Fisheries and Oceans Canada | Pêches et Océans Canada

Multi-Partner Research Initiative (MPRI): Oil Spill Science for Science-Based Decision Making

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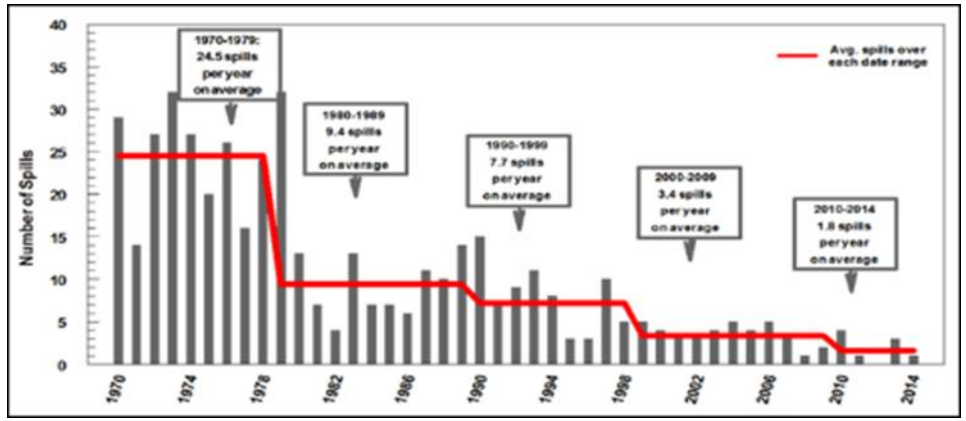
Ecosystem Science

Fisheries and Oceans Canada

C-NLOPB Spill Prevention and Response Forum: Working on the Water
Co-hosted by CAPP and One Ocean
January 13, 2021

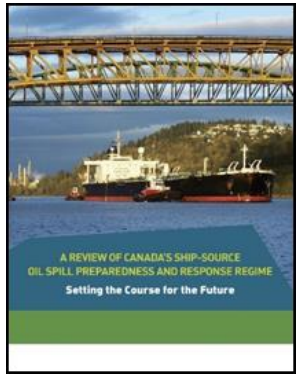
Concerns with the Potential Release of Petroleum in the Marine Environment

- Spills from tankers at sea have declined
- The risk of accidental releases of petroleum hydrocarbons is expected to increase with increases in marine shipping traffic (including the Arctic), anticipated increases in exploration & production of offshore oil and gas, and potential increases in pipeline and rail transport along coastal regions



Multi-Partner Research Initiative (MPRI) - Canada's Oceans Protection Plan

GOAL: To establish an *integrated, global research network to advance oil spill research* in Canada and enhance Canada's level of preparedness and response capability.



PRIORITIES: Aligned with recommendations of the Royal Society of Canada 2015 Report on Behavior & Environmental Impacts of Crude Oil Released into Aqueous Environments as well as Transport Canada's Tanker Safety Expert Panel Report

FOCUS: To advance scientific knowledge and science-based decision making in oil spill response operations by *improving our knowledge of current and emerging oil spill response and remediation strategies*

How do we expand our tool box for oil spill response?

Multi-Partner Research Initiative (MPRI)

TRAINING THE NEXT GENERATION: Nearly all projects have significant budgets for training of students and other levels of personnel

NETWORKING: Oil spills are a global concern. The MPRI network of projects will create valuable training opportunities in academia and industry and foster *collaborations and partnerships* with key international organizations in oil spill research

ENGAGEMENT: Involvement of key clients and stakeholders that include representatives from the Federal Government, Provinces and Territories, Indigenous Groups, the Oil and Gas Industry, regulators, operational oil spill response organizations, academia, fisheries groups NGO's, and international research organizations

MPRI Program Areas

1. Spill treating agents
2. In situ burning
3. Oil translocation
4. Decanting and oily waste disposal
5. Natural attenuation
6. Cross-Cutting

The first four are referred to as **Alternative Response Measures (ARMs)** which represent a mix of tools which allow for the strengths of some response tools to offset the limitations of others. Many of these are not approved for use in Canada.

ARMs complement conventional mechanical measures to enhance cleanup, when there is a net environmental benefit.

Considered as an operational response strategy. In some cases active procedures cannot be applied due to logistical constraints or concerns that they may cause more harm than good.

Core research needs common to all strategies, i.e. toxicity, oil detection, chemical analysis, etc.

Scope of the MPRI Research Program

$45.5M funding:

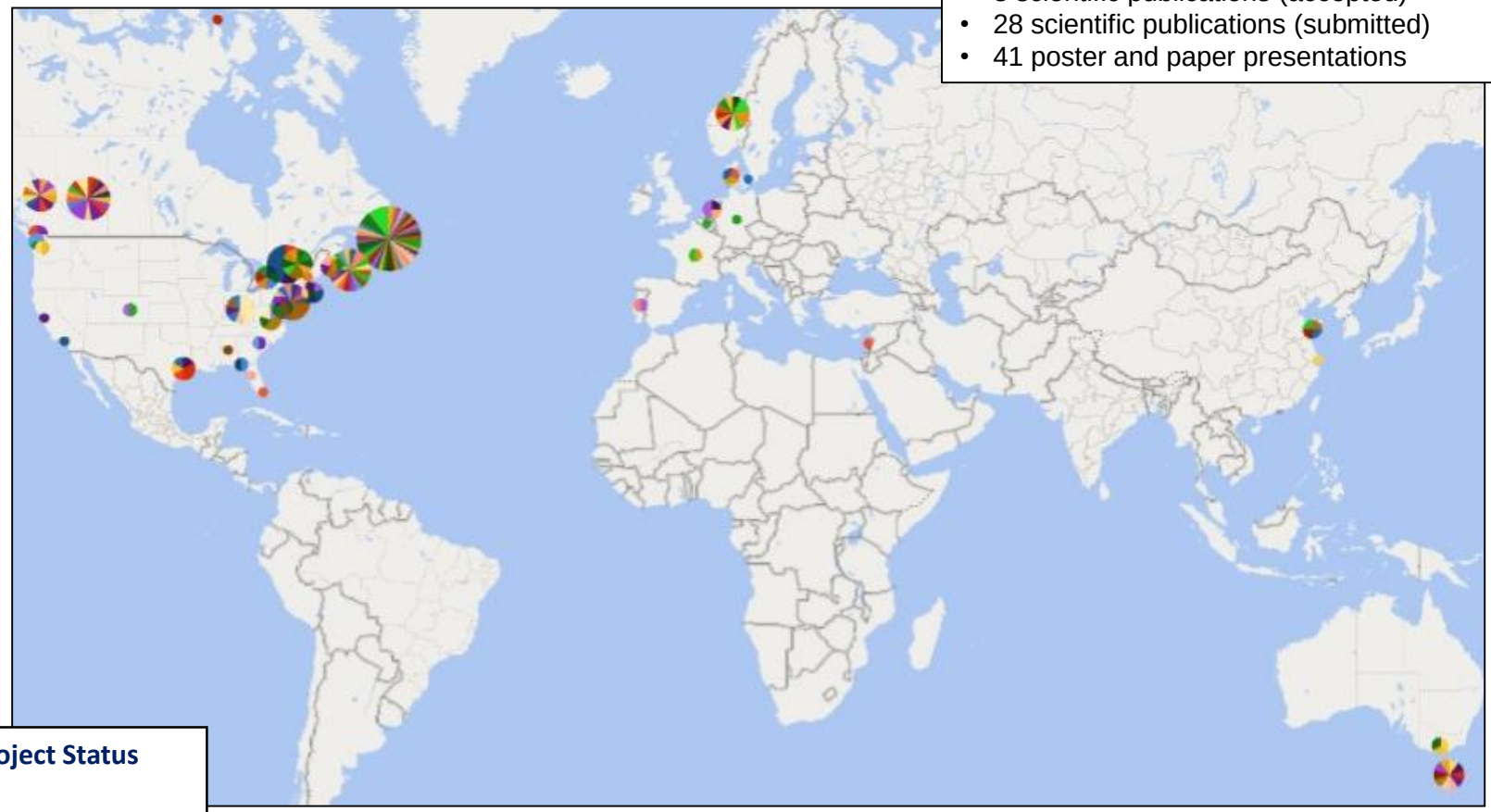
- 60 institutions
- 12 countries

Supporting:

