

# **NRC Research to Support Arctic Shipping and Offshore Operations**

**Ivana Kubat**

**National Research Council of Canada**

**Ocean, Coastal and River Engineering**

**North America Shipping Forum – St. John's, NL, Canada – October 2018**



National Research  
Council Canada

Conseil national de  
recherches Canada

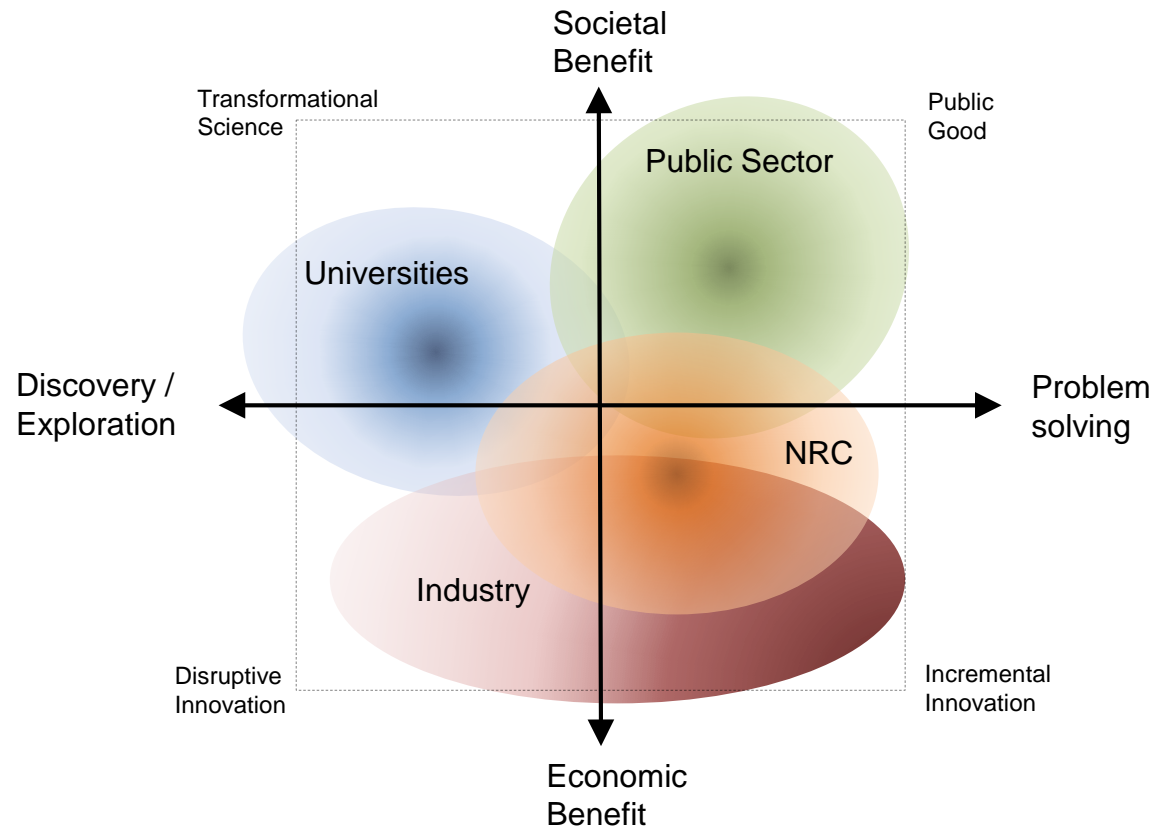
**Canada**

# Presentation Content

- 1. NRC OCRE overview**
- 2. Examples of research supporting shipping and offshore operations**



# Positioning the NRC in Canada's innovation landscape





# The National Research Council of Canada

## Mandates:

- Federal policy mandates
- Advancing knowledge
- Business innovation

## Resources:

- 3,700 personnel
- \$1.1B (CDN) in annual expenditure
- 178 buildings in 72 locations





# NRC works through collaboration

## Last year we worked with:

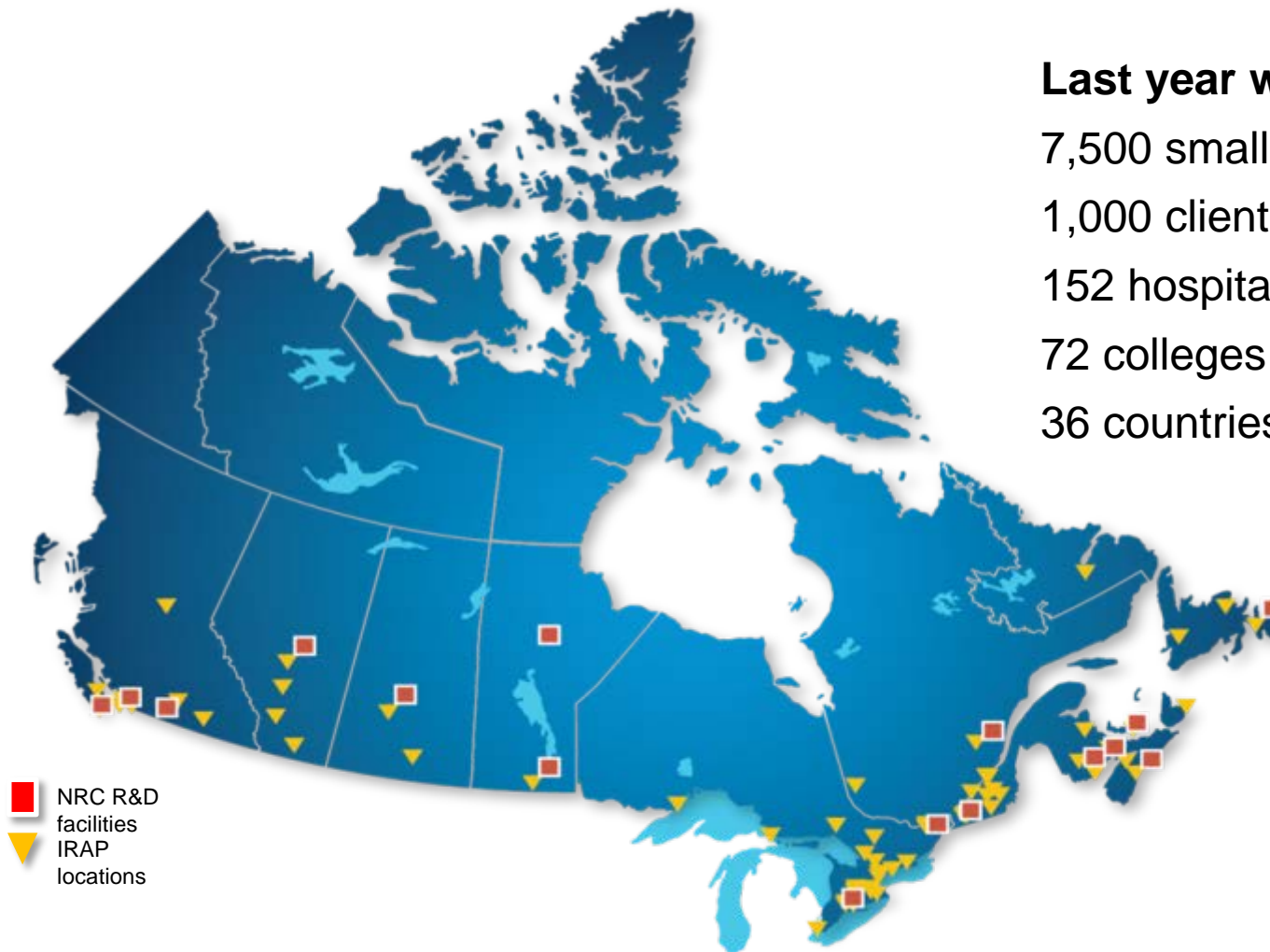
7,500 small firms (IRAP)

1,000 clients (research)

152 hospitals

72 colleges and universities

36 countries



# Areas of Research and Development



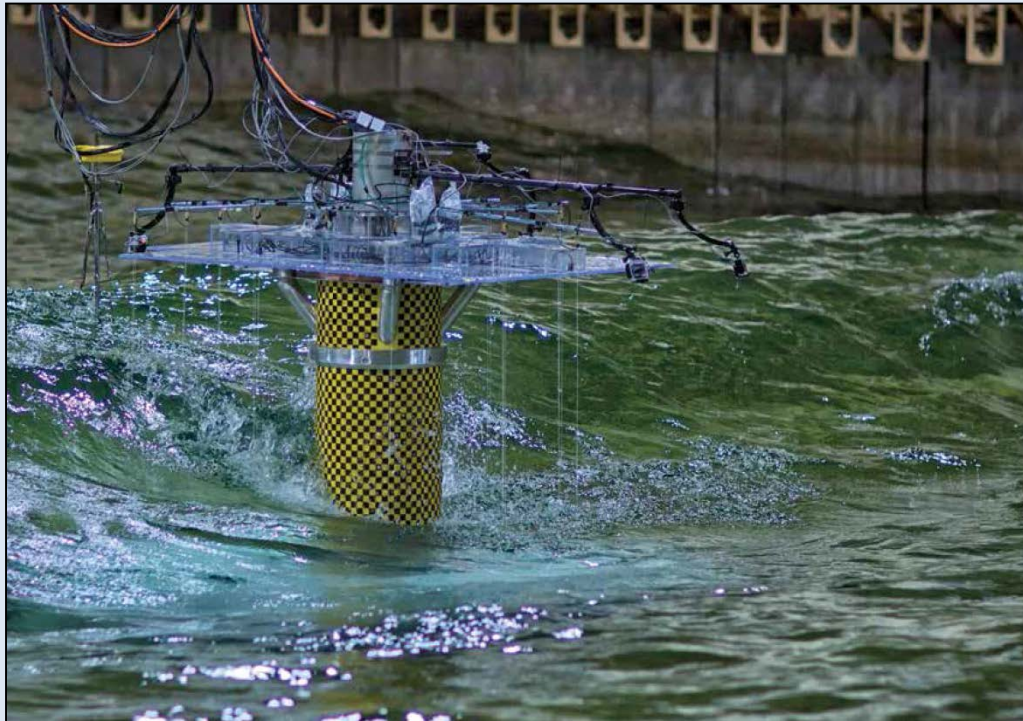
## Expertise in 14 areas of R&D

- › Aerospace
- › Automotive & Surface Transportation
- › Construction
- › Energy, Mining & Environment
- › Ocean, Coastal & River Engineering
- › Aquatic & Crop Resource Development
- › Human Health Therapeutics
- › Medical Devices
- › Nanotechnology
- › Digital Technologies
- › Advanced Electronics and Photonics
- › Metrology
- › Astronomy & Astrophysics
- › Security & Disruptive Technologies



# NRC-OCRE Research Facilities – St. John's, NL

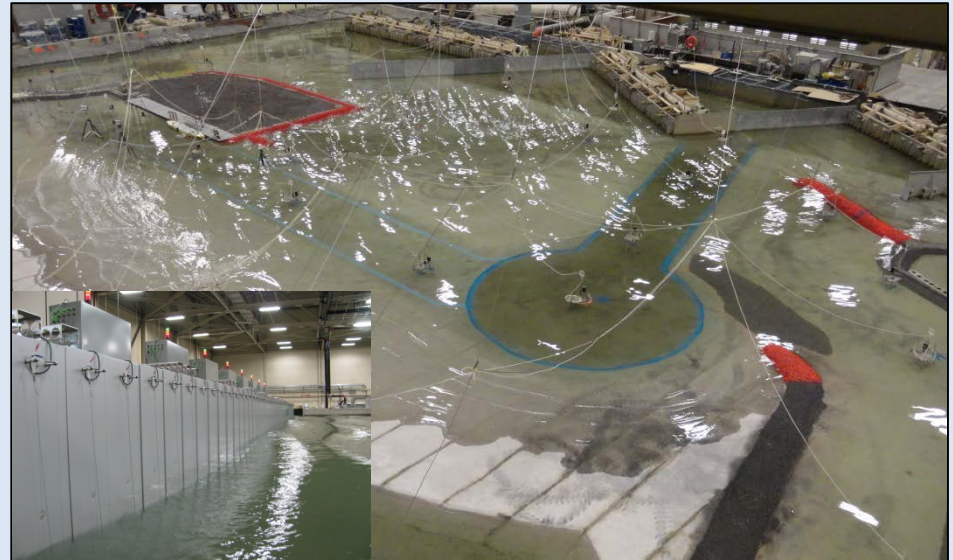
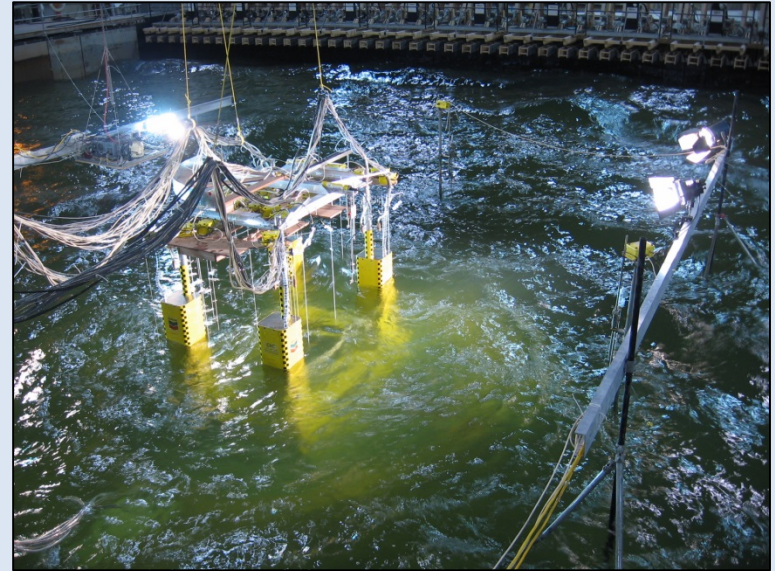
- 200 x 12 x 7m Towing Tank
- 75 x 32 x 3m Offshore Eng. Basin
- 90 x 12 x 3m Ice tank (Refrigerated Towing Tank)





