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Real-time measurements, monitoring and data science for water and environmental monitoring: Frazil ice, microplastics, winter roads and more

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Data Science and Artificial Intelligence Team

Ocean, Coastal and River Engineering (OCRE) Research Centre of the National Research Council (NRC) of Canada

National Research Council Canada (NRC)

2,151
SCIENTISTS, ENGINEERS, TECHNICIANS, AND OTHER SPECIALISTS
including 255 SME industrial technology advisors

179
BUILDINGS MANAGED
(equivalent to 354 NHL hockey rinks) in 22 locations

$1.1B
ANNUAL EXPENDITURE
including an IRAP contribution budget of $293M for SMEs

1,577
R&D COLLABORATIONS AND HELPED 8,000 SMEs

ADVANCE
SCIENTIFIC AND TECHNICAL KNOWLEDGE

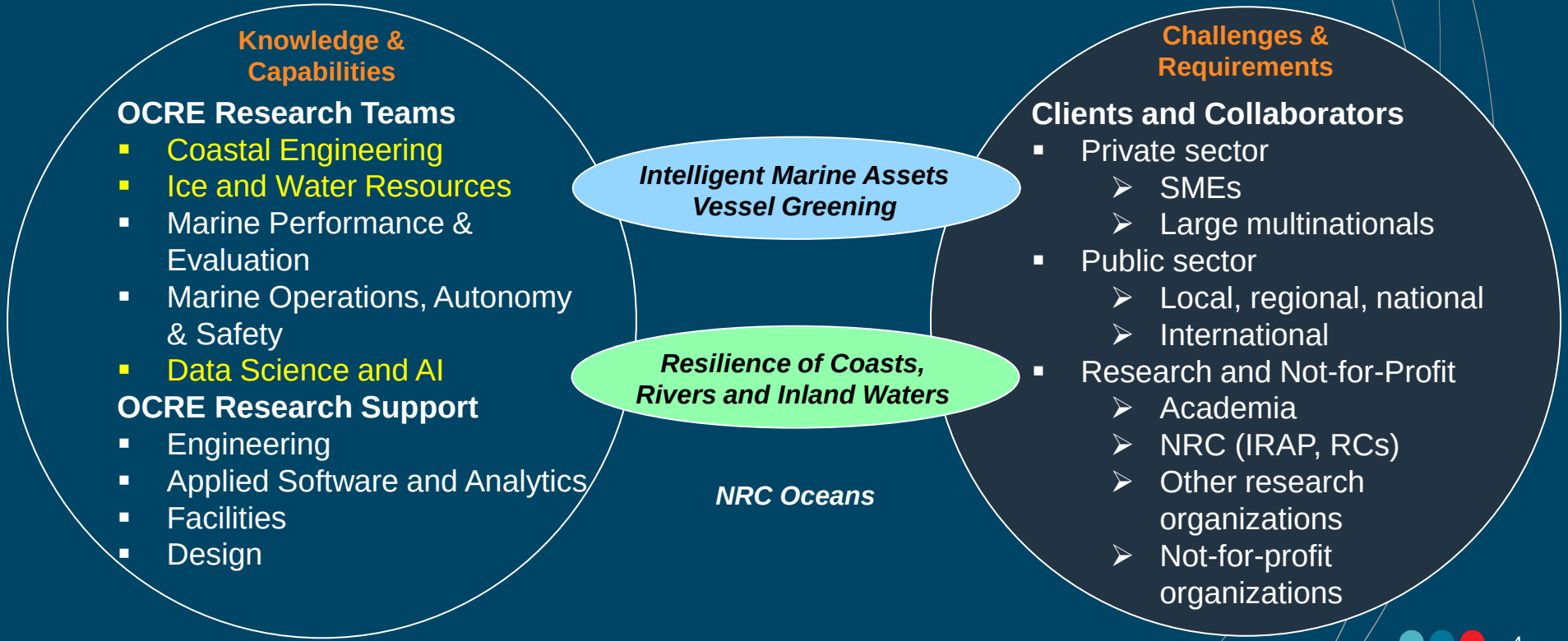
SUPPORT
GOVERNMENT POLICY OBJECTIVES

SUPPORT
BUSINESS INNOVATION

NRC Research Centres and geographic locations

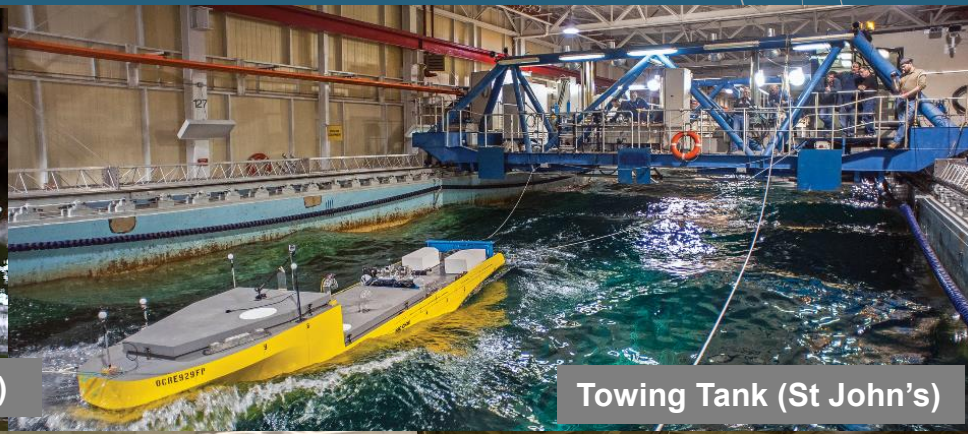
- Advanced Electronics and Photonics Research Centre
- Aerospace Research Centre
- Aquatic and Crop Resource Development Research Centre
- Automotive and Surface Transportation Research Centre
- Construction Research Centre
- Digital Technologies Research Centre
- Energy, Mining and Environment Research Centre
- Herzberg Astronomy and Astrophysics Research Centre
- Human Health Therapeutics Research Centre
- Medical Devices Research Centre
- Metrology Research Centre
- Nanotechnology Research Centre