- >220 researchers
- 26 PDFs
- 54 post-graduate students

Data dissemination (Nov. 2020):

- 77 scientific publications (published)
- 8 scientific publications (accepted)
- 28 scientific publications (submitted)
- 41 poster and paper presentations

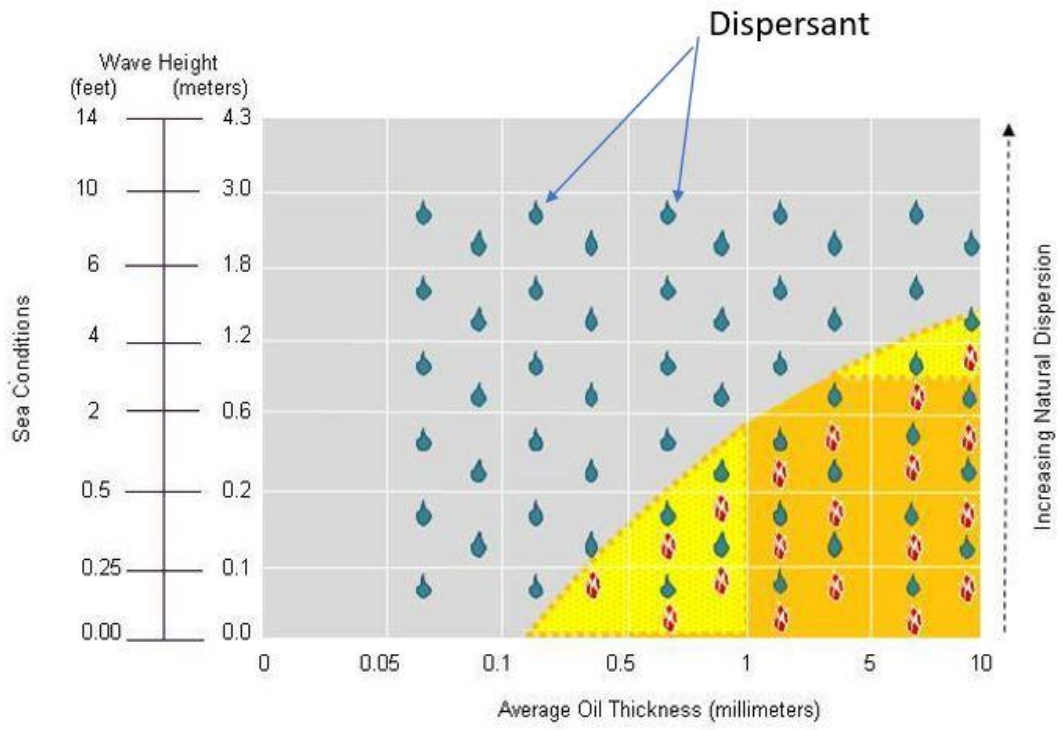


2020/2021 Project Status

- 35 Ongoing
- 6 Completed

SPILL TREATING AGENTS

Evaluation of current and development of new chemical products that change the behaviour of spilled oil in the environment to facilitate response and clean up



SPILL TREATING AGENTS

New Product Development

RSC Advances

PAPER

Fly ash based robust biocatalyst generation: a sustainable strategy towards enhanced green biosurfactant production and waste utilization

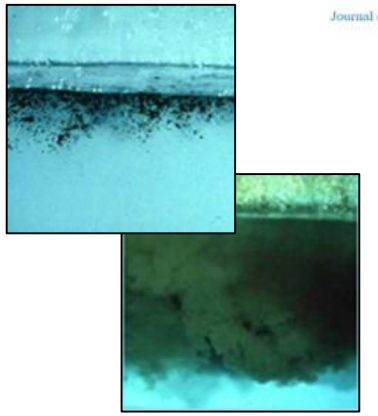
Zhiwen Zhu,[a] Baiyu Zhang,[a*] Bing Chen,[a] Jingjing Ling,[a] Qinghong Cai[bc] and Tahir Husain[a]

frontiers in Bioengineering and Biotechnology

ORIGINAL RESEARCH

Fish Waste Based Lipopeptide Production and the Potential Application as a Bio-Dispersant for Oil Spill Control

Zhiwen Zhu[1], Baiyu Zhang[1*], Qinhong Cai[2], Jingjing Ling[1], Kenneth Lee[3] and Bing Chen[1]



Journal of Hazardous Materials 403 (2021) 123944

ELSEVIER

Journal of Hazardous Materials

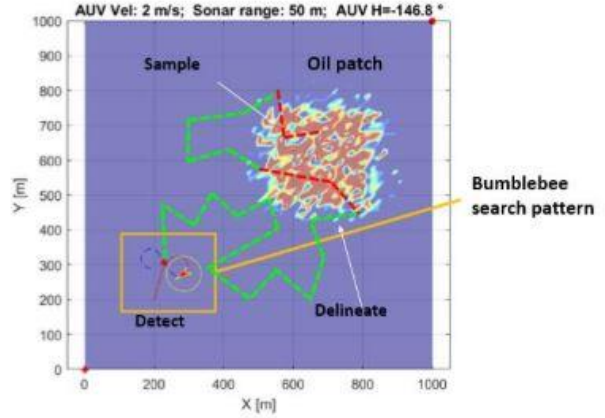
Volume 402, 15 January 2021, 123464

Exploring the use of cellulose nanocrystal as surface-washing agent for oiled shoreline cleanup

Zhikun Chen [a], Chunjiang An [a], Jianan Yin [b], Edward Owens [c], Kenneth Lee [d], Kaiqiang Zhang [e], Xuelin Tian [a]

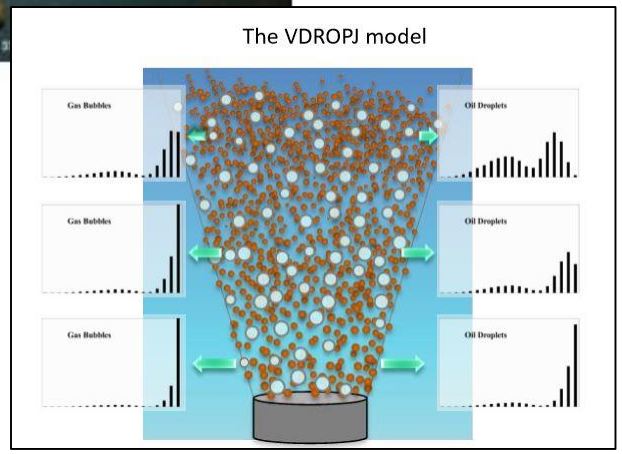
Oil Spill Reconnaissance and Delineation through Robotic Autonomous Underwater Vehicle (AUV) Technology

* Compliments NRC's OceanVision™ project focused on the development of new marine technologies and products to enable collection of underwater robotics data