# NRC-OCRE Research Facilities – Ottawa, ON

- 50m x 30m Large Area Basin
- 36m x 30m Multidirectional Wave Basin
- 64m x 14m Coastal Wave Basin
- 93m x 2m Large Wave Flume
- 63m x 1.4m Steel Wave Flume
- 21m x 7m Ice Tank

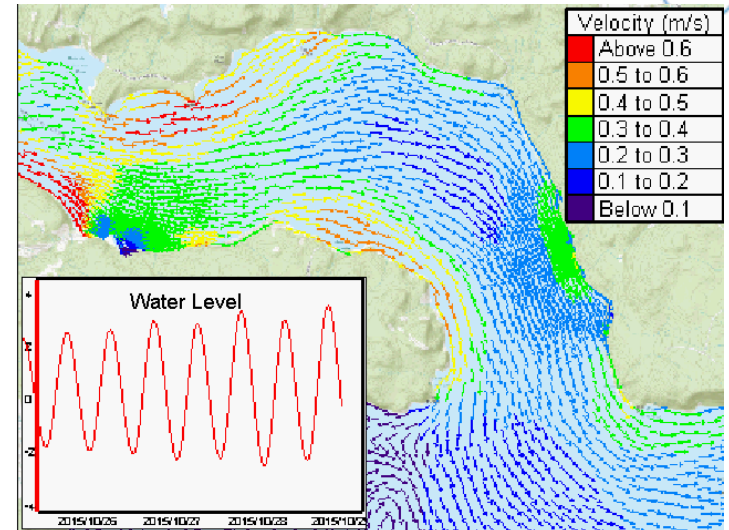




# Research: Field, Physical, Numerical Modelling



Courtesy Ivana Kubat, NRC



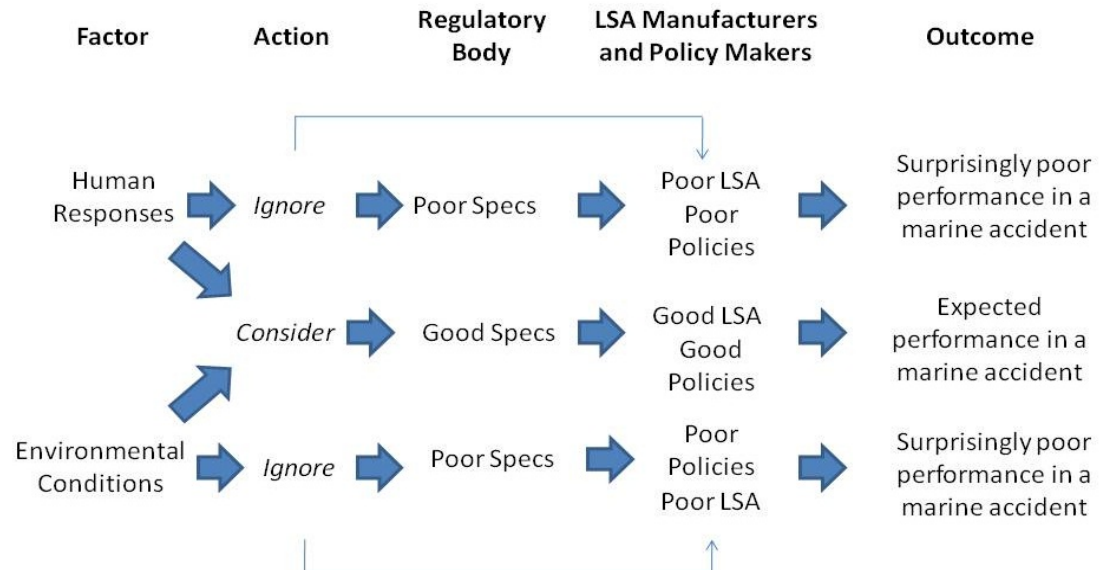
Courtesy Michelle Johnston, NRC



# Marine Safety Technologies for Extreme Environments

## Why Safety R&D?

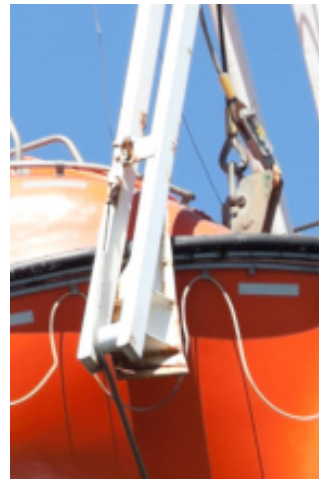
- Equipment often tested/certified in benign conditions
- Poor performance in real world conditions
- Results in a knowledge gap – expected versus actual performance





# Evaluation of life saving appliances (LSA) in extreme environments

- Lifeboats – ice covered waters; recovery methods
- Liferafts – towing various sizes (16, 42, and 150 person)
- Immersion suits – effects of wind and waves on predicted survival time (PST) with human participants



# Estimating survival in Arctic Locations

- Exposure time project: based on multiple factors (time of year, location, weather, etc.) how long would someone be exposed to Arctic conditions while awaiting rescue?
- Compare those times against PST for various clothing ensemble used in Arctic cruises to determine if people could survive until rescue



# Evaluation of life saving appliances (LSA) in extreme environments

- **Polar Code Review**

- Collaboration with Transport Canada and Aker Arctic to review the IMO Polar Code to determine if current LSA can meet the requirements it specifies

- **Equipment evaluation for Canadian military**

- Working with armed forces to evaluate various pieces of equipment to increase performance in extreme environments





# Vessel Performance Evaluation

## Goal - Example Outcomes

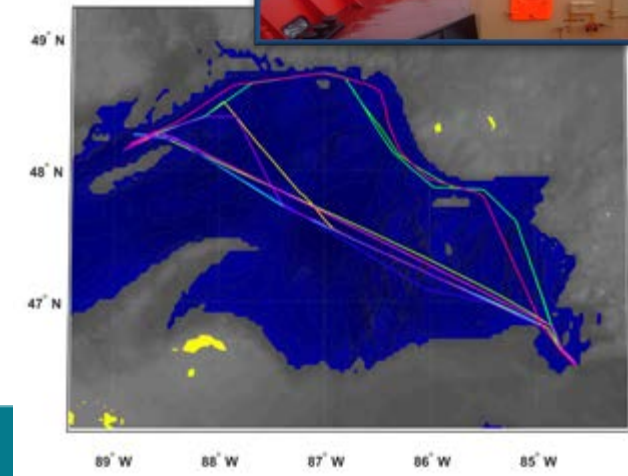
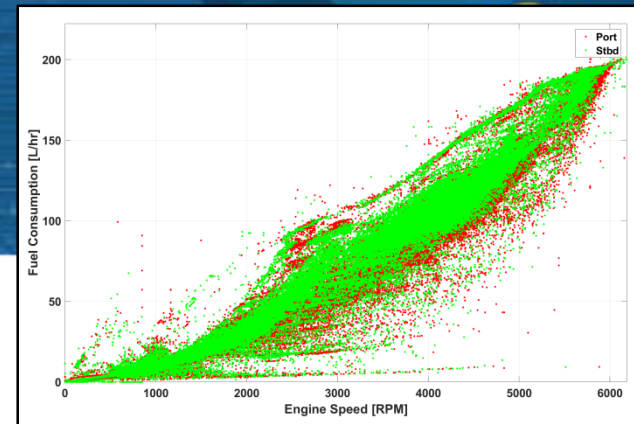
- Continuous evaluation of vessel performance
- Baseline data for future design or equipment changes
- Quantification of effect of significant factors on fuel efficiency
- Insight towards emission reduction
- Effects of maintenance or system alterations on fuel efficiency

## Hardware

- Vessel performance monitoring systems

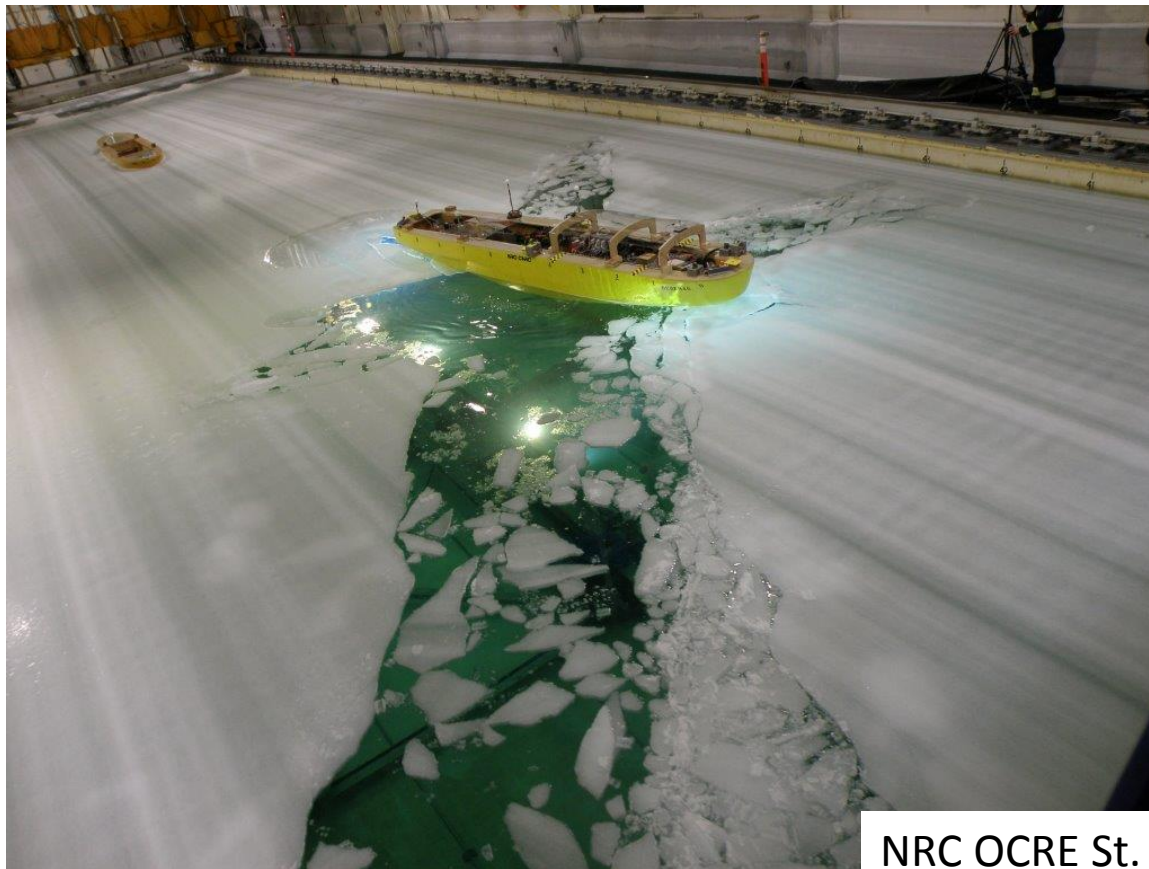
## Software and Analysis

- Versatile and proven analysis procedures
- Experience with government and commercially operated vessels



# Research Supporting the USCG Heavy Polar Icebreaker Program

Dr. John Wang's ASF presentation

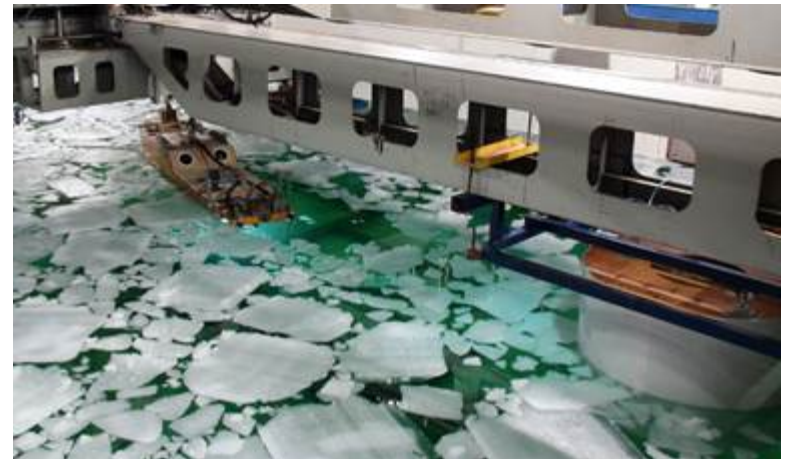
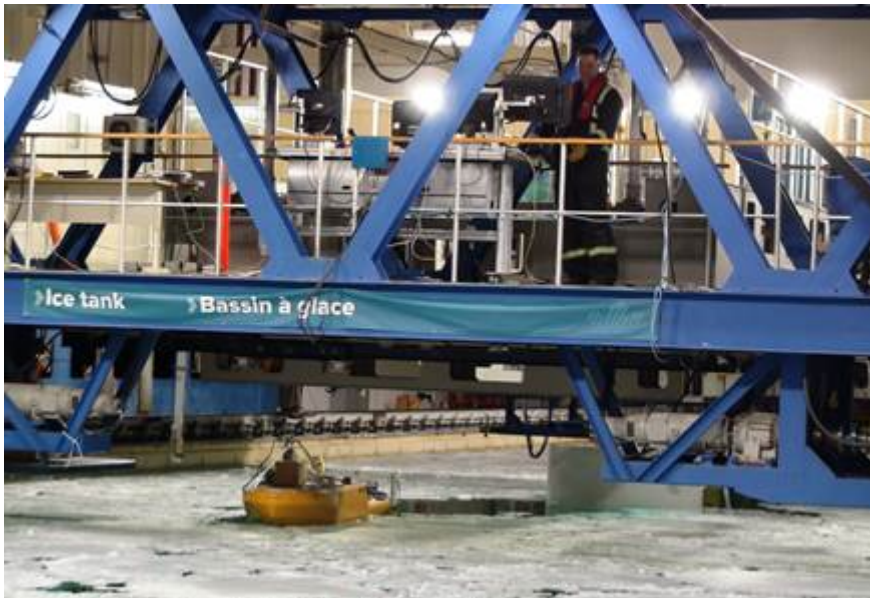
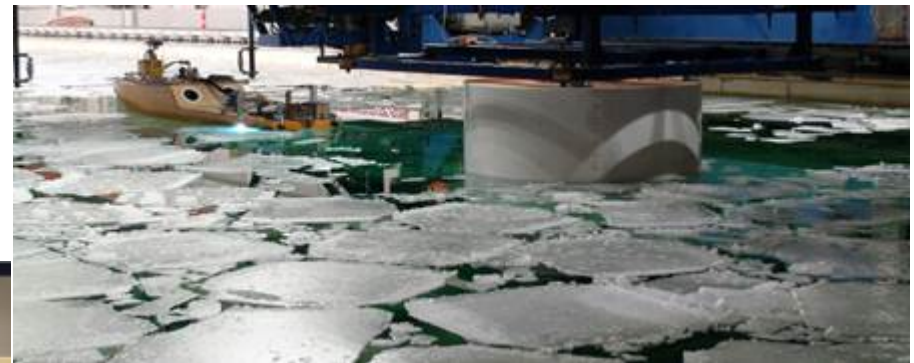