OCRE at a Glance



OCRE Facilities

Offshore Engineering Basin (St John's)



Towing Tank (St John's)

Large Ice Tank (St John's)

Coastal Wave Basin (Ottawa)

Large Area Basin (Ottawa)

OCRE Activities pertinent to real time monitoring

Resilience of Coasts, Rivers and Inland Waters

Nature-based solutions for flood and erosion protection

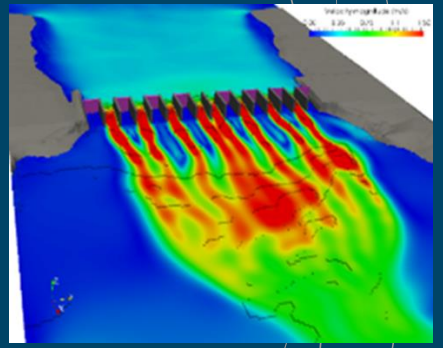
Coastal structures, ports and harbours

Physical and numerical ice modelling

Hydrological, hydraulic and hydrodynamic modelling

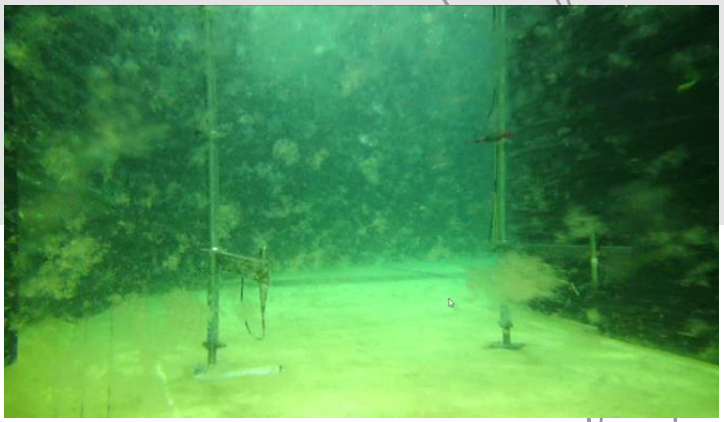
Environmental decision support systems

Climate risk assessment



Frazil ice

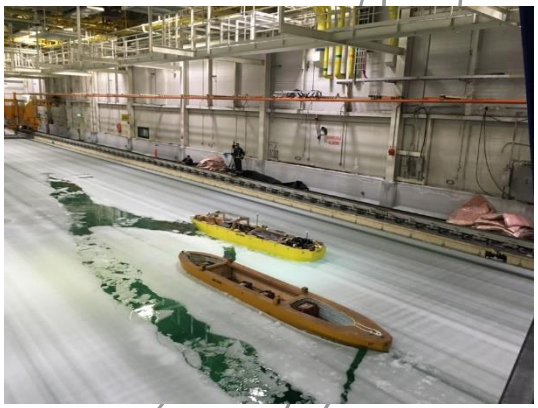
- Frazil ice forms in supercooled highly turbulent waters
- It is the precursor to river which can cause river ice jams and is notorious for adhering to submerged objects it contacts with
- It regularly clogs or blocks water intakes
- Blockages can negatively impact hydropower plants, nuclear power facilities, water supply facilities ….
- …therefore can lead to reduced power generation capacity, potential damage to equipment etc.



Daly, Steven F. 1991. “Frazil Ice Blockage of Intake Trash Racks.” COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH.

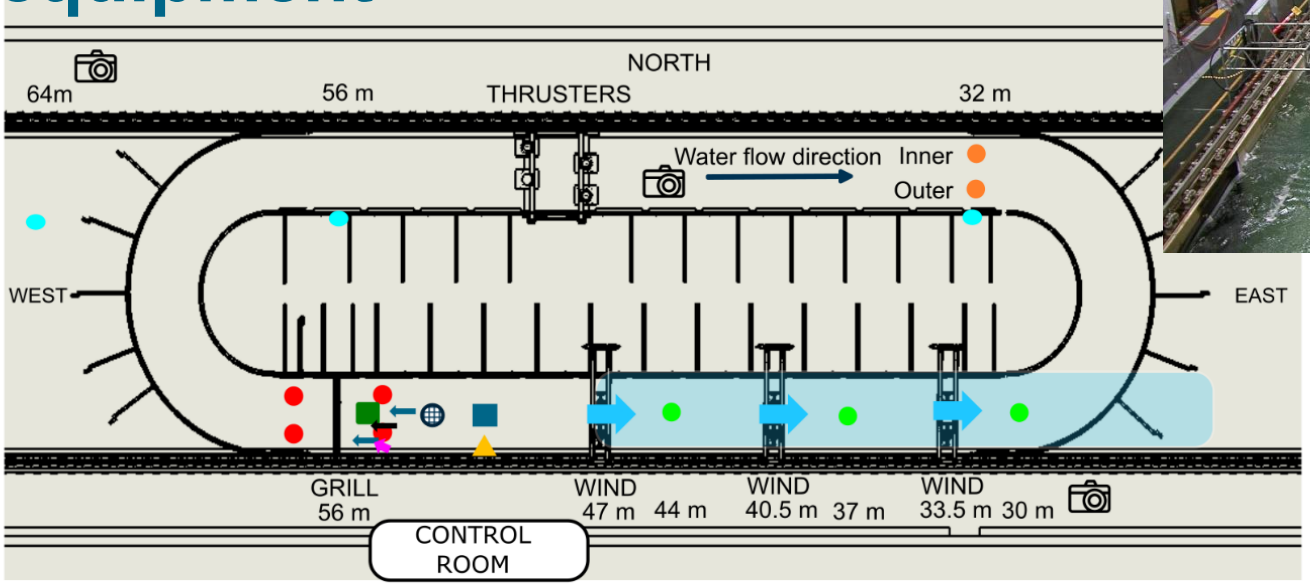
St John's Ice Tank/Frazil facility

- Purpose designed and build in the 1980s for simulating ice interactions with vessel and structures and related studies
- 90 m long [76 m usable] x 12 m wide x 3 m deep
    - ~3,000 m^3
- Water can be chilled to just above freezing
- Air can be chilled to -20°C
- Can grow ice an ice sheet @ 2.5 mm an hour to a maximum thickness of 200 mm
- Typically uses a type of model ice made from 'EGADS' (Ethanol Glycol, Aliphatic Detergent and sugar)