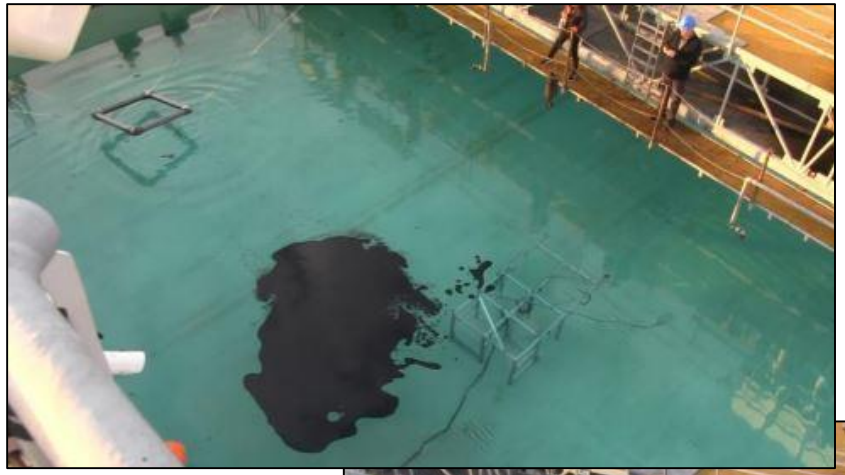


SPILL TREATING AGENTS

Oil droplets at depth and at the water surface



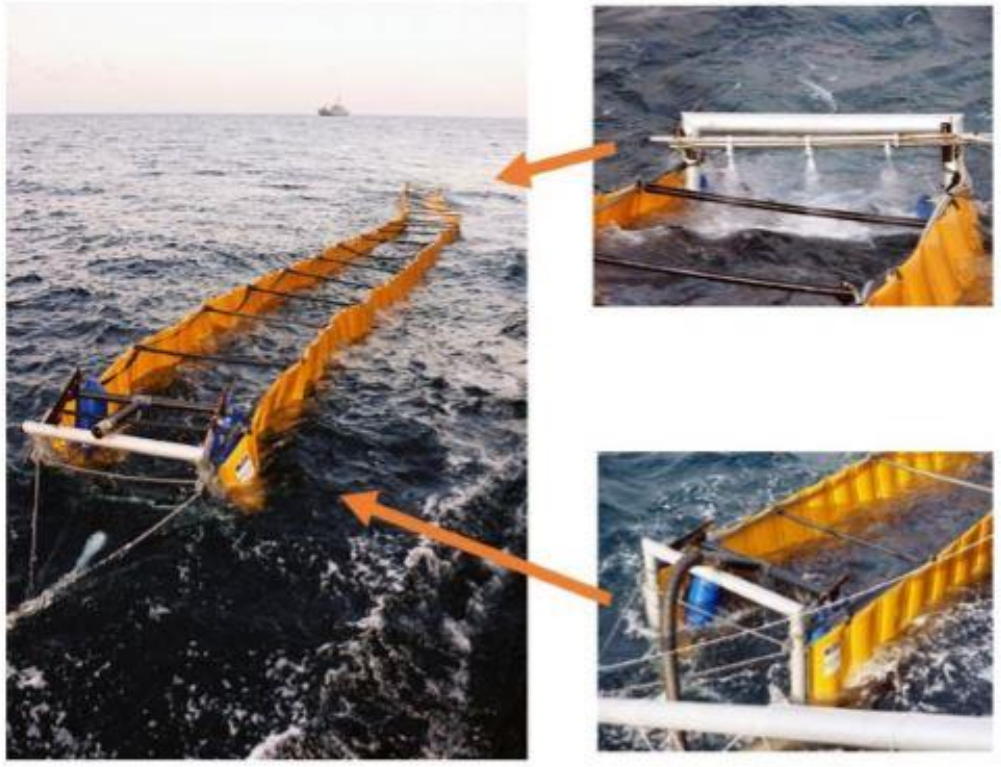
Chemical herders to reduce the area and increase thickness of oil slicks



SPILL TREATING AGENTS

Artificial energy by water flushing after dispersant treatment in calm seas or ice-infested waters

Oil Dispersant Field Trials (pending approvals)



In Situ Burning

Controlled burning of oil on the water's surface, supported by the use of fire-resistant booms, herders, or within ice with a starter product and ignition source

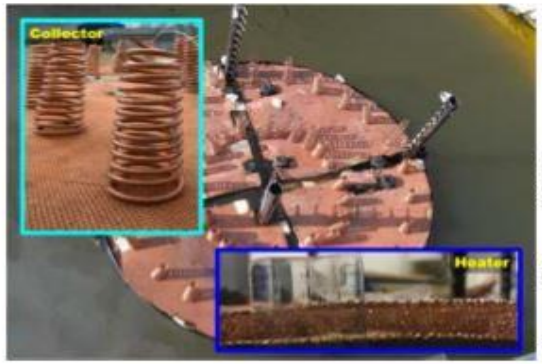
- Small-scale tests on effectiveness of fire booms, chemical herders and chemical dispersants with various crude and fuel oils transported in Canada to determine "Windows of Opportunity"
- Development of analytical techniques to quantify burn efficiency-based on chemical analysis
- Improve knowledge about the ISB residues and their environmental effects

ISB Technology Development

(Field trials pending approvals)

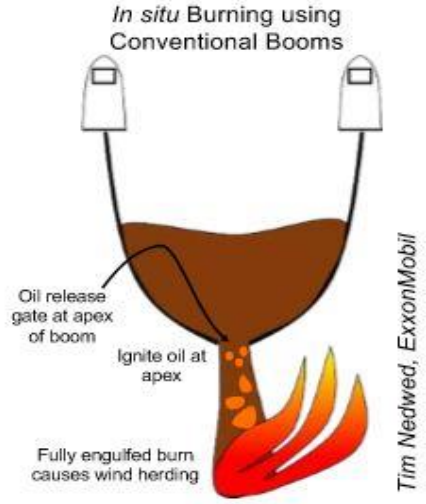
Three novel ISB technologies

- ❑ Extending ISB window of operations
- ❑ Reducing the operational cost
- ❑ Improving burning efficiency
- ❑ Reducing smoke and residue production



Karen Stone, BSEE

Flame Refluxers allow faster burning, with 50% less production of black smoke



Tim Nedwed, ExxonMobil

Burning Tongue allows ISB with conventional booms, reducing operational cost

Tim Nedwed, ExxonMobil

RSV (remotely-operated surface vehicle)-**assisted herding** extends operational window

New generation of monitoring technologies

- ➢ **SMART Protocols** for rapid data collection and reporting
- ➢ **UAS**-borne smoke sampling and monitoring
- ➢ **ROV-** and **AUV-**borne burn residue sampling & monitoring.

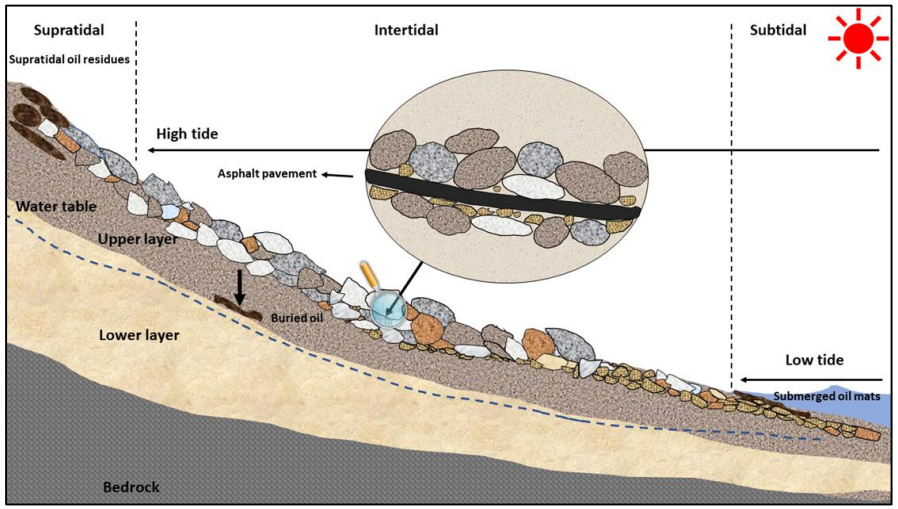
Brian Gullett, USEPA

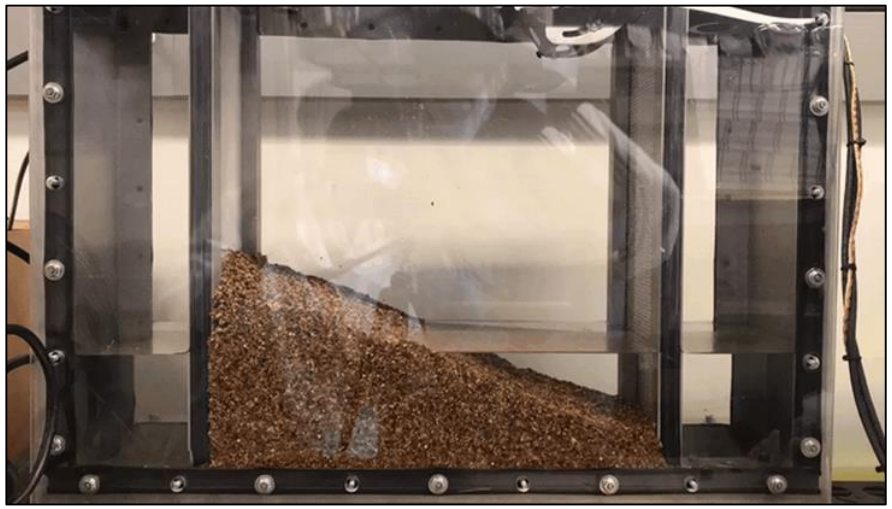
A UAS with a "Kolibri" smoke sampling system

Oil Translocation

Definition: The physical transport of oil from one compartment of the environment to another where the oil can be recovered more easily or is degraded at a higher rate.