NRC OCRE St. John's Ice Tank



# Ice Management

- Model scale tests investigating multiple ice management techniques for offshore petroleum operations
- Collaboration between NRC, Memorial University, with input from CNLOPB

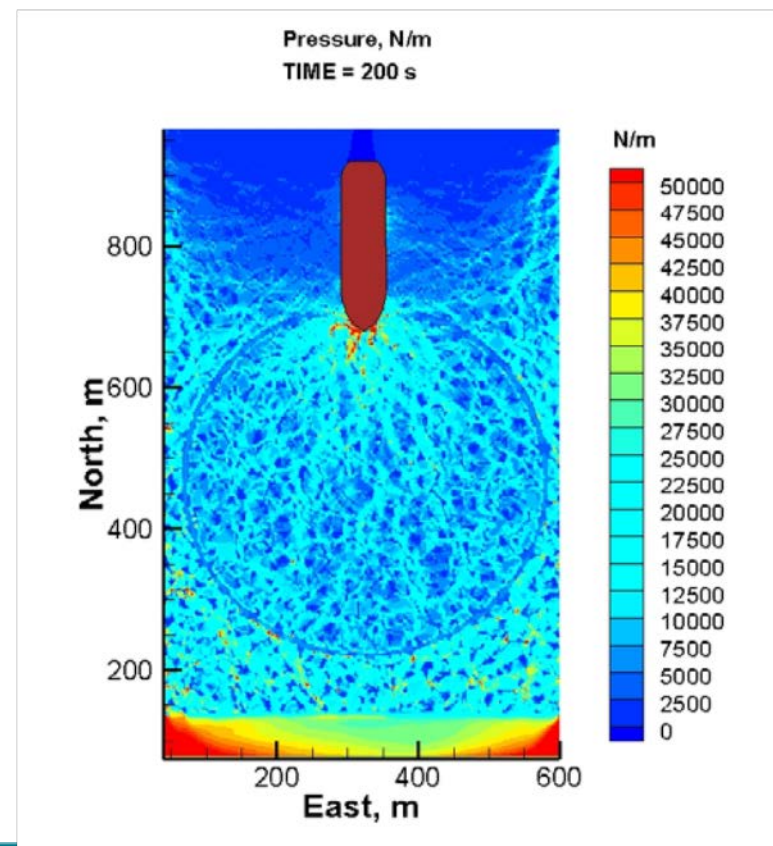
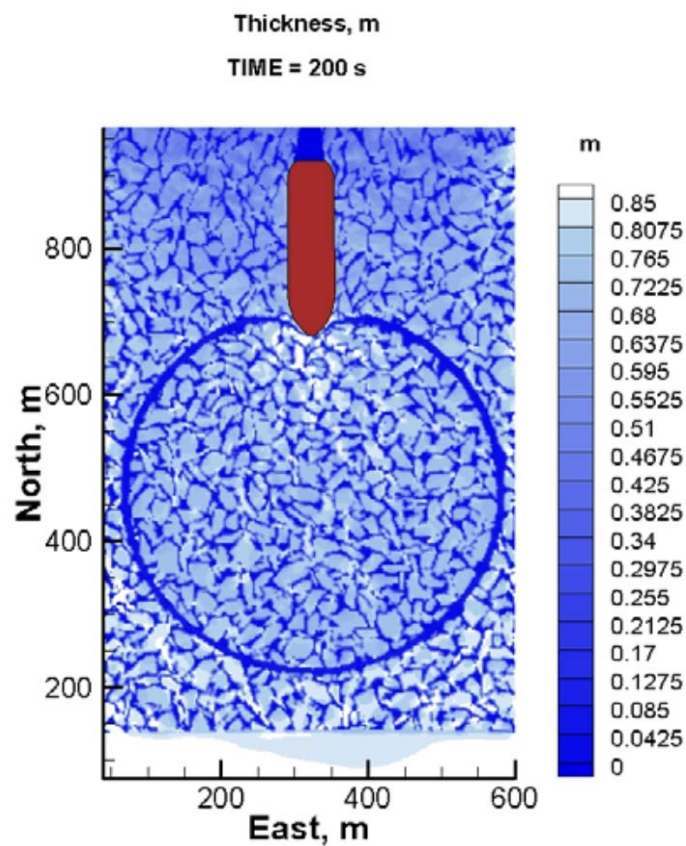




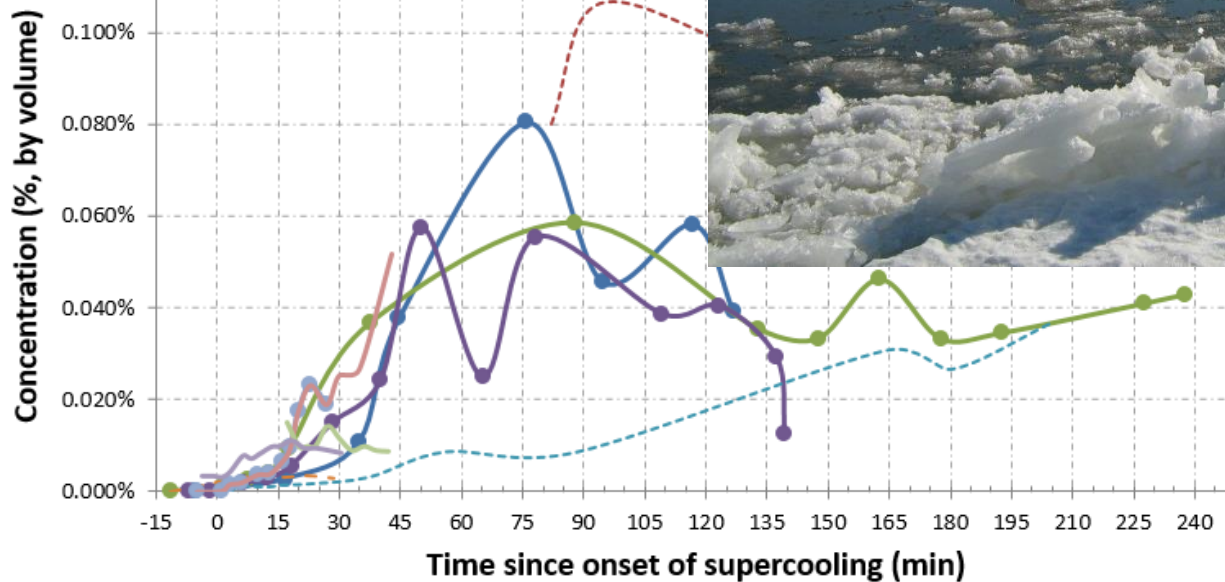
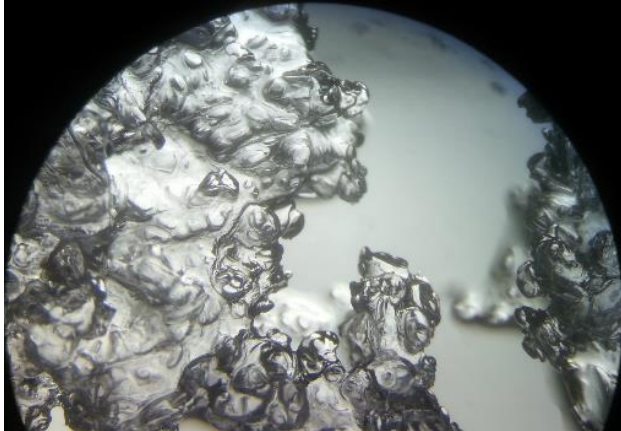
# Ice Management

## Numerical Modelling

Effect of brash ice and icebreaking patterns on the forces and vessel response



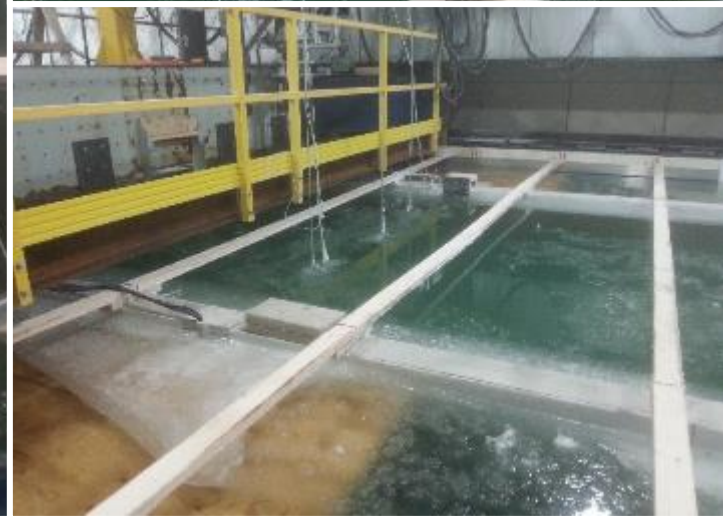
# Generation of Frazil Ice in the Ice Tank



Courtesy Martin Richard, NRC



# NRC-OCRE Ottawa Ice Tank



# Laboratory Testing

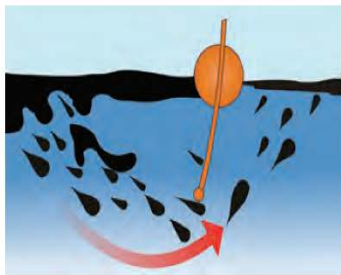




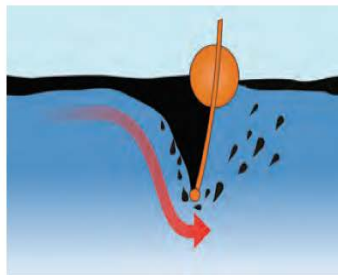
# High-speed Oil Collection Booms

Goal: Improve boom performance at higher tow speeds

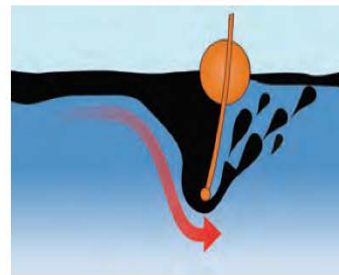
- CFD modelling of oil-water-boom interaction
- Concept development
- Scale model tests of boom concepts to assess performance



▲ Figure 3a: Entrainment.



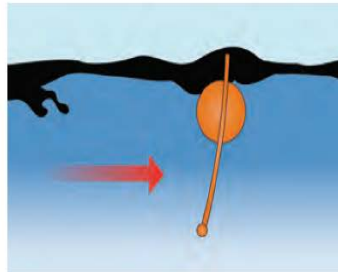
▲ Figure 3b: Drainage failure.



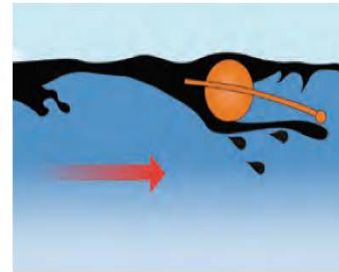
▲ Figure 3c: Critical accumulation.



▲ Figure 3d: Splash-over.



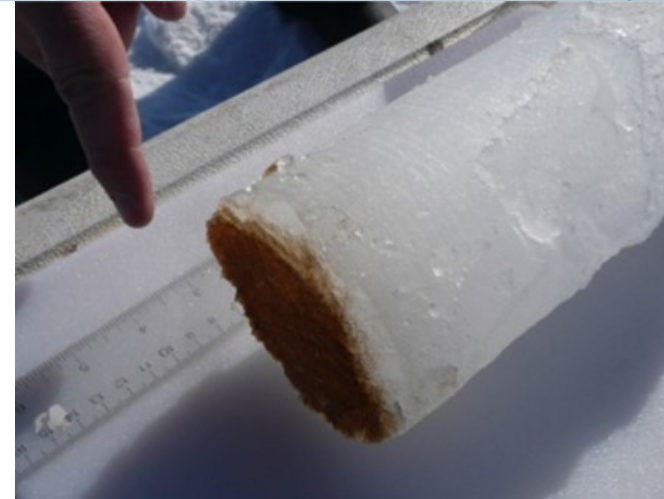
▲ Figure 3e: Submergence.