https://nrc.canada.ca/en/research-development/nrc-facilities/ice-tank-90-m-research-facility

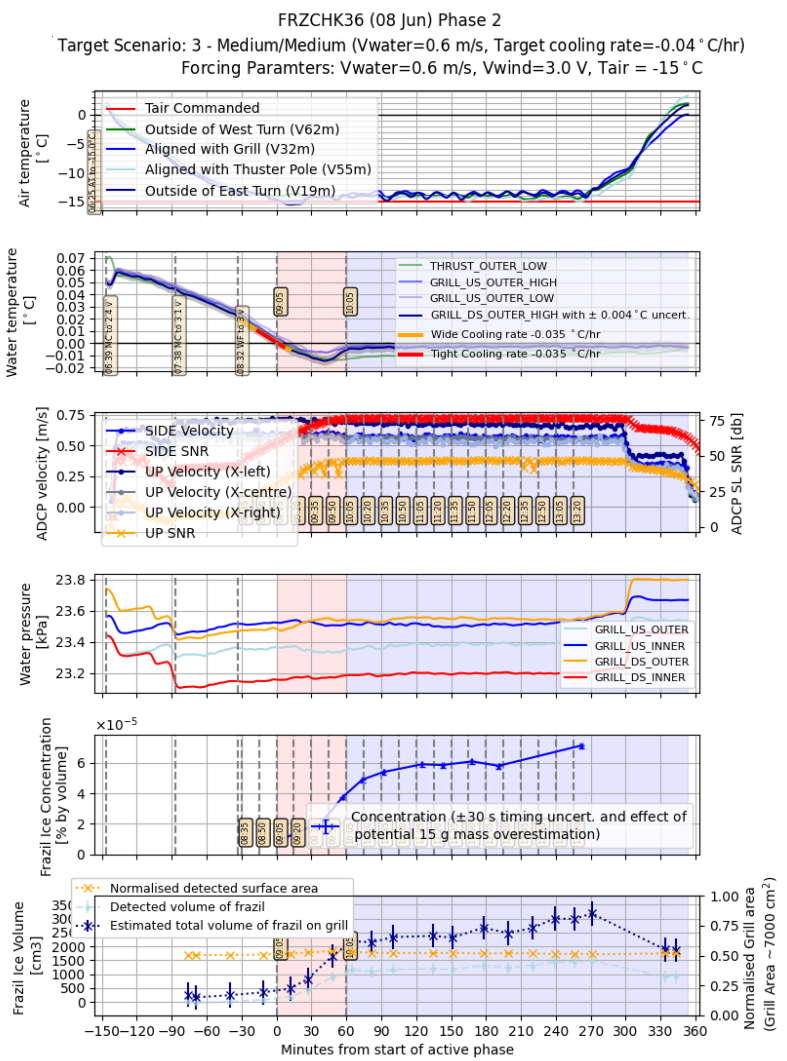
Frazil ice - real time monitoring equipment



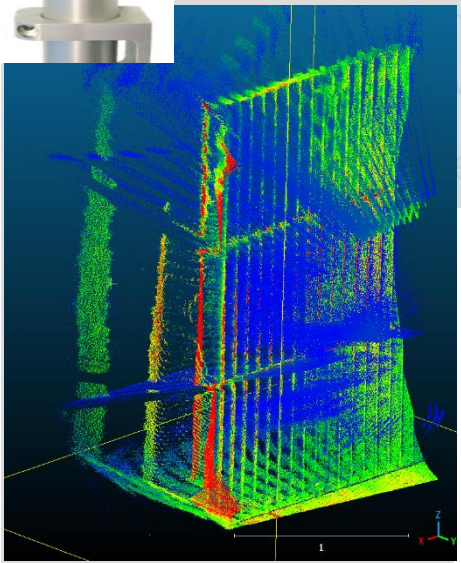
- Temperature Pole - downstream from Thrusters (RBR & RTD @1m and RBR @ 2m depth
- Temperature/Pressure Pole ~2 m upstream/downstream from Grill (as above with Pressure sensors at base)
- Air temperature (hanging from ceiling)
- Wind fans (arrow is wind direction) - Faint blue rectangle is approximate wind field
- Wind anemometer (disconnected during experiments)
- Sampling net location
- Sideways looking ADCP (8 m upstream of grill, halfway up the wall (1/2 water depth ~3 m)
- Upwards looking ADCP (8 m upstream of grill along the centre line)
- ADV (~1 m upstream of Grill)
- Laser scanner location
- Other laser scanner locations used during testing
- Video cameras - orientation shows approximate look angle