- Improve our understanding of oil particle-interactions in oil translocation and biodegradation (natural attenuation)

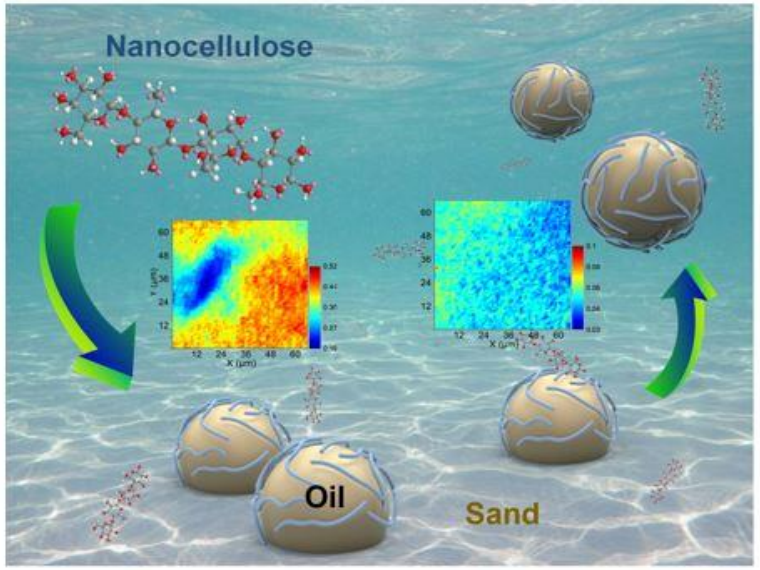




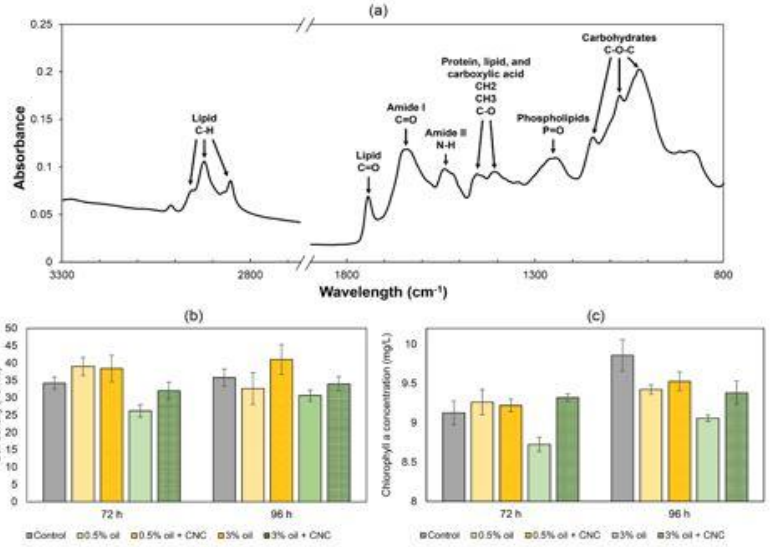
- Transporting to shorelines - Evaporation, Oxidation, Partition, Aggregation
- Distribution and transport on shorelines - Penetration, Remobilization, Retention
- Attenuation and fate - Remaining amount and chemistry characteristics

Oil Translocation

Effect of Nanocellulose on Oil Behaviors



❑ Existence of *nanocellulose in seawater* ➔ *Accelerate the release* of stranded oil

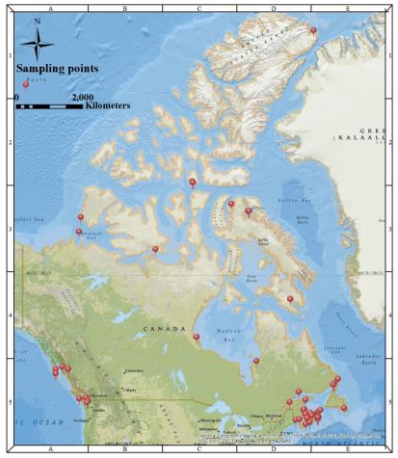


❑ Biotoxicity tests on algae
➔ *No additional* toxicity
+ *Mitigate* the oil toxicity

Journal of Hazardous Materials, DOI: 10.1016/j.jhazmat.2020.123464

Oil Translocation

Development of a Decision Support Tools for Oil Spill Response



Database

Earth observation
- Sea temperature
- Current
- Wave
- Salinity
- Wind

Response options
- Applicable conditions
- Pros and cons

Oil library
- API
- Pour Point
- Viscosity
- Density
- Constituent
- Distillation Cuts

Geographic dataset
- Coastal geomorphology
- Wave and tide energy
- Environmental sensitivity

Model Base
- Oil spill model
- GIS
- Artificial intelligence (AI)
- Mathematical programming
- Multi-Criteria Decision Making (MCDM)
- Developed oil spill response toolkits