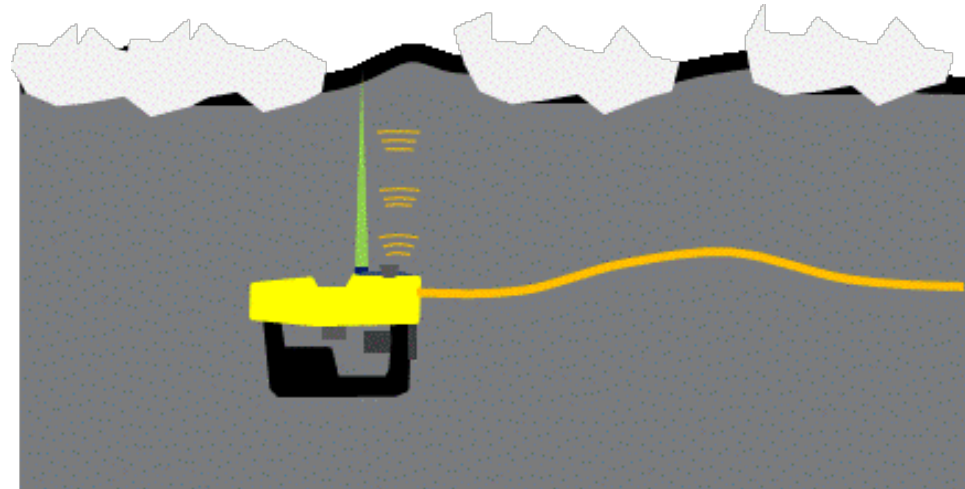
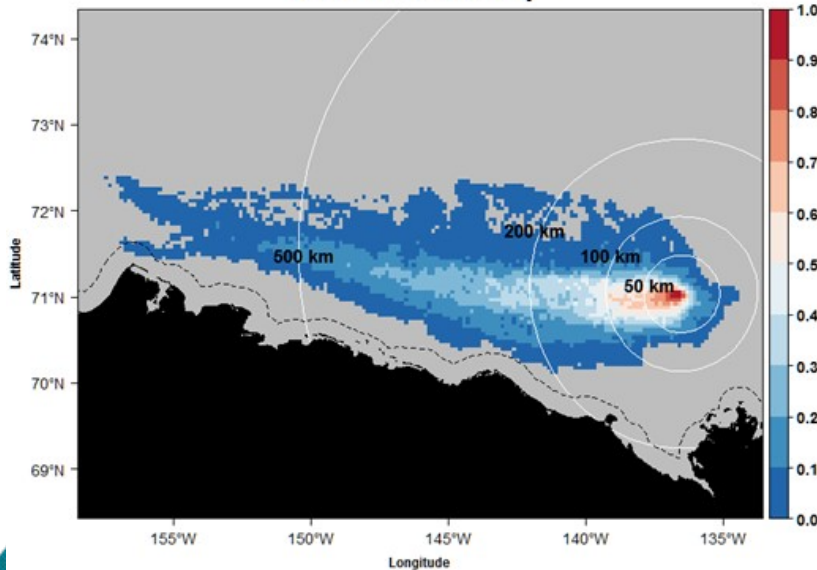
▲ Figure 3f: Planing.



# Oil Spill Detection, Forecasting, and Bioremediation

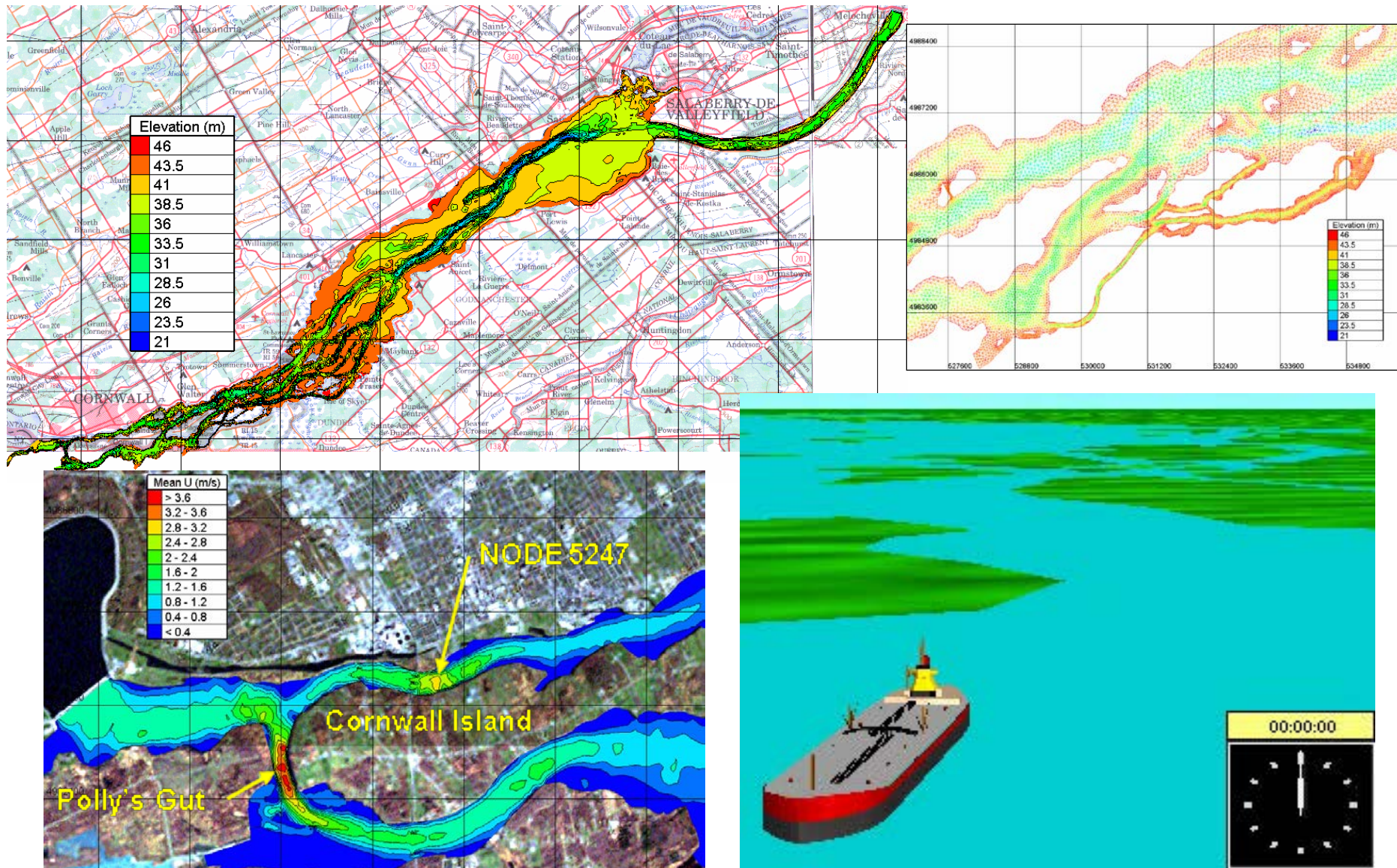


Contamination Probability





# Modelling fate of pollutants





# Waste water and sewage treatment



**Bioelectrochemical degradation of sewage under anaerobic conditions – fully scalable (boats, houses, communities).**



# CASRAS – Canadian Arctic Shipping Risk Assessment System

CASRAS is an integrated risk assessment system for marine transportation in the Canadian North that enables sound decision-making leading to safer, more efficient shipping in this harsh environment while ensuring the minimal negative impact on the life of Northerners, and decreasing the risk of polluting the environment.



# CASRAS objectives

- ✓ **Assess the risk associated with shipping in various Polar regions**
- ✓ **Document mariners knowledge, places of refuge and information on local communities**
- ✓ **Promote Arctic shipping best practices**
- ✓ **Support regulatory process transparency (including Polar Code)**
- ✓ **Minimize the effects due to limited access to Internet**
- ✓ **For use in the office and onboard the vessel: stand alone system, all data stored locally on a PC - not dependent on access to Internet when in the High Arctic**

## CASRAS content

**76 datasets**

**230 GB**

**over 200,000 files**

CASRAS onboard a vessel in summer 2017



Courtesy Captain Fowler

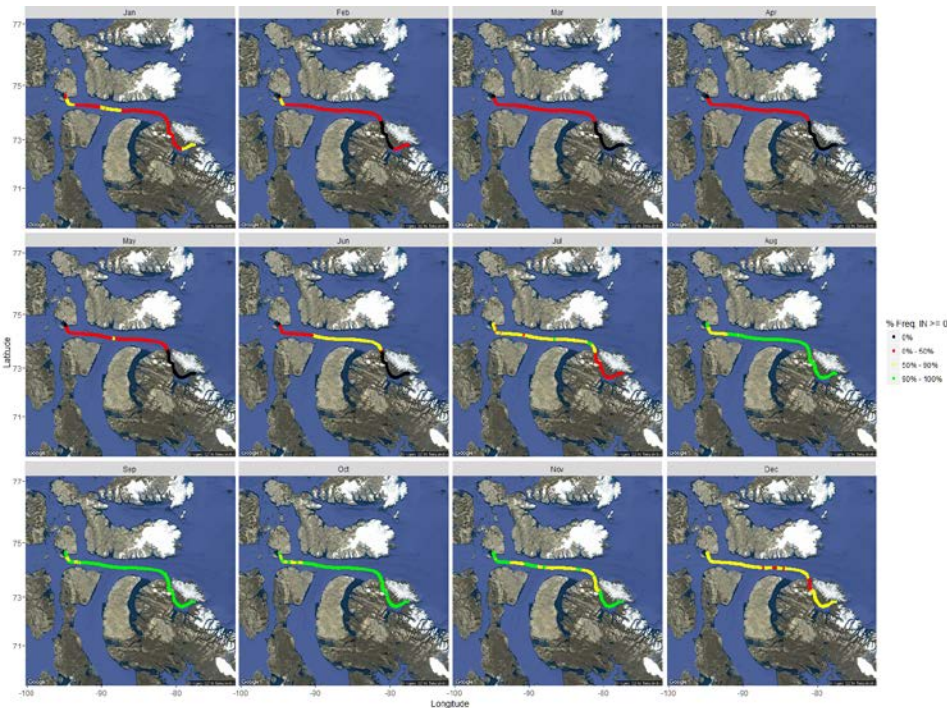
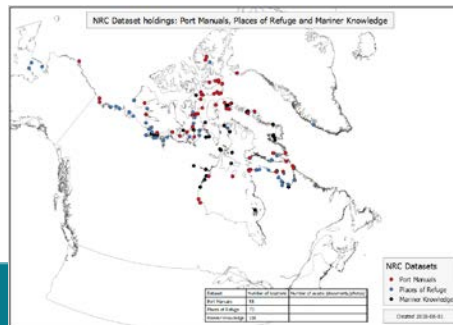


# CASRAS

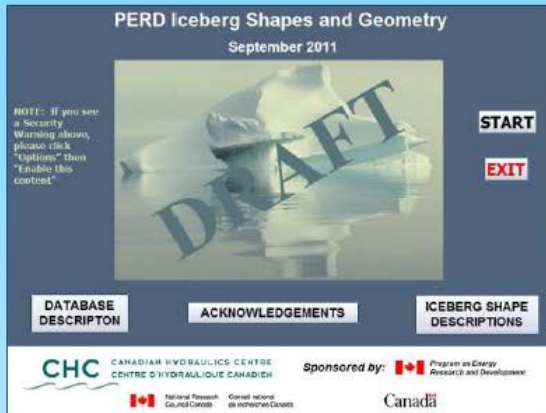
- CASRAS has been used and tested onboard CCG vessels and in the CCG ROC Ice Office in Montreal.
- CASRAS has been licensed to the Marine Institute as a training tool - Polar Code and Ice Navigation training program at the Centre for Marine Simulations

## Customizing CASRAS based on users' feedback:

- New functionalities will be implemented
- New reports designed and generated
- New data/datasets included
- The system can be integrated with other tools and systems (e.g. NRC Pressured Ice/ Pack Ice Drift Forecasting Model)



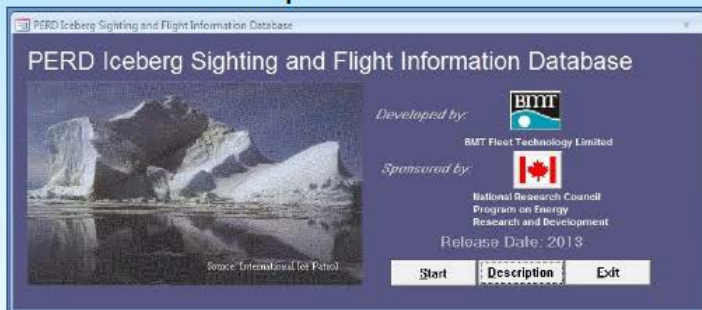
# Ice Databases



Iceberg  
Shapes



Iceberg Management



Iceberg Sightings

NRC-PERD Iceberg databases

**NRC-CNRC**



Marine Icing Database  
Pressured Ice Database  
Local ice Pressure Catalogue  
AIRSS and Ice Damage Db  
Beaufort Sea Engineering Db





# Ice dynamics and Iceberg Drift Modelling

- Iceberg Drift and Deterioration Model
- Pressured Ice and Pack Ice Drift Model
- Ice-Ship Interaction and Stationkeeping Model