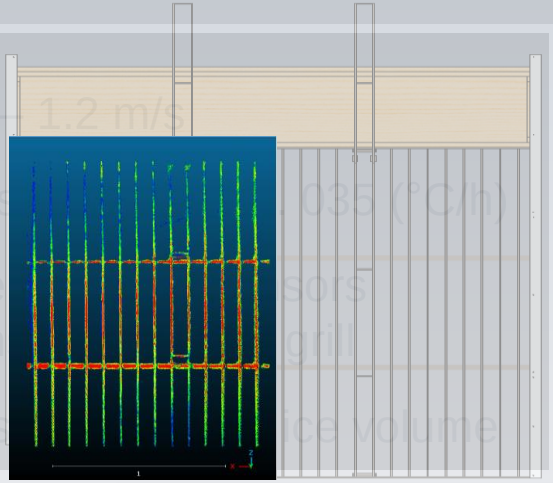
Typical output data

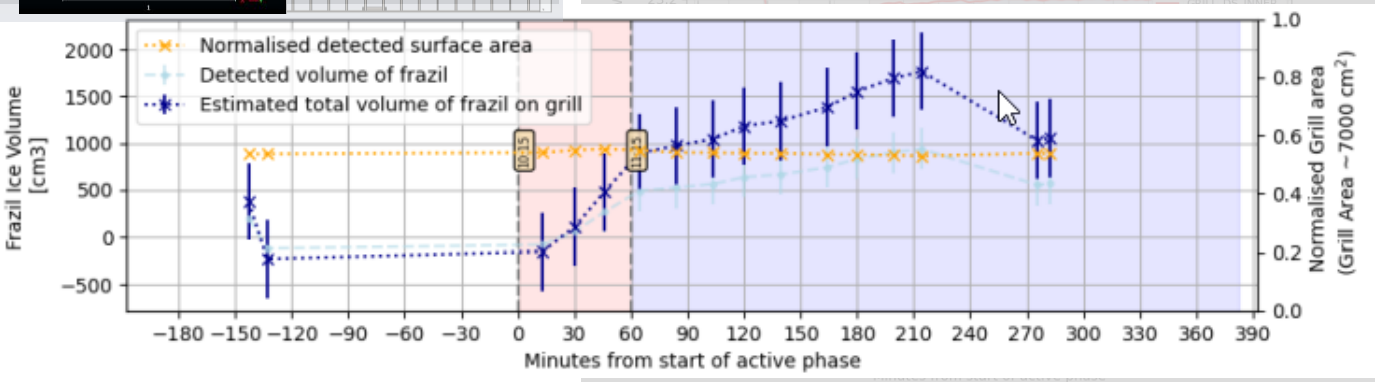
- Medium water flow – 0.6 m/s
- A cooling rate of ~0.035 (°C/h)
- 3rd subplot is the pressure sensors upstream and downstream of the grill highlighting that clogging was not induced
- 5th subplot is the estimated frazil ice volume
- Note the 7- 8 hr duration of the experiment



Lidar scanning of frazil on surfaces – clogging of grill







Microplastics - Research Agenda

Modeling of Microplastics in waterways

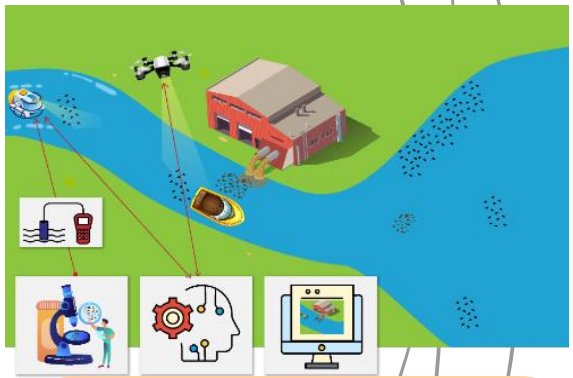
Fate and Transport Predictive Tools

In-situ Technology Development

Physio-Chemical Characterization

Biological Characterisation: Impact on Marine Life

Decision Support System



COLLABORATIONS

NRC : EME, ACRD, METRO, OCRE

Federal: ECCC, ISC

Private/Non-profit: Ocean-wise, Ocean Diagnostic

Academic: University of McGill, University of Ottawa, DFKI (Germany)