Knowledge Base
- Expert elicitation
- Rules
- Historical oil spill cases

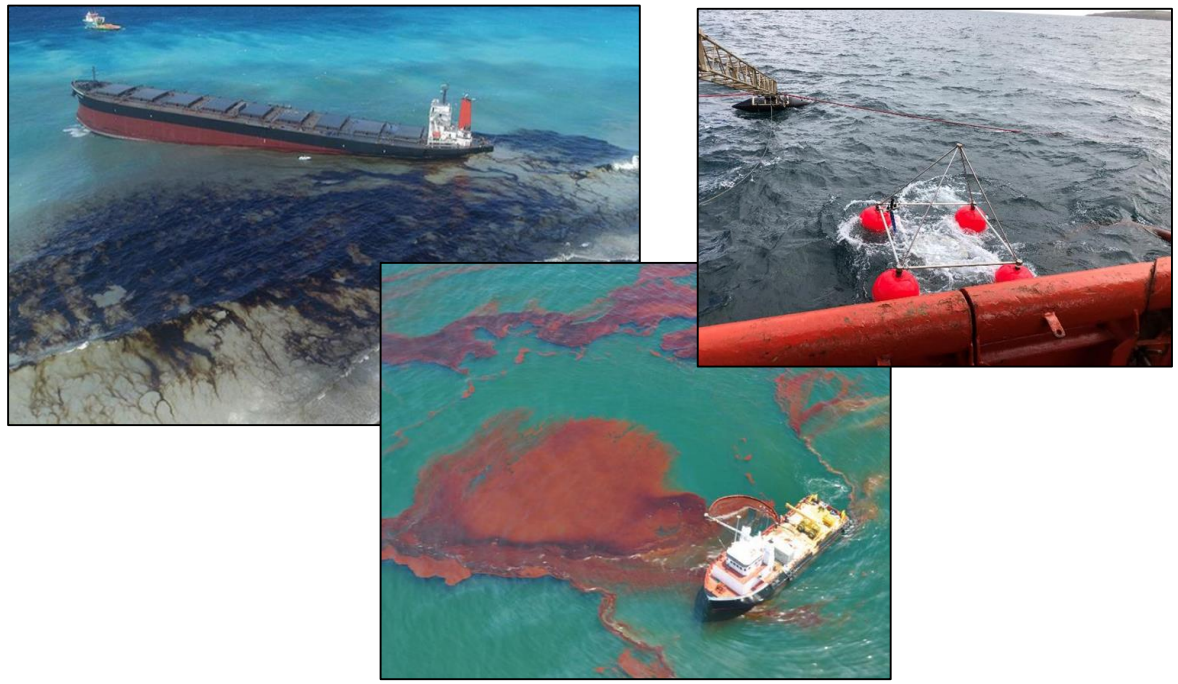
User interface

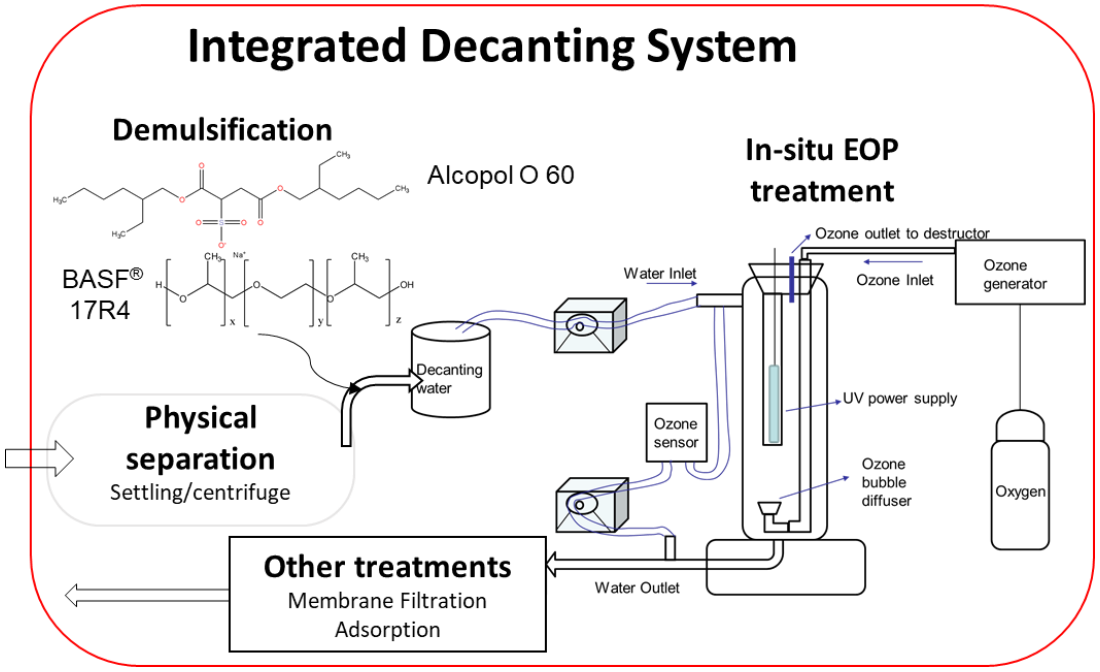
Future decision support for OSR
- Qualitative and quantitative risk assessment
- Real-time high-resolution spills monitor and detection
- Advanced trajectory and fate model available on open water and ice-ocean
- Recommendation for offshore countermeasures and shoreline clean-up techniques
- The optimum configuration for response operations

Deconting and Oily Waste Disposal

Oil spills can generate 10 times more volume of oily waste than initial volume of spilled oil in the form of solid and liquid waste.

- Effective technologies required for decanting/in-situ treatment to reduce field storage, transportation, and disposal capacity bottlenecks once oily-water has been collected

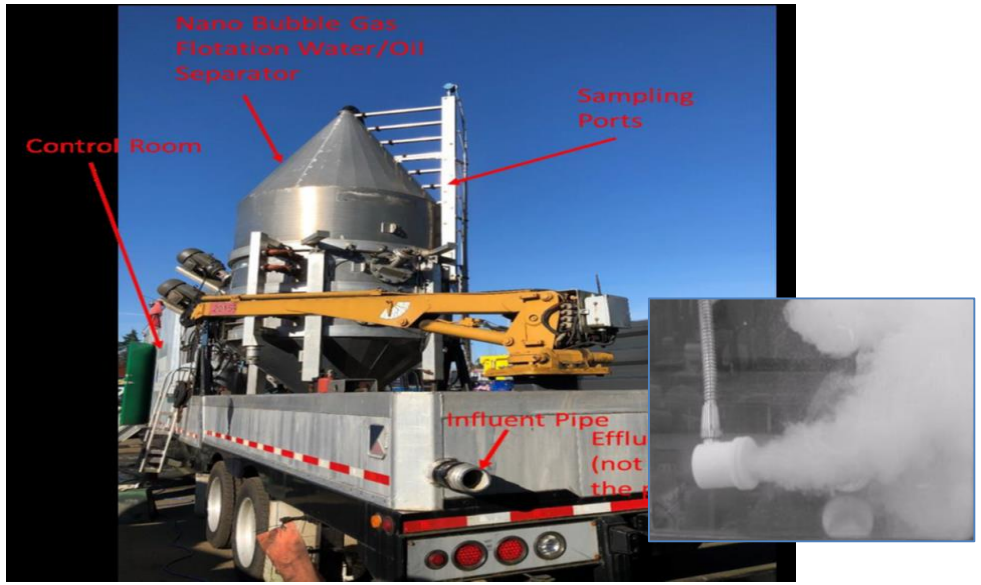




Decanting and Oily Waste Disposal

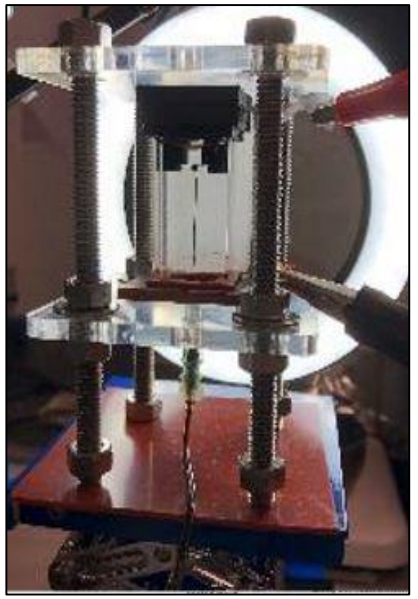
Nano and/or Microbubbles Gas Flotation Technology

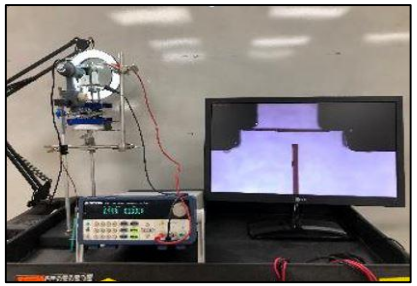
Development of a nano/micro -bubble flotation system for decanting oil-water mixtures at sea

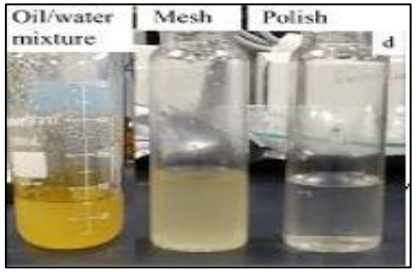


Hydrophilic Mesh and Activated Carbon for Oil Water Separation

Reach up to 99% TPH removal if combining with a polishing process using graphene oxide.