Courtesy Dave Watson, NRC

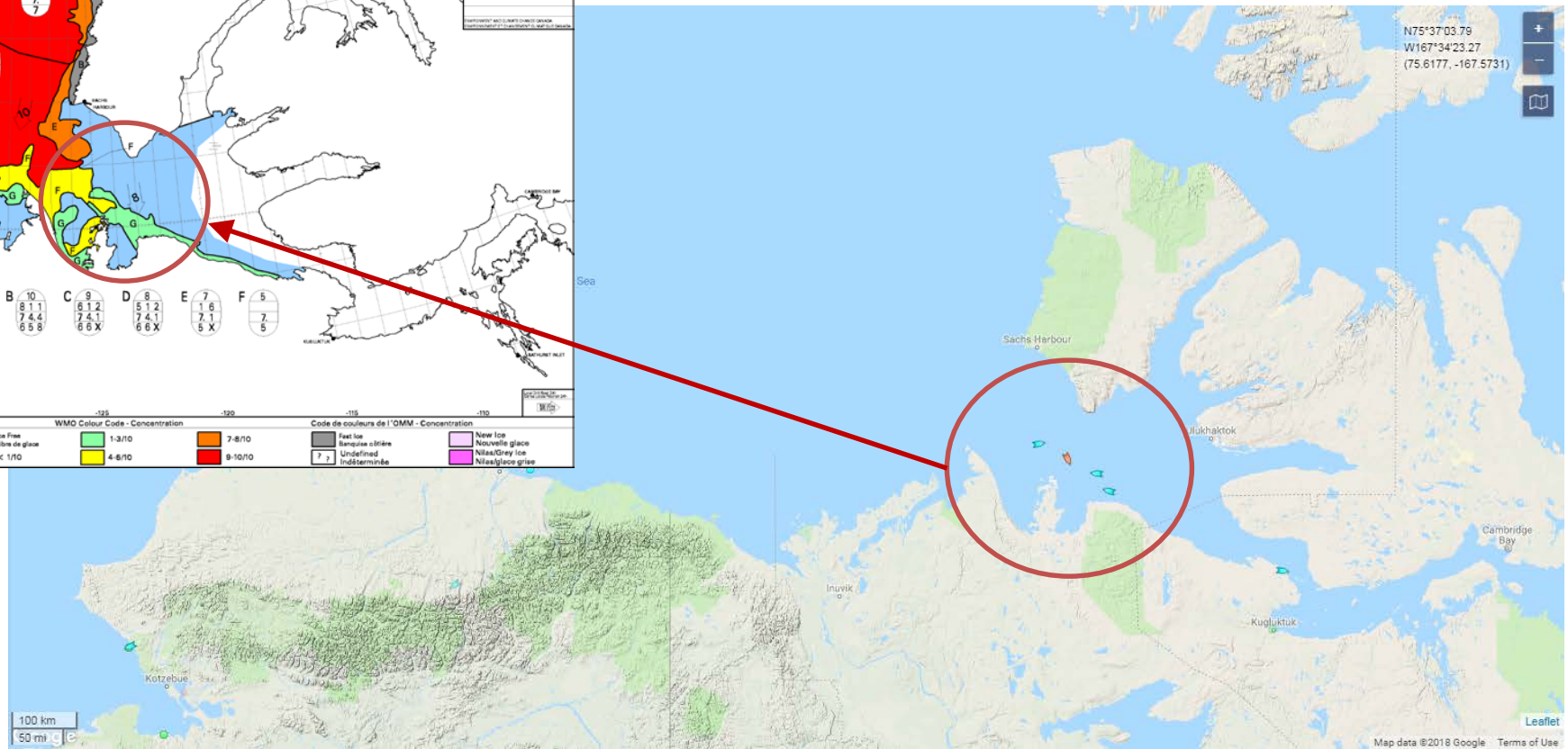
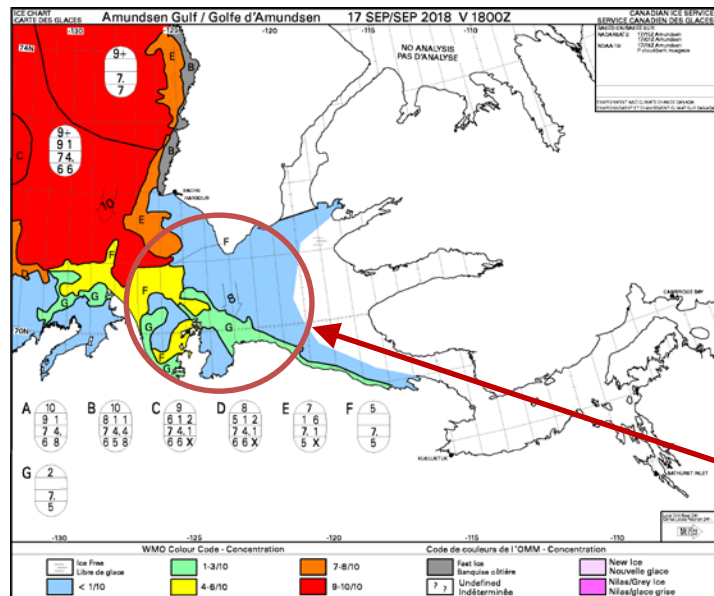


Courtesy Captain Broderick, CCG



Courtesy Dave Watson, NRC

# Severe ice conditions in the Amundsen Gulf



<https://www.marinetraffic.com/> (sept 18, 2018)



# Amundsen Gulf September/October 2018



© Environnement et Changement climatique Canada, Guillaume Paradis, 2018



© Environnement et Changement climatique Canada, Guillaume Paradis, 2018



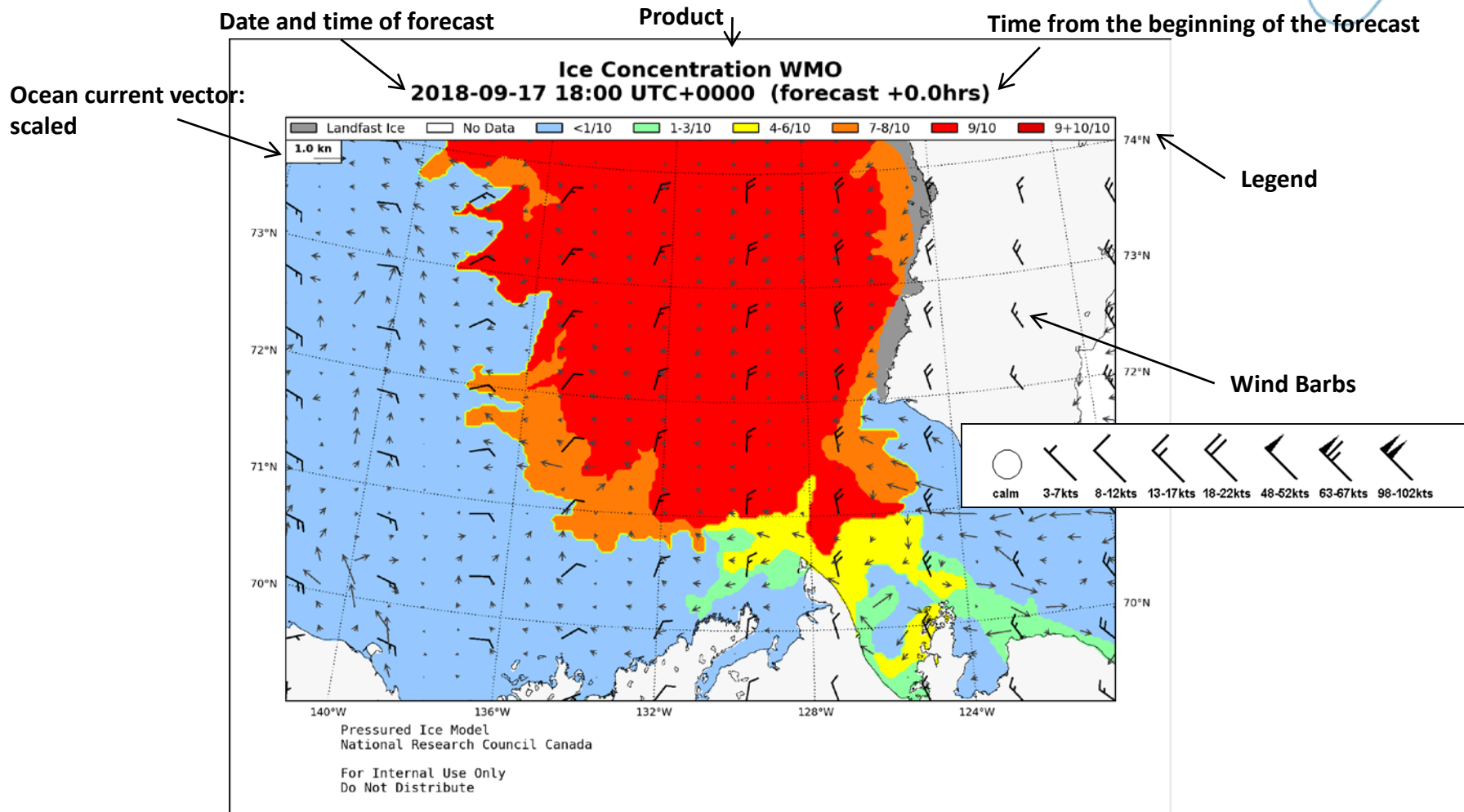
© Environnement et Changement climatique Canada, Guillaume Paradis, 2018