Modeling of Marine Microplastics

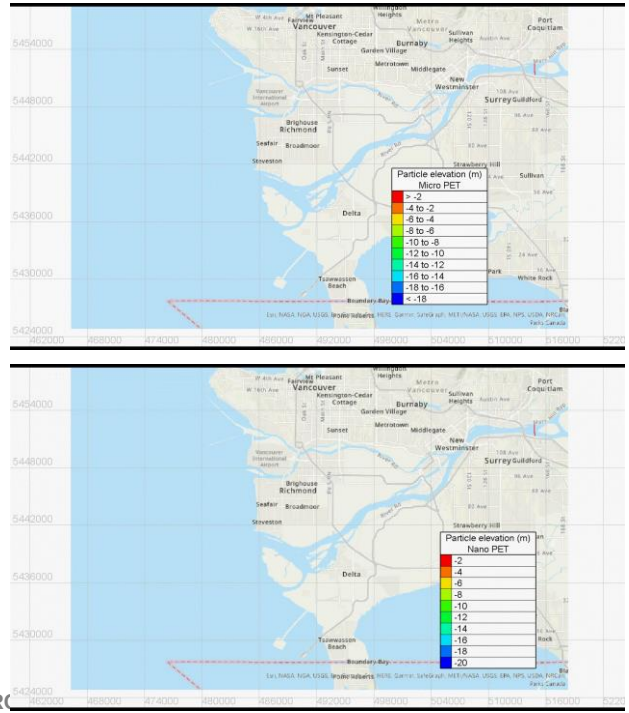
PARTICLE-TRACKING MODELLING

3D HYDRODYNAMIC MODELLING

3D Particle Tracking Model

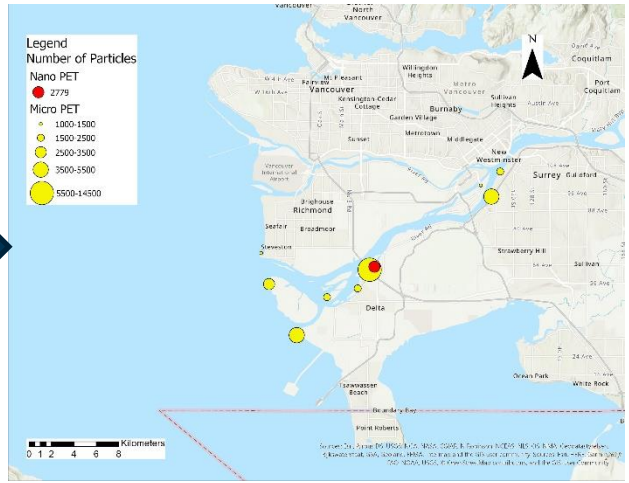
Micro - PET

Nano - PET



AI model

Accumulation zones and potential sources

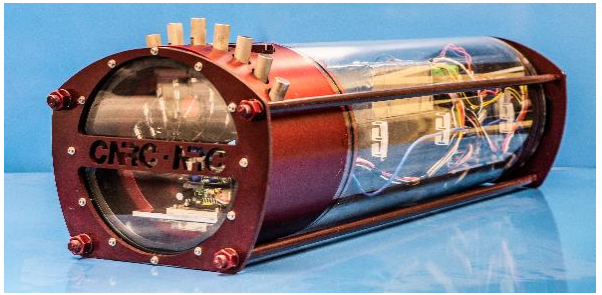


In-situ Detection and Characterization Sensors for micro-plastics (EME)

Development of an in-situ Sensing Instrument

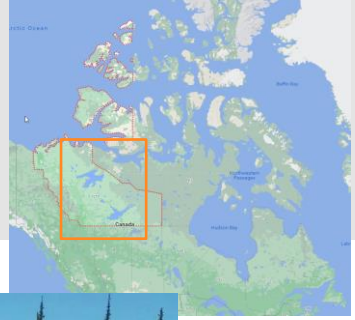
- To detect, size and characterize micro-plastics (100µm – 5mm) in water bodies.
- Combining new or cutting-edge acoustic, optic, spectroscopic technologies;
- Including AI-based data processing and analysis for particle characterization (plastic?; type of plastic?; size?)
- Deployable underwater prototype to map the concentration of micro-plastics in aquatic environments.

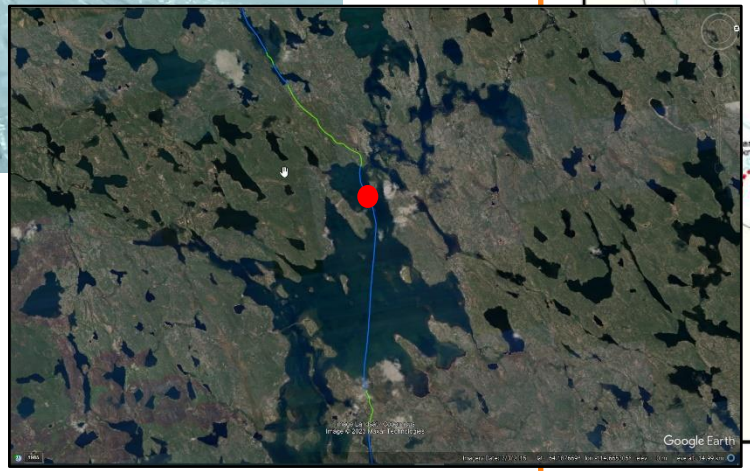
Previous project:
NRC Oil spill detection underwater Prototype