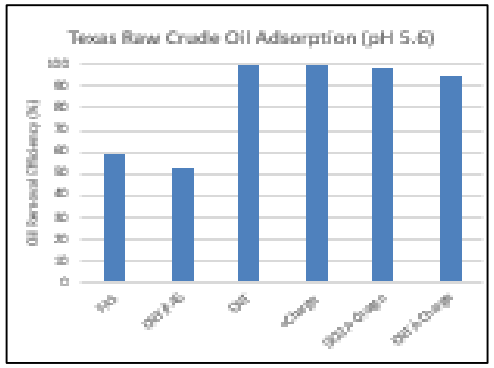


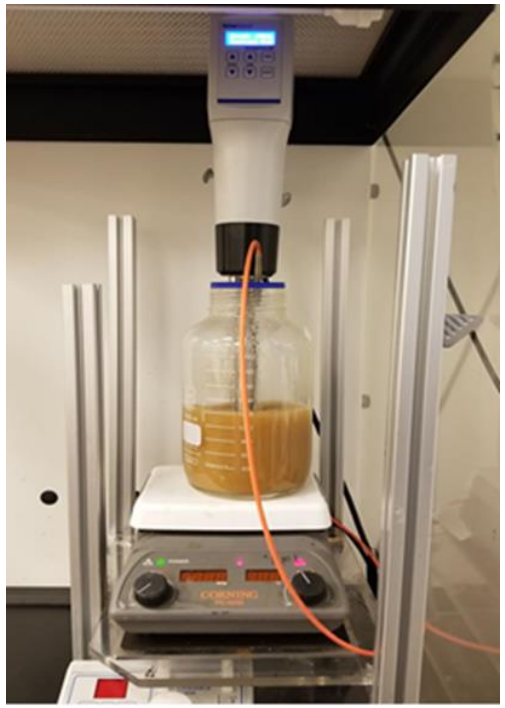




Decanting and Oily Waste Disposal

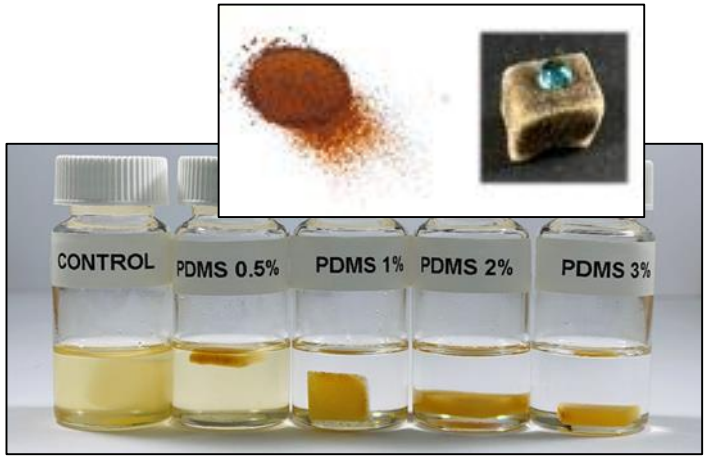
Surface Engineered Sponge Adsorbents for Oil Spill Response





Novel porous polymers and solid demulsifying agents for oil spill recovery

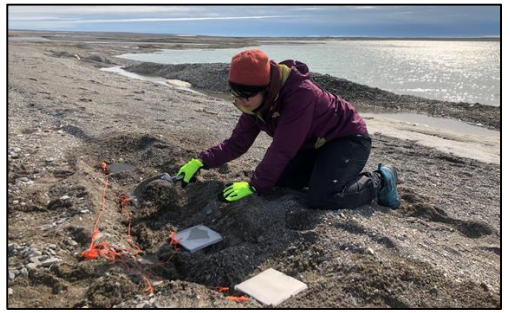
- Development of technologies to stabilize porous nanoparticles on substrates to support the use of Porous Organic Polymers (POP) for tertiary treatment and Solid Demulsify Adsorbent (SDA) to break extreme oil content emulsions



Natural Attenuation

Baseline monitoring of hydrocarbon contaminants and microbial genomics

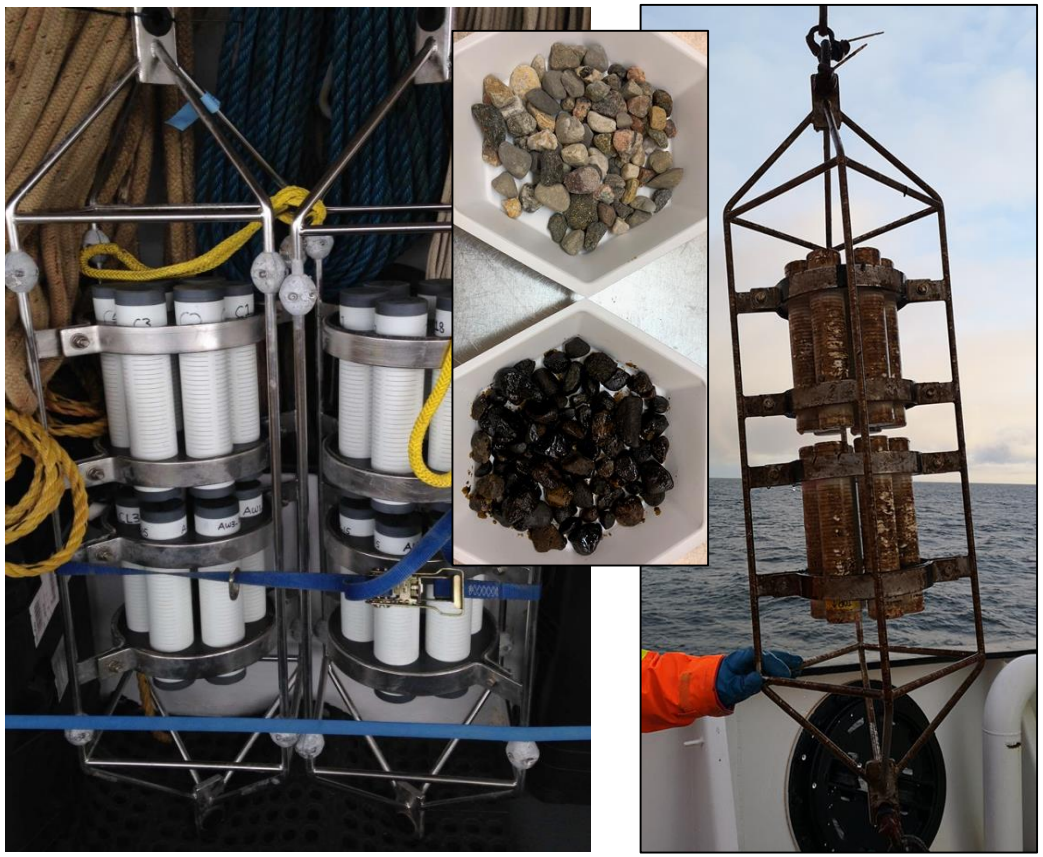
Oil biodegradation potential in Arctic marine environments

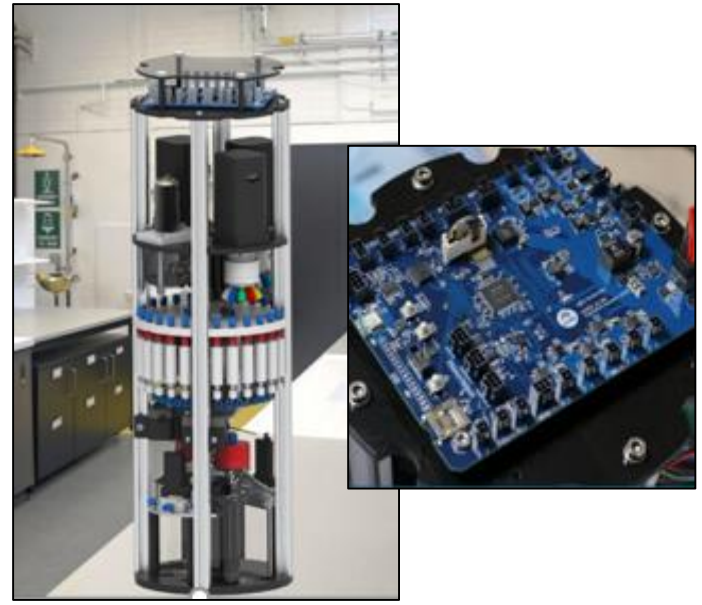


Optimized sampling strategy for microbial and genomics analyses and residual hydrocarbon analyses to determined the potential of natural microbial hydrocarbon biodegradation and bioremediation strategies in Arctic waters and shorelines?

Natural Attenuation

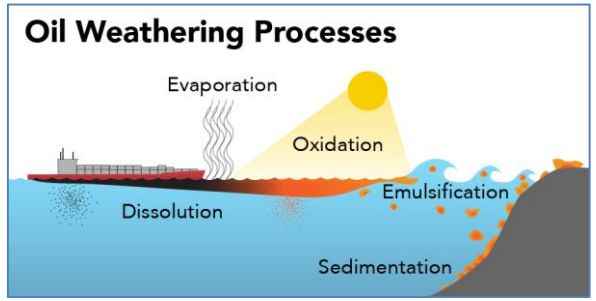
Development in situ sampling and monitoring technologies for hydrocarbon and microbial analysis





* Compliments NRC/Canada's Ocean Supercluster OceanDNA System™ project to revolutionize how we assess, monitor and characterize the ocean by collecting and analyzing environmental DNA (eDNA) using next-generation sequencing.

