited a lot from this collaborative work. For example, I had the opportunity to participate in several workshops in Montreal and discuss my research with some top experts from Canada, US and Norway. They gave me many valuable comments and suggestions regarding my research. Under the umbrella of the MPRI program, I'm also looking forward to the further discussions with the stakeholders from DFO and other academic/industrial partners.

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

A: At this time, the SWA products approved for use by the Canadian government are very limited. The U.S. Environmental Protection Agency (EPA) has approved more than 70 agents. There is still a gap between the available SWAs and the increasing application need, especially in the context of Canadian coastal environments. My current research can provide an effective alternative to the SWAs which can be used in Canada. I believe the outcomes from my SWA research may help enhance Canada's level of preparedness and response capability.

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

A: With the support of MPRI, I successfully finished my Master defense this summer and have started my doctoral studies this fall at Concordia University. During my MASc, I published three papers in the top environmental journals Chemical Engineering and Journal of Hazardous Materials. I was also awarded the Gina Cody School of Engineering and Computer Science Graduate Scholar-ship for my PhD study. In my current research, I will keep exploring new initiatives in oil cleanup using SWAs. I hope my work can make a contribution to the efforts of oil spill control and marine environment protection in Canada. The MPRI program has played an important role in both my Master's program and current PhD studies. The scientific network established by MPRI will be very helpful for my future career development. I would like to show my most sincere appreciation!

Award Honours

The Norwegian research organization SINTEF in collaboration with SL Ross Environmental Research Ltd. (a Canadian consulting firm specializing in oil spills and their control) was awarded the 8th annual ITOPF R&D Award for their project co-funded by SINTEF, the Norwegian Coastal Administration and MPRI entitled "Characterization of Low Sulfur Fuel Oils (LSFO) - A new generation of marine fuel oils".

ITOPF, a not-for-profit organization that provides technical expertise and services to ensure effective response to ship-source spills in the marine environment, established its annual 'R&D Award' to encourage organizations world-wide to think innovatively and explore ideas that could provide solutions to some of the challenges faced in spill response and environmental monitoring.

"This is a timely and relevant project due to the current lack of knowledge and experience about the properties of new [LSFOs] and speculation about their potential fate and behaviour when spilled". Dr. Karen Purnell, ITOPF Managing Director

The main type of "bunker" oil for ships is heavy fuel oil, derived as a residue from crude oil distillation. Crude oil contains sulphur which, following combustion in the engine, ends up in ship emissions. Sulphur oxides (SOx) are known to be harmful to human health, causing respiratory symptoms and lung disease. In the atmosphere, SOx can lead to acid rain, which can harm crops, forests and aquatic species, and contributes to the acidification of the oceans. To address this concern, in 2020 the International Maritime Organization (IMO) set new standards to limit the sulphur content in fuel oil (S < 0.5 %m/m) used on board ships operating outside designated emission control areas.

This SINTEF led project aimed to provide responders with improved science-based advice to improve preparedness and response measures for spills involving the new generation of LSFO on the market today. The project included laboratory studies on LSFO with a focus on fate, behaviour, and potential toxicity with relevance to the effectiveness of different oil spill response options (use of dispersants and in-situ burning).

Dr. Benjamin de Jourdan: New Brunswick Innovation Foundation's 2020 Star Mentor of the Year

Dr. Benjamin de Jourdan has recently been awarded the New Brunswick Innovation Foundation's 2020 Star Mentor of the Year Award under the institutions category and received a $50,000 grant to continue his efforts in mentoring the development of highly qualified personnel (HQP). The award honours star mentors from New Brunswick's universities, colleges and research institutions who have shown an exemplary job of training the next generation of researchers.

Dr. de Jourdan is a research scientist at the Huntsman Marine Science Centre, in St. Andrews, New Brunswick, Canada.

His work focuses primarily on understanding the behaviour and impact of chemicals in the environment. Dr. de Jourdan supervises at least half a dozen graduate students and post-docs as the lead investigator on the MPRI's two aquatic toxicity analysis projects (***see** Cross-cutting Research on Pg. 11*), as well as supporting student research under the Natural Attenuation Program Area.

"MPRI has certainly been a great boost to our ability to participate in this type of HQP development, and the support is greatly appreciated." — Dr. Ben de Jourdan

Program Area: **Cross-Cutting Toxicology Research**

***Continued from** page 8*

Led by Huntsman Marine Science Centre, the goal of MPRI's toxicology studies is to provide real-world data and insights on the potential lethal and sub-lethal effects of ARMs under environmentally-relevant concentrations and exposure conditions on indigenous species at relevant life stages. These data are essential for the development of predictive models for use in risk/damage/recovery time analysis and NEBA for the selection of the most appropriate spill response options, etc. Huntsman will also be leading efforts to update standard protocols for ecological research on the effects of oil and dispersed oil with a focus on ensuring ecological relevance. These protocols will ensure continuity and enable comparison of results between different projects and labs.

Learn more about Oil Spill Response Research from Dr. Lee

Filmed on January 8, 2020 in front of a public audience at Dalhousie University in Halifax, Nova Scotia, Dr. Kenneth Lee's lecture entitled Oil Spill Science and Alternative Response Measures is now available to the public via DFO's YouTube channel.

With the aide of vibrant photos and videos, Dr. Lee explains what is known about oil that enters the marine environment, where it comes from (natural vs. operational/accidental releases), what happens to it if we do nothing (including the natural processes that act upon it), and what we need to know in order to facilitate oil spill clean-up and recovery to minimize impacts to the environment.

Dr. Lee introduces the various oil spill response options and the current research efforts to evaluate and enhance Canada's oil spill preparedness and response capabilities and decision making.

This video will serve as an invaluable educational resource for students, researchers, stakeholders, and communities around the world. This is intended as a first in a series of MPRI lectures/videos on oil spill response measures science and assessment.

Dr. Lee introduces the various oil spill response options and the current research efforts to evaluate and enhance Canada's oil spill preparedness and response capabilities and decision making.

***Watch Now:** youtube.com/watch?v=cIwReiRA3GM*

More information

Resources
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