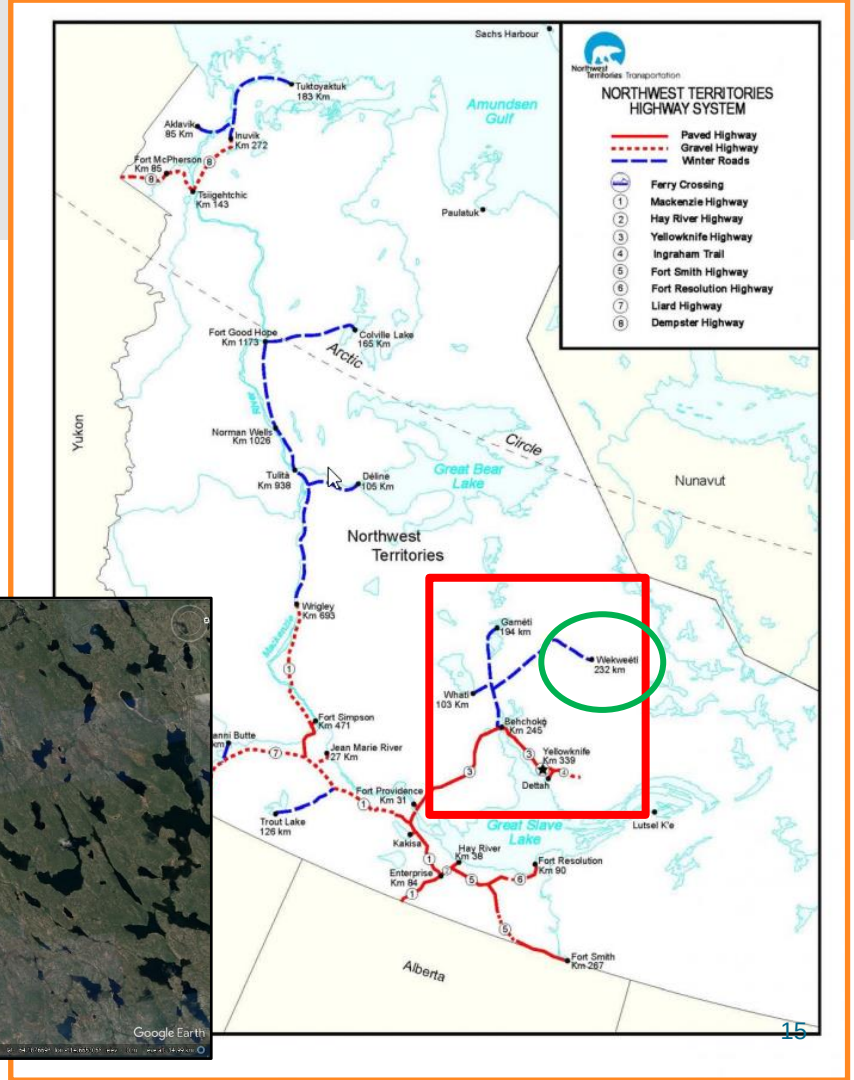


The prototype to be developed would enable a better/faster survey of the ocean micro-plastic pollution (sources detection, accumulation area detection, support to predictive modelling, mapping and evolution of pollution over time …)

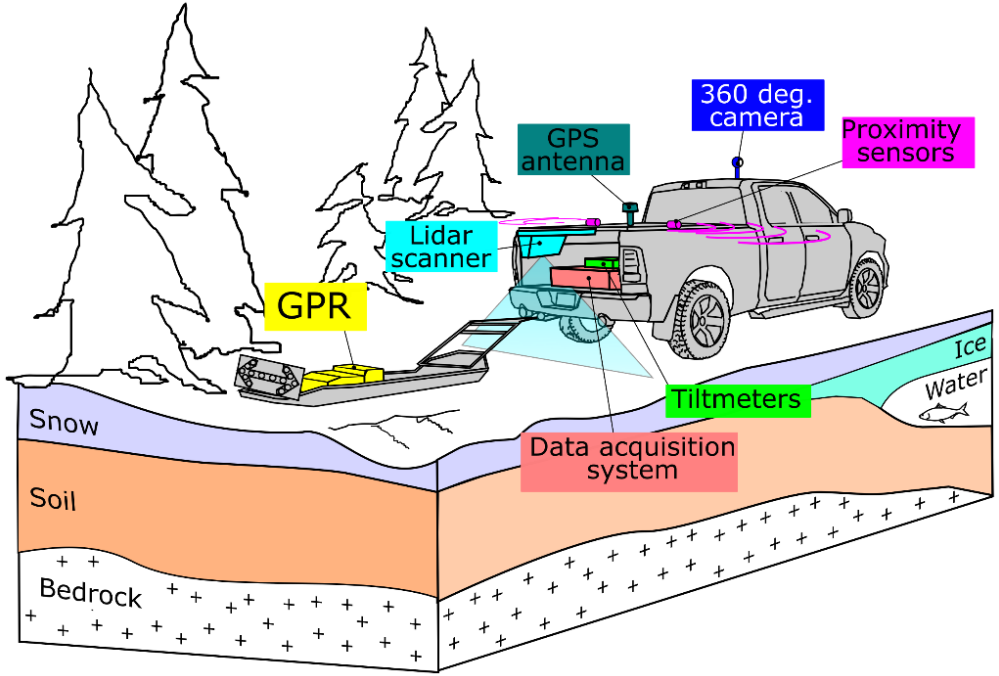
Real time monitoring for Winter Roads





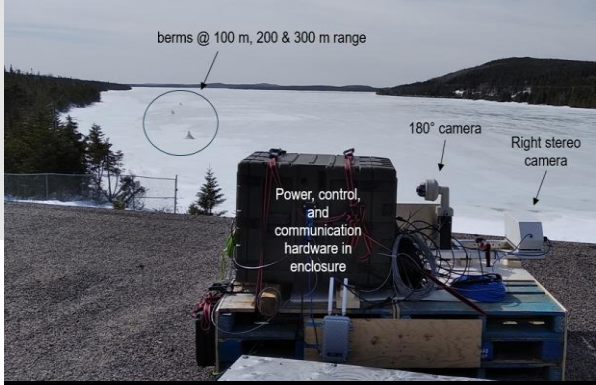


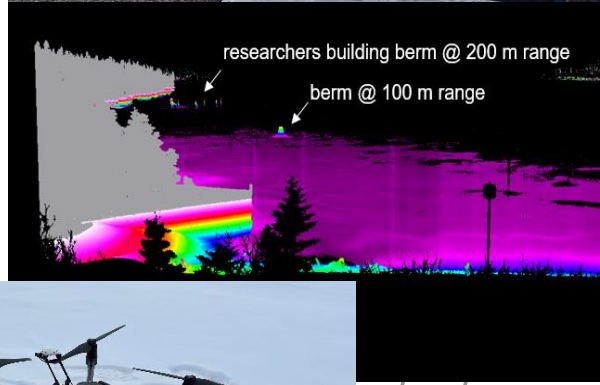
Winter Roads Survey Tool concept sketch and analogous systems

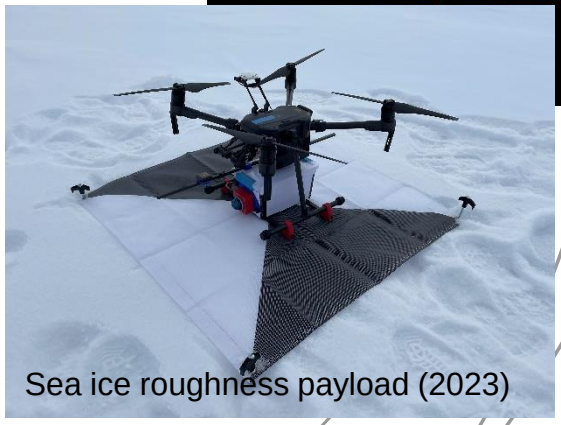


Barrette, P.D., Hori, Y. and Kim, A.M., 2022. The Canadian winter road infrastructure in a warming climate: Toward resiliency assessment and resource prioritization. Sustainable and Resilient Infrastructure. 10.1080/23789689.2022.209412