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# NRC Pressured Ice Model

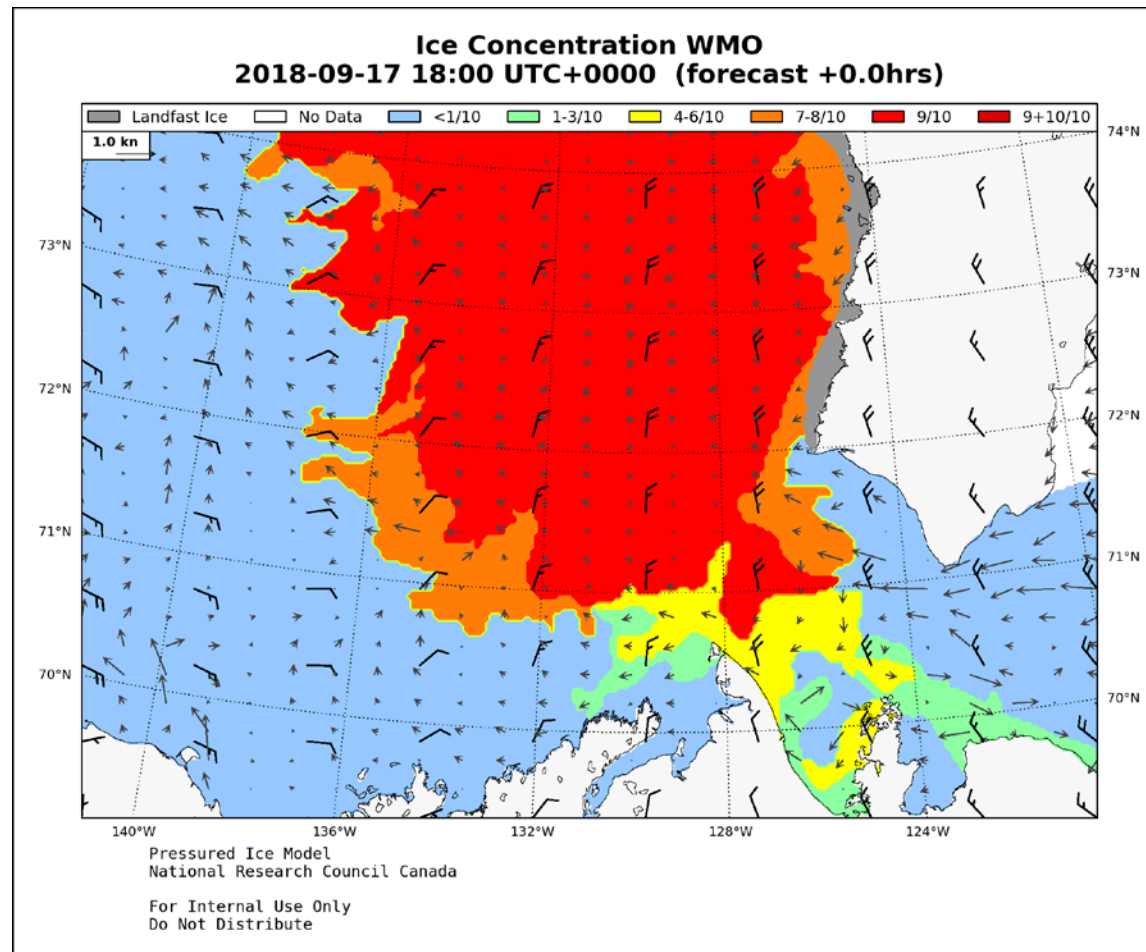
## Data Products Example





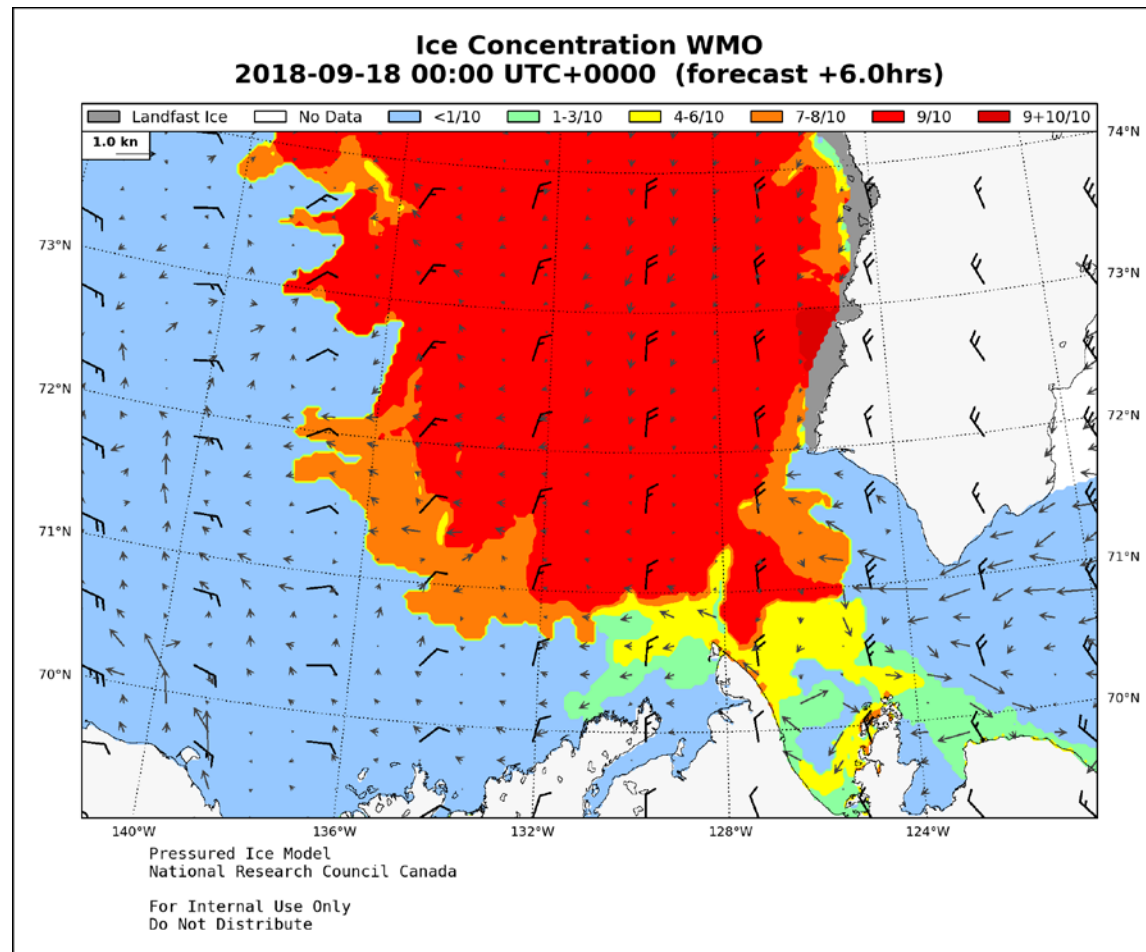
# Pressured Ice Model

## Data Products Example



# Pressured Ice Model

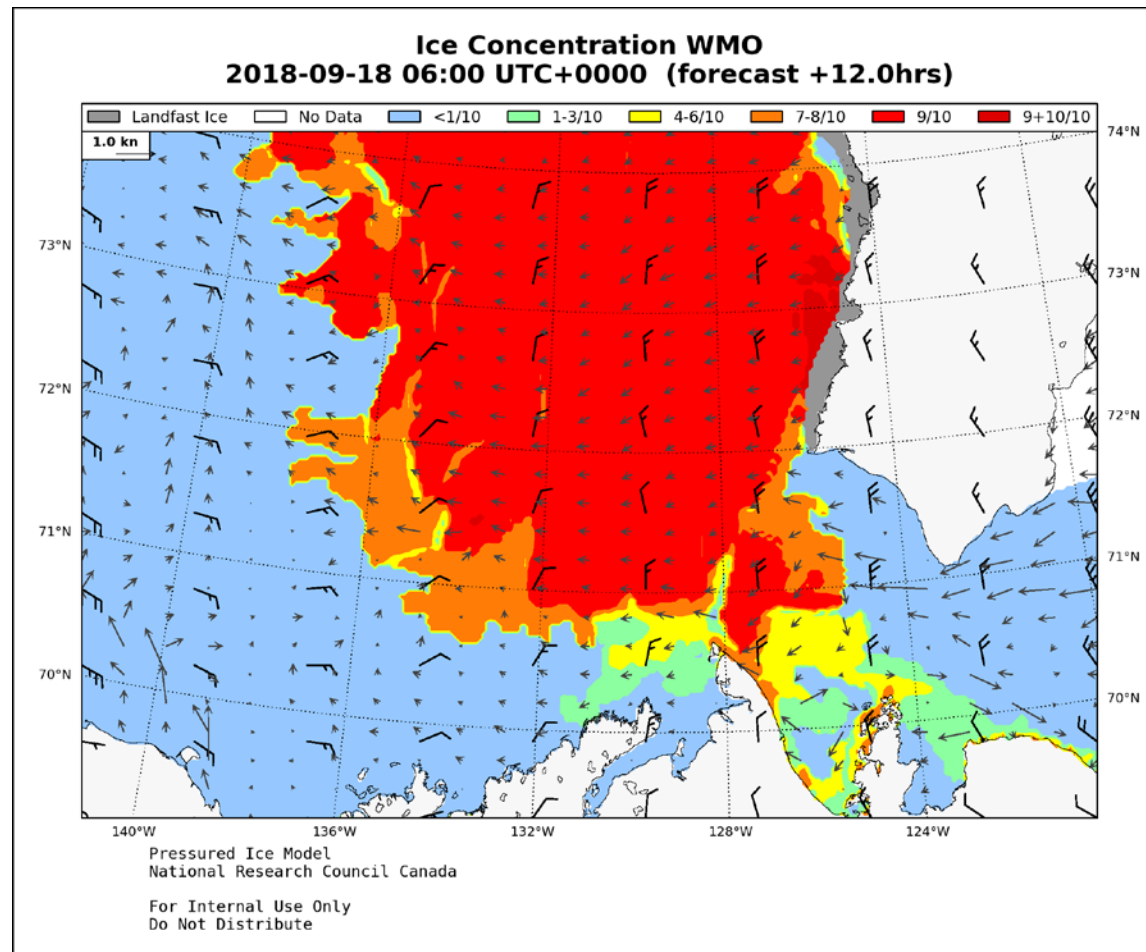
## Data Products Example





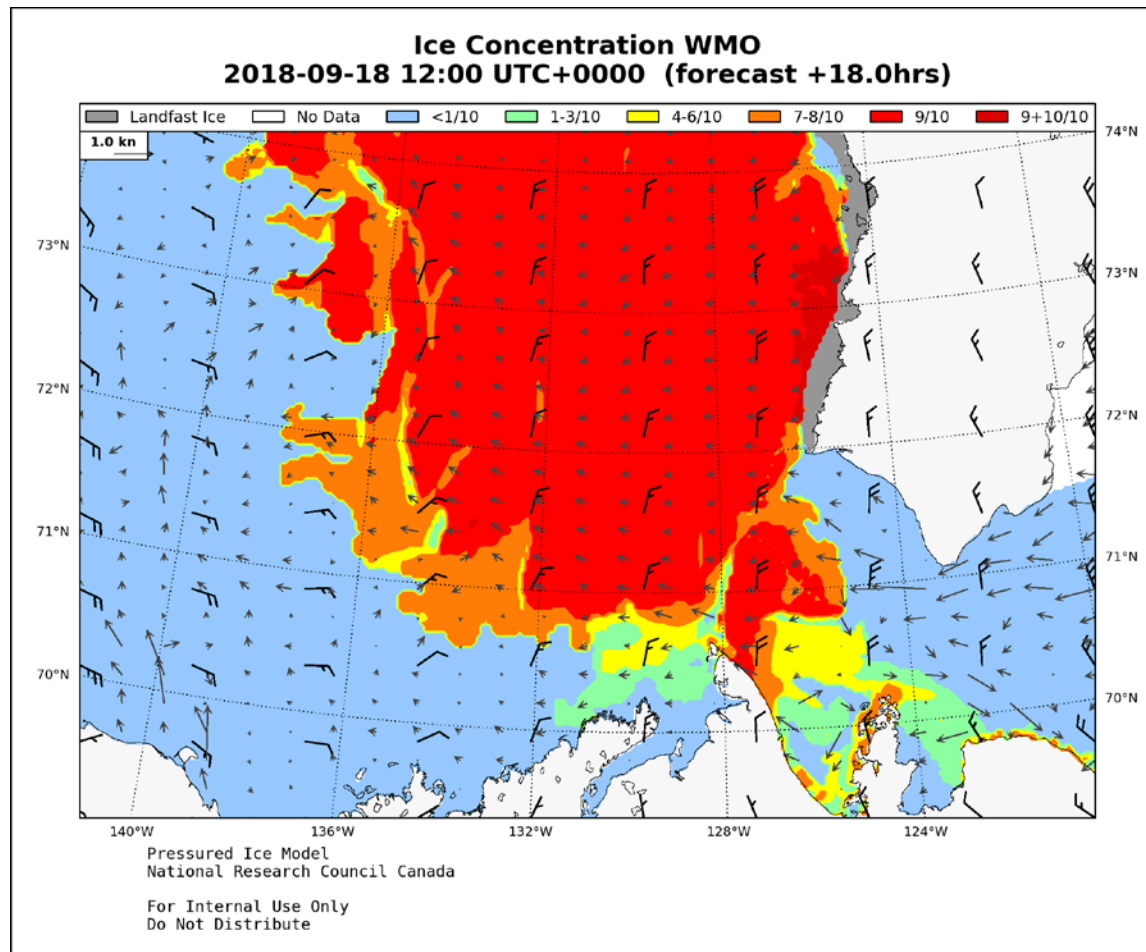
# Pressured Ice Model

## Data Products Example



# Pressured Ice Model

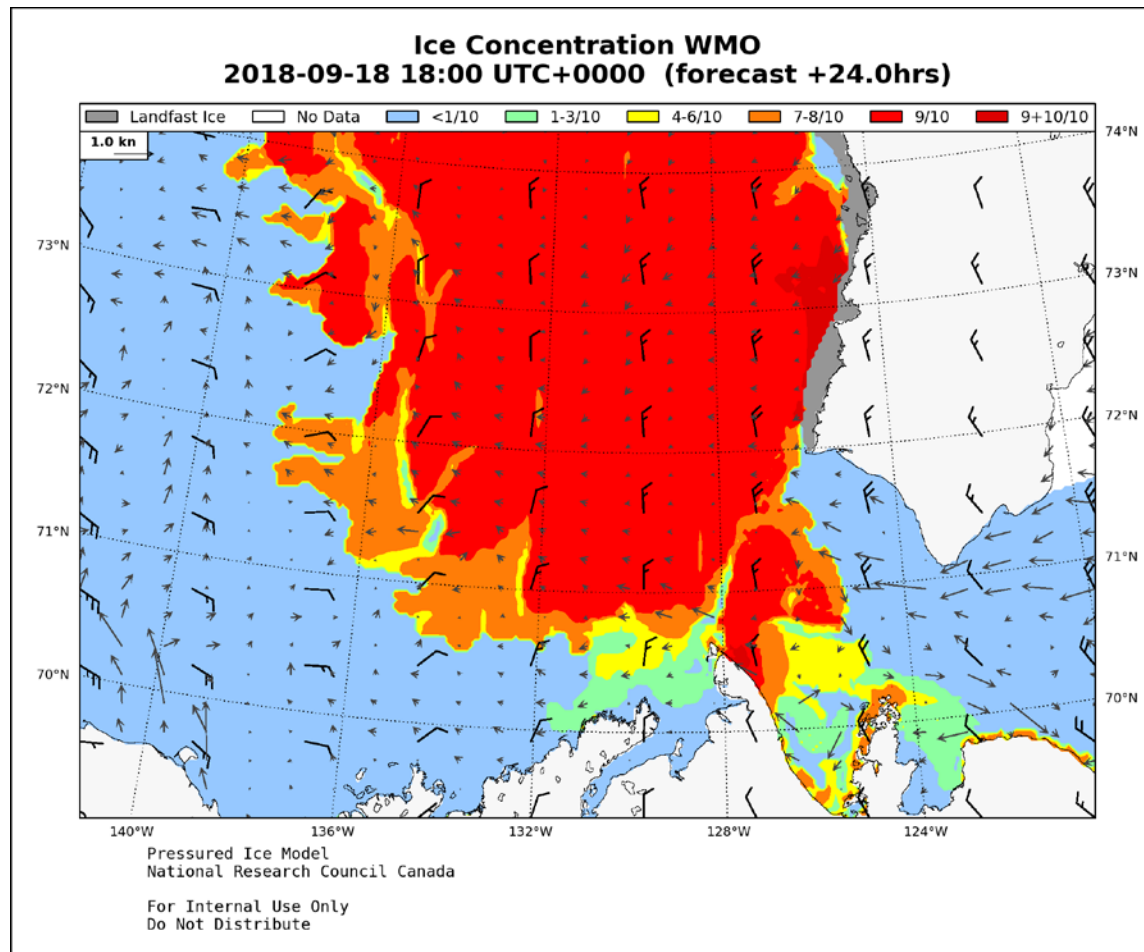
## Data Products Example





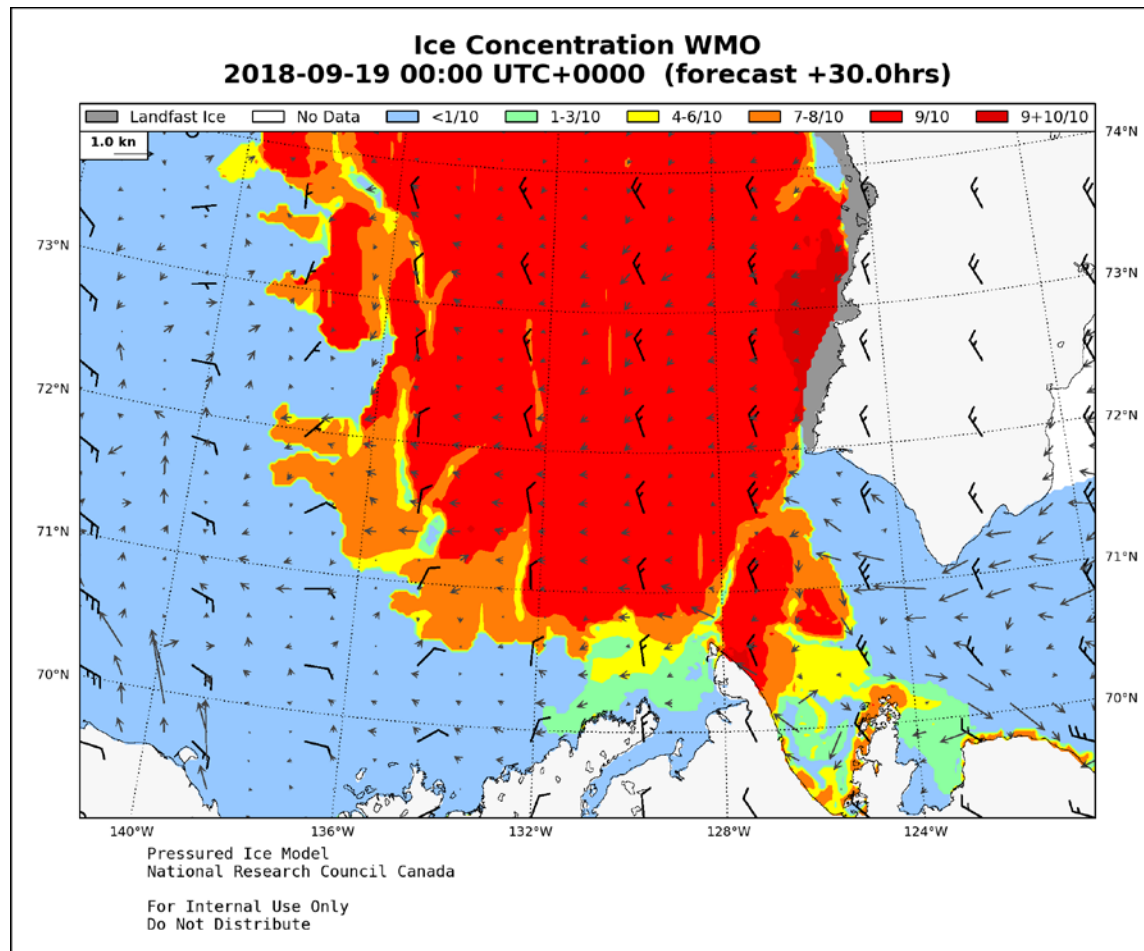
# Pressured Ice Model

## Data Products Example



# Pressured Ice Model

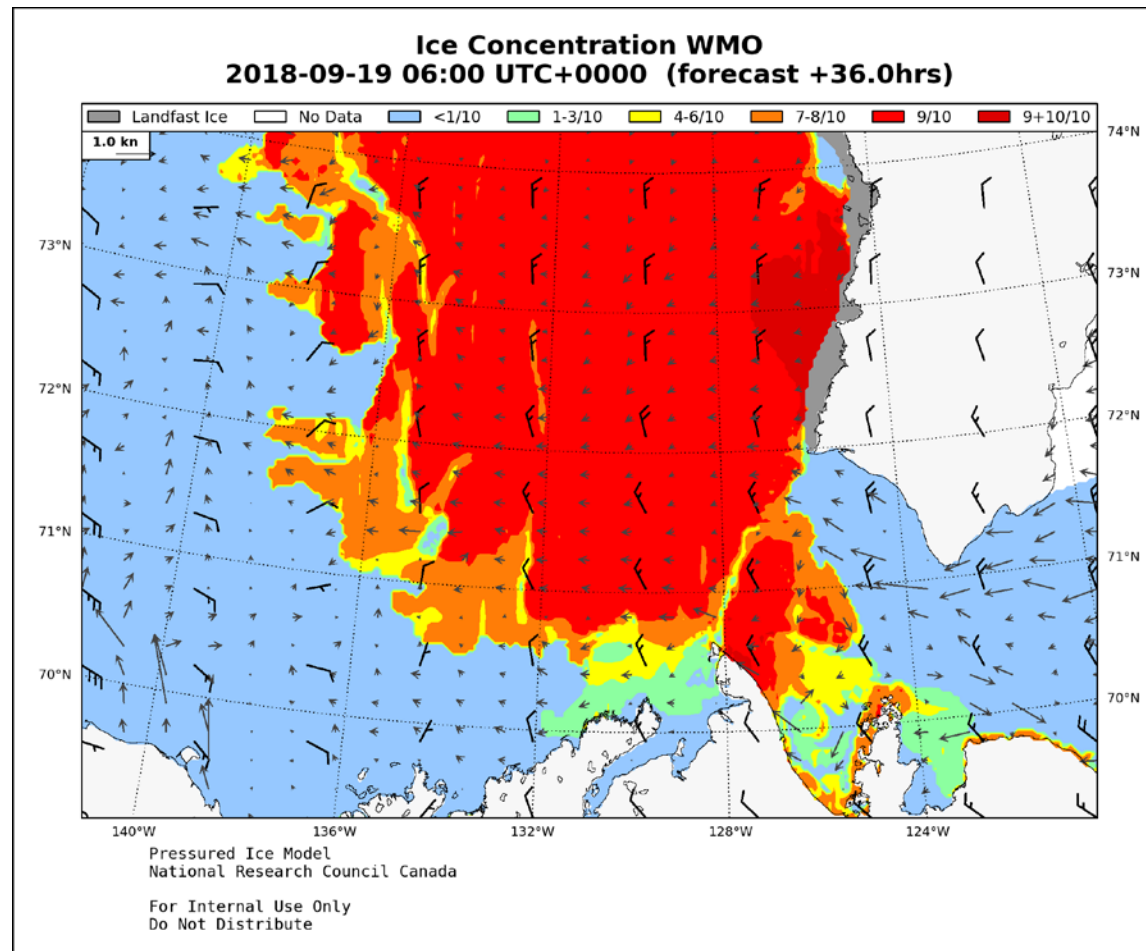
## Data Products Example





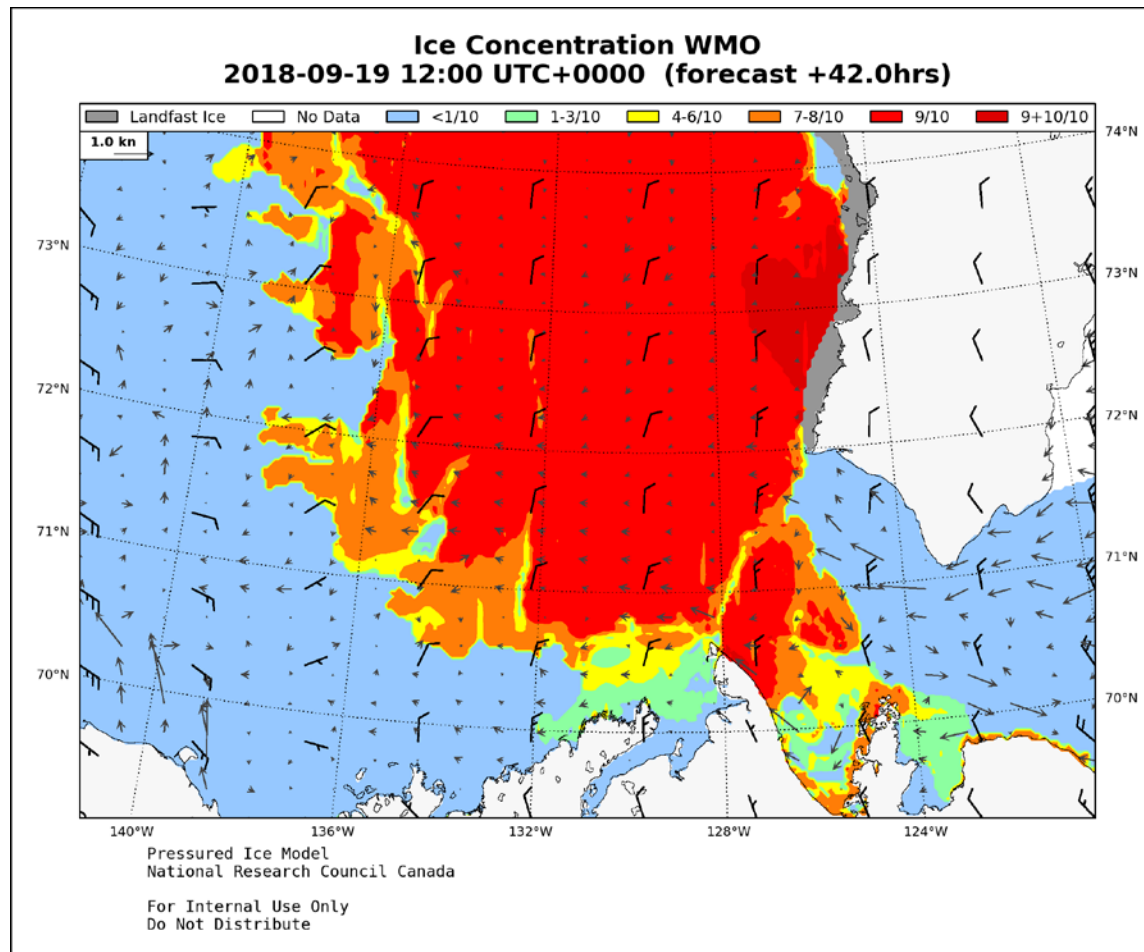
# Pressured Ice Model

## Data Products Example



# Pressured Ice Model

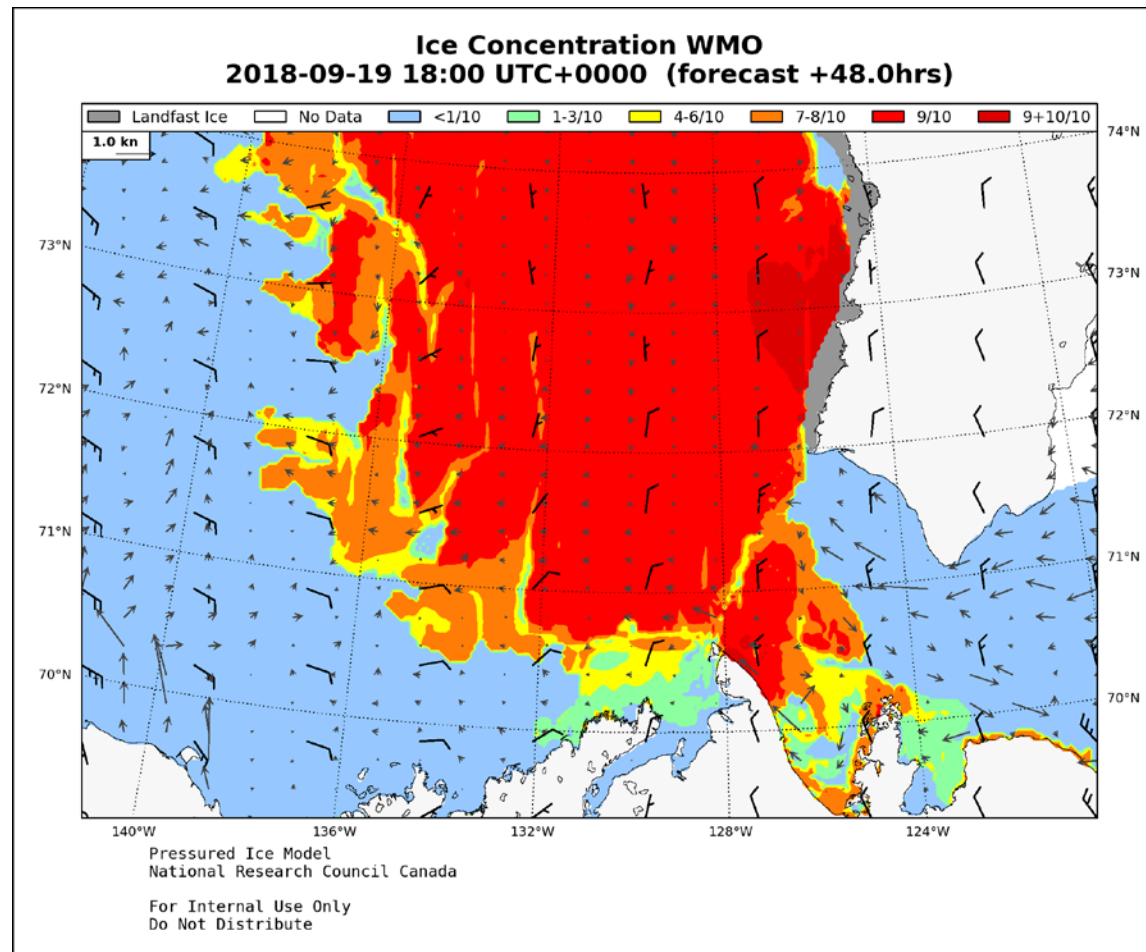
## Data Products Example





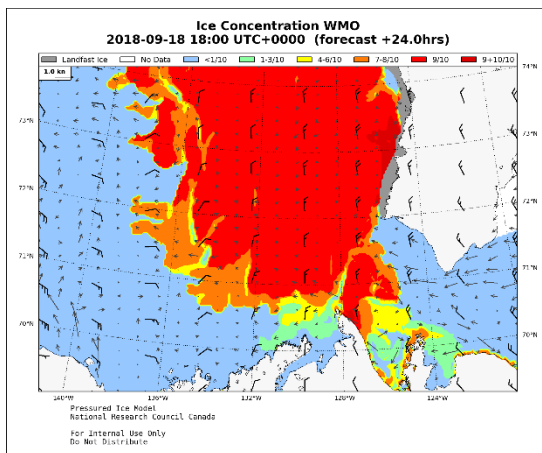
# Pressured Ice Model

## Data Products Example

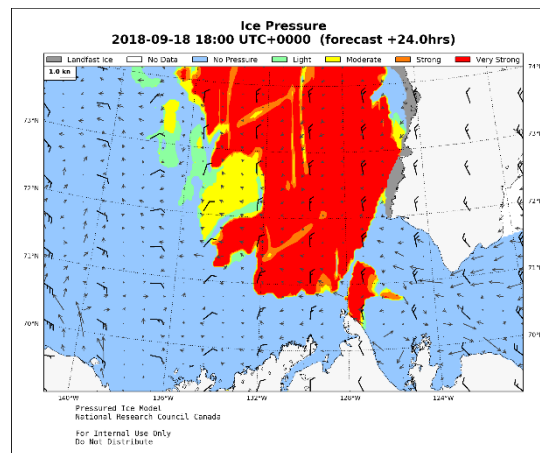


# Pressured Ice Model

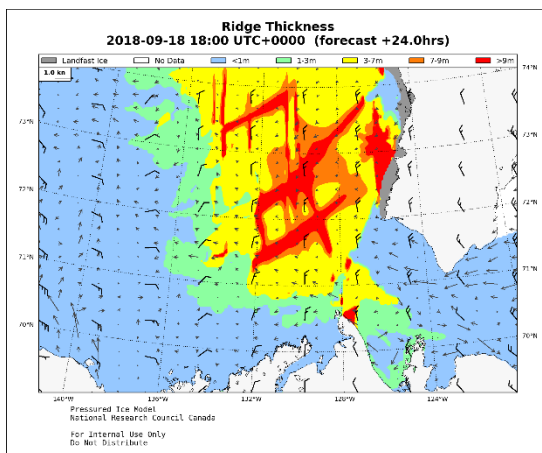
## Data Products – Ice Conditions



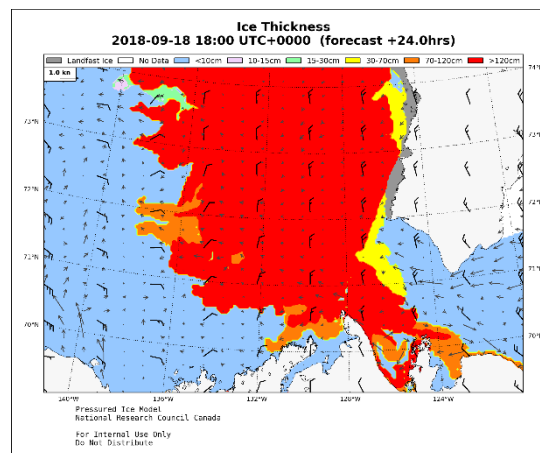