Cross-cutting Core Science Activities



Chemical Composition and Properties

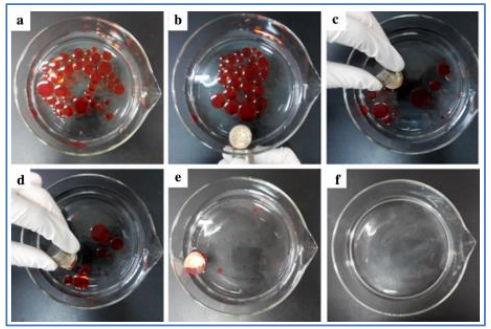
- Characterization of fresh and weathered crude, unconventional crude and refined oils

Oil Detection and Identification

- Environmental forensics; remote sensing / In situ monitoring

Oil fate, behaviour, and transport

- Oil droplets; oil-particle interactions; oil-ice interactions
- Oil trajectory modelling; mass balance



Microbial ecology/genomics

- Microbial population and community structure
- Microbial degradation potential, bioremediation/phytoremediation

Biological /Toxicity analysis

- Natural variability (population & community response); environmental effects monitoring; baseline information
- Fisheries impacts

Data analysis for oil spill prevention, preparedness, response and recovery

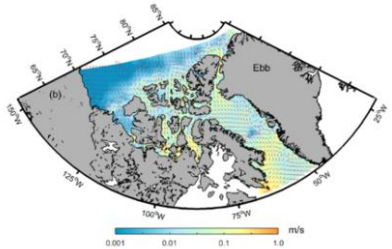
- Environmental risk assessment; resilience to oil; ecosystem recovery, predictive modelling impacts/recovery
- Decision support system development; spill control strategies
- Endpoints for clean up; Net Environmental Benefit Analysis; ecosystem services and socio-economic impacts

Oil Detection and Characterization

Characterization of Low Sulphur Fuel Oils

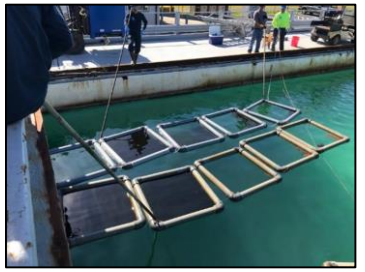
- New international regulations (IMO/Marpol Con.) limiting sulphur content in fuels has led to new generation of Low Sulphur Marine Fuel Oils
- Document variability in the fate and behavior of LSFOs spilled in cold waters and their interaction with different response options (e.g., dispersants, ISB, etc)

Risk Assessments of Potential Oil Spills in the Canadian Arctic Archipelago



- Develop a high resolution hydrodynamic/ice model to support oil spill risk assessment & to inform regulation/policy.

Comparing Advances in Estimating and Measuring Oil Slick Thickness



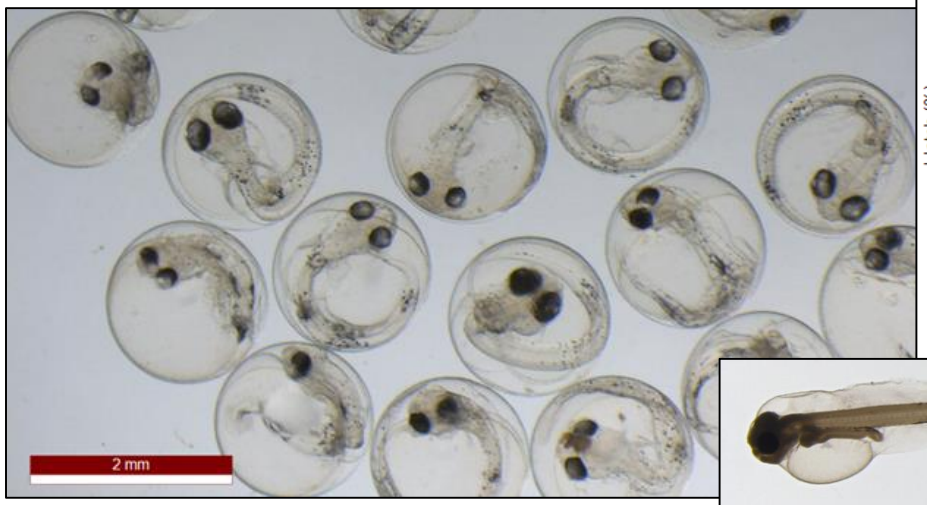
» Development & evaluation of technologies to determine oil spill thickness

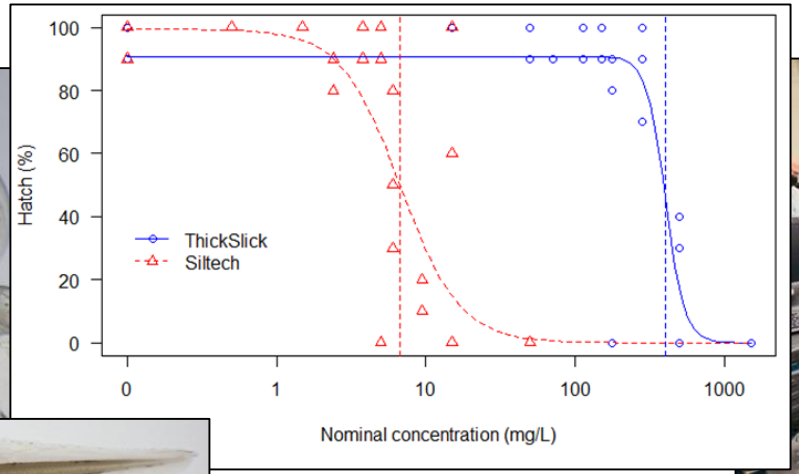
Oil Toxicity / Biological Endpoints (How clean is clean?)

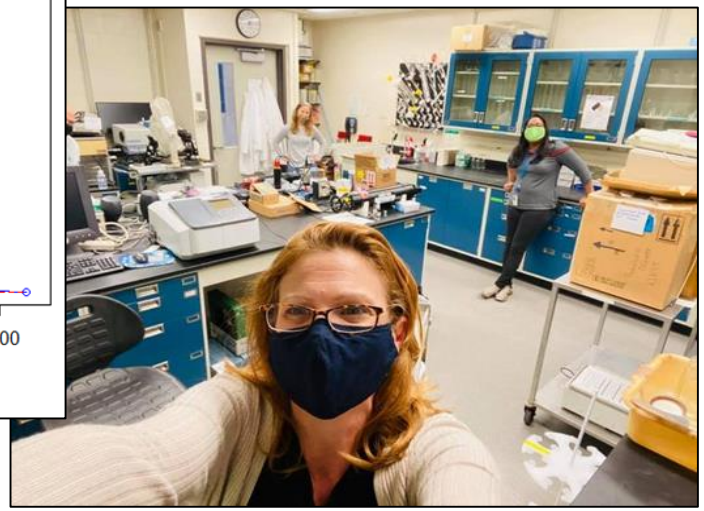
Toxicity of ARMs using Non-standard Species & Customized Methods

Given that some agents are designed to remain in the environment with oil that is not mechanically recovered, there is a need to better understand toxicity of oil-agent mixtures and potential exposure to marine biota, and the long-term fate of these materials in the environment.