Testing ship based lidar/camera system on Windsor Lake, Nfld (2021)

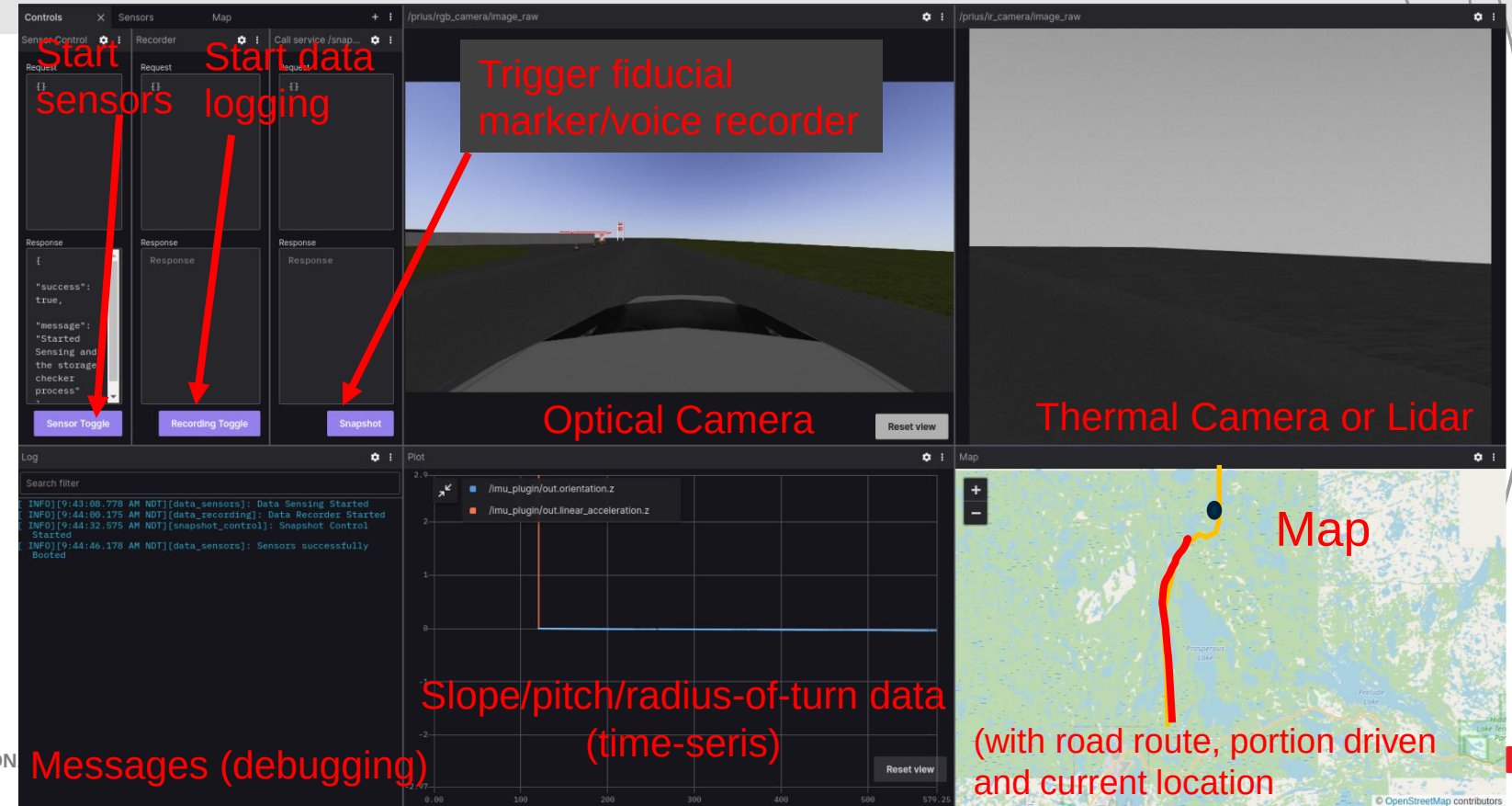






Sea ice roughness payload (2023)

Winter Roads Tool Interface for real-time surveys



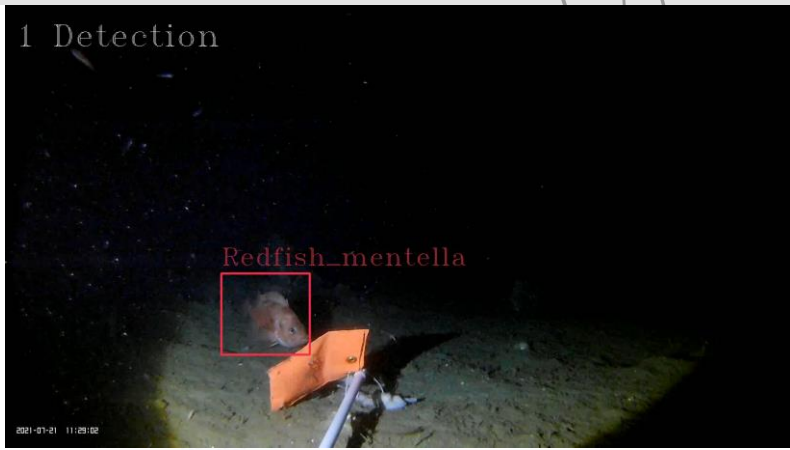
Fish detection and classification

Objective:
Measuring effects of seismic surveying on groundfish resources off the coast of Newfoundland, led by DFO.

NRC Participation:
Implementing machine learning methods to automatically identify and count Atlantic Cod and produce a numerical database of statistical analysis.

Imaging system
100x custom camera housing (B) with commercially available camera (A).

Ongoing work
1. Work with DFO morphologist to develop training dataset
2. Train model to identify multiple species from field programs
3. Process video library (80 TB of HD footage)

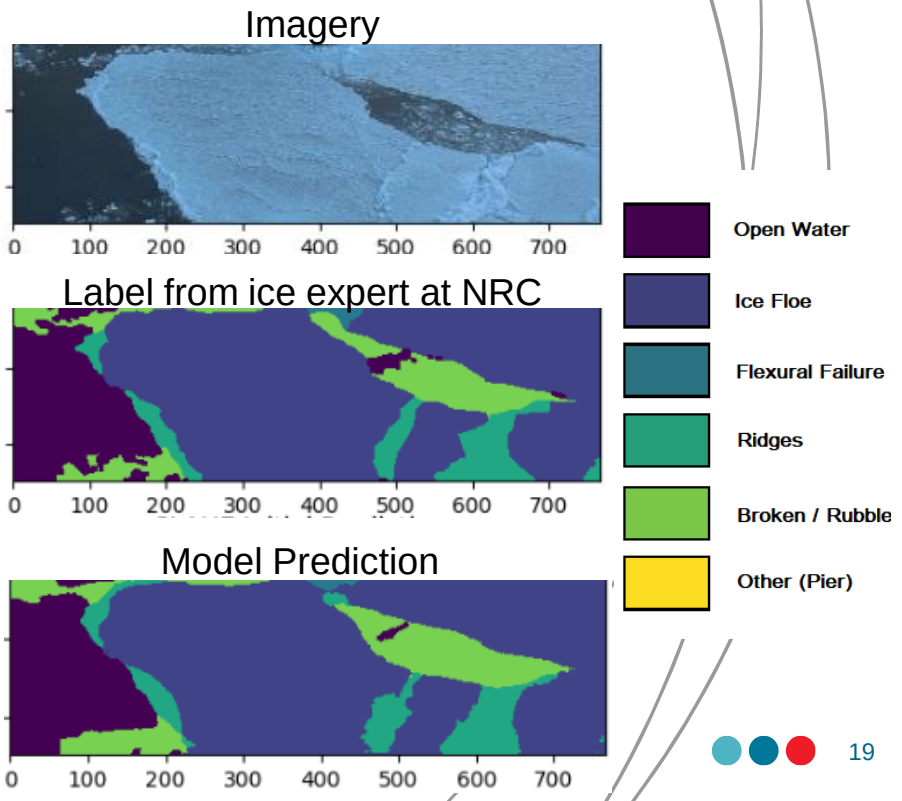


Ice Characterization Using Visual Sensors

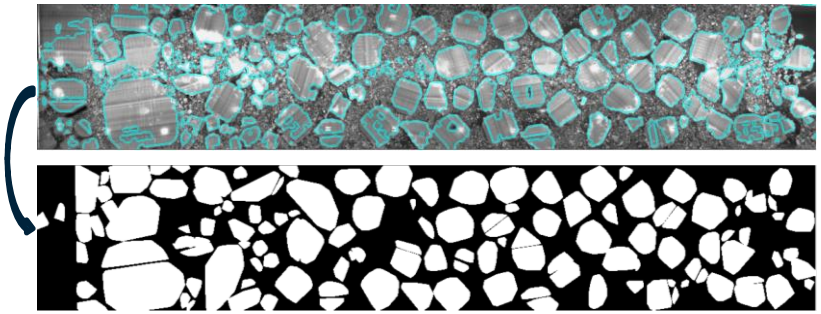
Objective:
Classify the form of ice and ice surface features using semantic segmentation method and convolutional neural network.

Data Source:
Side-looking camera mounted on a fixed structure (bridge).

Next steps
1. Generalize the methods on ship-mounted sensors.
2. Review and expand the dataset with international standard, such as SIGRID-3.



Ice Characterization Using Visual Sensors



Defining operational limitations

Target Detection Using Remote Sensing Products

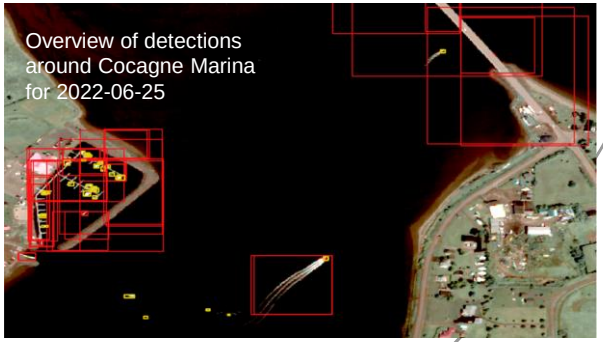
Transport Canada's **Navigation Protection Program (NPP):** keeping Canada's navigable waters open for transport and recreation

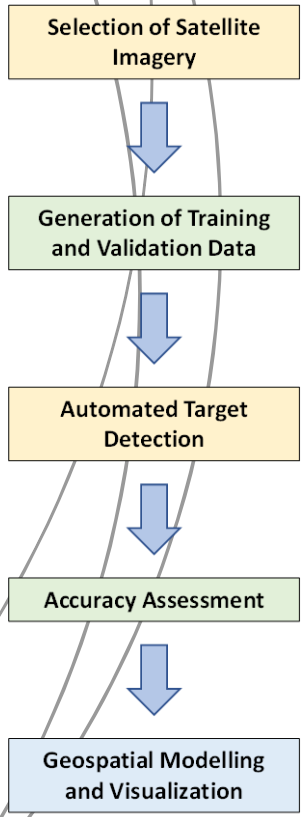
Objectives:

Phase 1. Demonstrate the utility of satellite imagery.

Phase 2. Develop automated processing of satellite imagery.

Phase 3. Implement prototype of operational, extendable scanning tool.





Thank you for you attention / Merci de votre attention

Questions (or find me afterwards)

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