- **Species:** American lobster, Atlantic cod, Blue mussels, Green Sea Urchin, green algae, Arctic ice algae
- **Testing:** crude and fuel oils, dispersants, herders



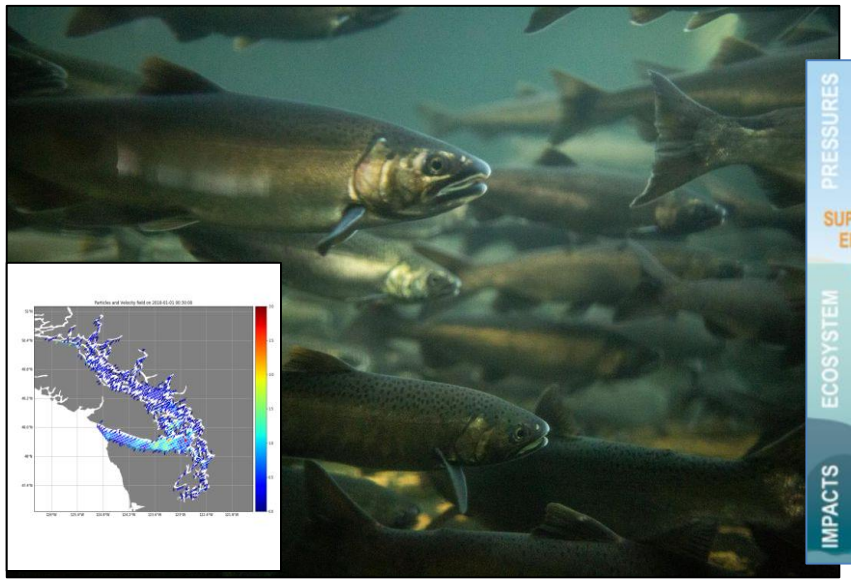


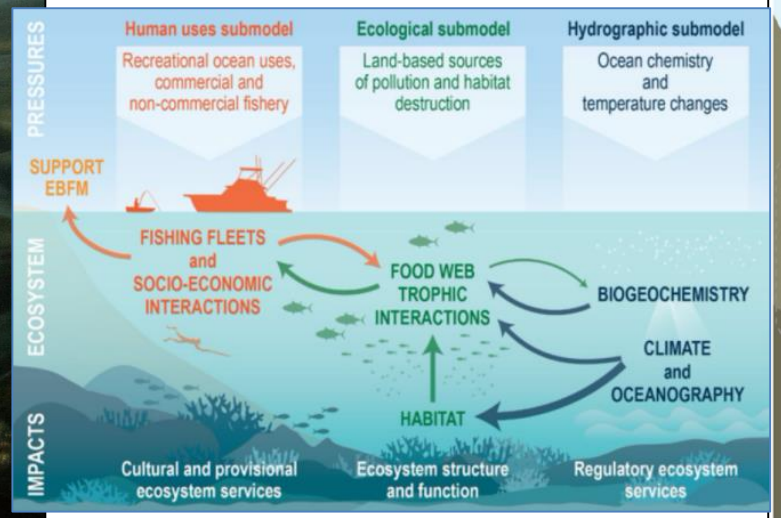


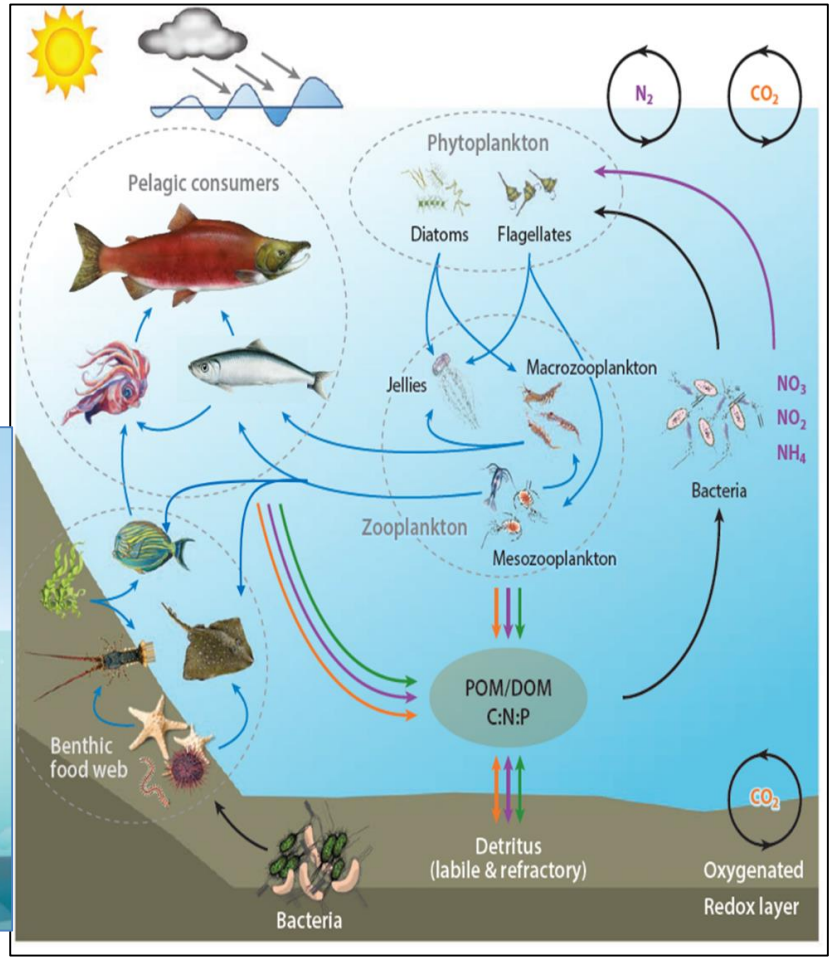
Oil Toxicity / Biological Endpoints

Whole of ecosystem responses to oil spills in quantitative models

- Examine ecosystem responses to multiple stressors
- Trace dispersal of oil spills
- Test response options to provide information in support of decisions minimizing impacts of oil spills







Expanding MPRI Research Impact

Communications and Outreach Activities

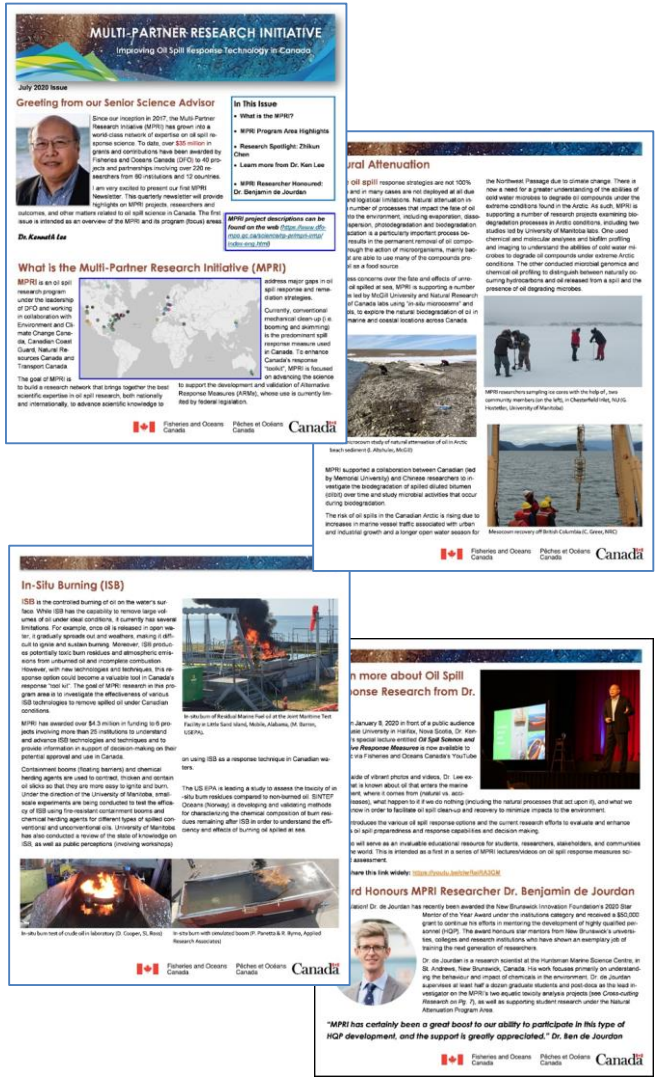
- Production of MPRI newsletter
- Work with DFO Science Outreach to produce additional videos on the science beyond Alternative Response Measures - https://youtu.be/cIwReiRA3GM

Science Advice Through the Canadian Science Advisory Secretariat (CSAS)

- CSAS process planned for spring of 2021 on the use of oil dispersants
- Planning for additional CSAS processes

Discussion Questions

- What are some ways for the MPRI team to engage with your respective organizations on research results that are available?
- Are there knowledge translation products that are commonly used by your organizations?



MPRI SCIENCE OUTCOMES & IMPACTS

- Improvement of Canada's oil spill preparedness and response regime by enhancement of science-based decision making
- Greater public confidence in the Government's ability to respond to and remediate oil spills
- Development, commercialization and application of oil spill response strategies
- Leveraged research will reduce duplication of effort between industry, academia and government agencies
- Enhance research capability, quality of advice and coordination within the Government of Canada
- Education of highly qualified personnel in oil spill research