Ice Concentration



Ice Pressure



Ridge Thickness

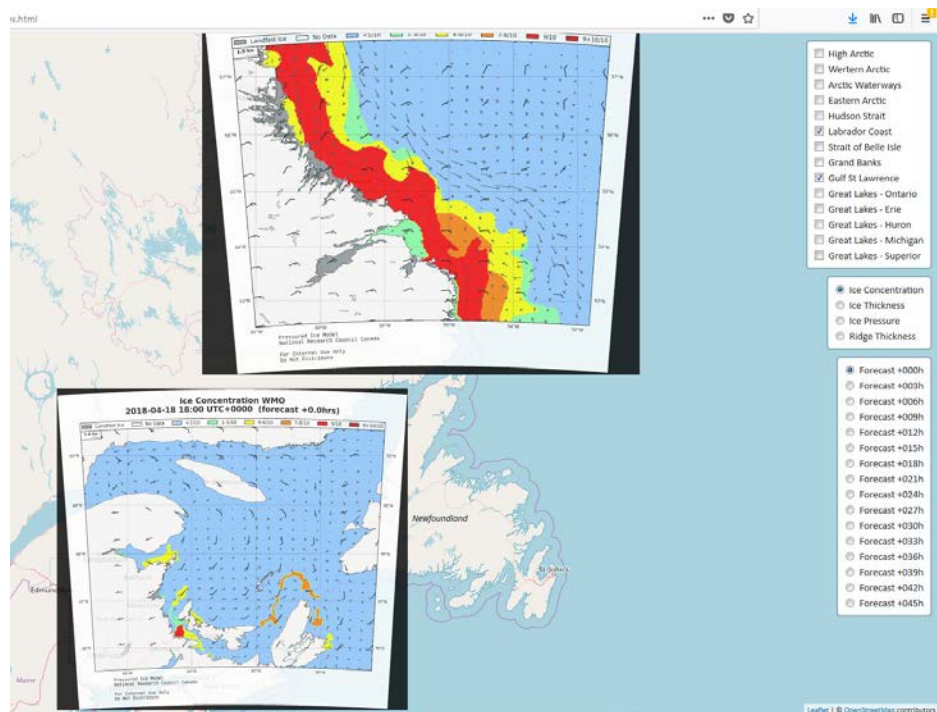


Ice Thickness

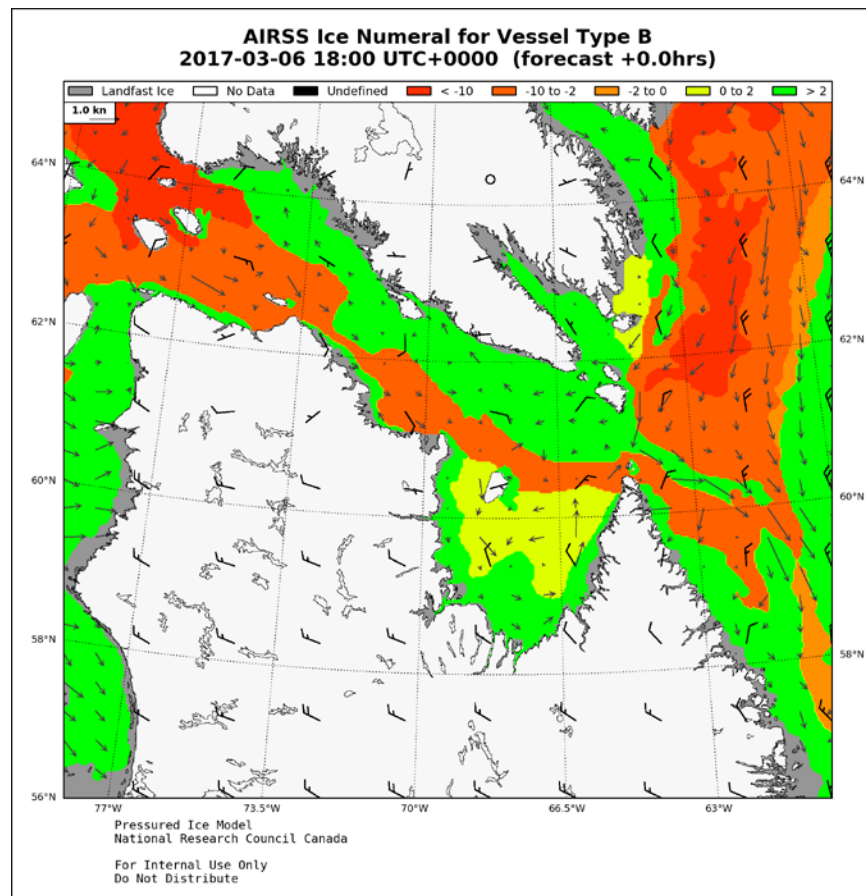


# NRC Pressured Ice Model updates

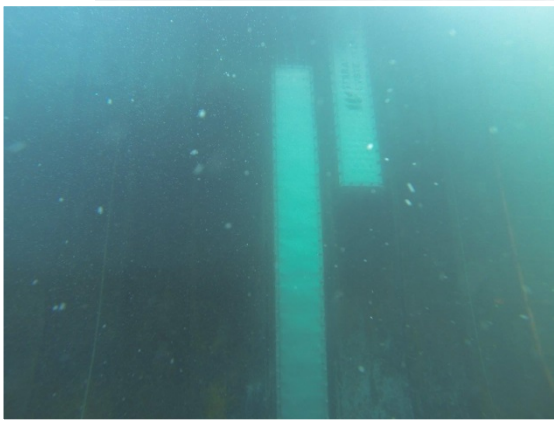
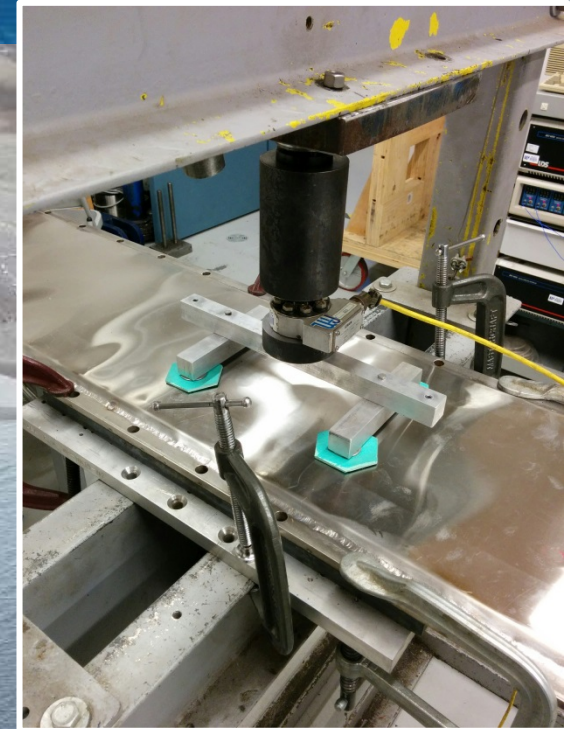
NRC Pressured Ice model maps  
accessible through the web interface



Ice Numeral calculation forecast



# Ice Load Monitoring – Nanisivik Wharf

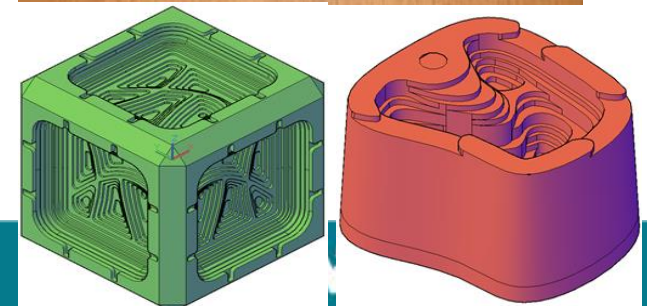
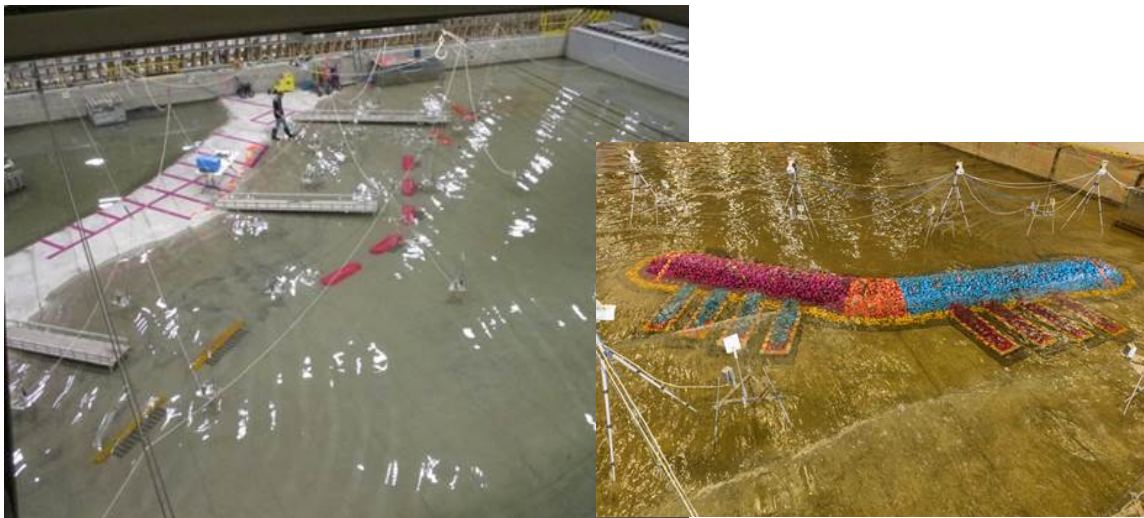


Courtesy of Defense Construction Canada



# Future work – examples

- Autonomous Vehicles (cold regions)
- Impact of noise
- Vessel Corrosion
- Coupling of hydrodynamics models with ice dynamics models
- Nature based defenses (nature based engineering)





# NRC climate change related work

- NRC is represented on the Northern Erosion Technical Subcommittee, which is developing a new CSA standard entitled “Erosion and Sedimentation Control for Northern Community Infrastructure”
- NRC is participating in an International Working Group (led by the US Army Corps of Engineers), which is developing new guidelines and a compendium of case studies to advise practitioners on how Natural and Nature-Based Features can be applied in the context of flood risk management
- NRC is developing a database of future storm surges and waves for the BC coast, which will be disseminated to transportation asset owners / operators (mainly ports) using a data visualization tool, to enable climate risk assessments and adaptation of infrastructure. The tool will be developed to be readily transferable to other coastal regions, such as the Arctic
- NRC is leading the development of new national guidelines for conducting coastal flood risk assessments to support design and rehabilitation of buildings and infrastructure. This includes input from Standards Council of Canada (which leads the Northern Infrastructure Standardization Initiative) and the Government of Nunavut

# Contact

**Ivana Kubat**

A/Director Research and Development, OCRE  
ivana.kubat@nrc-cnrc.gc.ca  
613-993-7695

**Allison Kennedy**

Research Officer  
Allison.Kennedy@nrc-cnrc.gc.ca  
709-772-8398

**Dr. Jon Power**

Research Council Officer  
Jonathan.Power@nrc-cnrc.gc.ca  
709-772-8430

**Dr. John Wang**

Research Officer  
Jungyong.Wang@nrc-cnrc.gc.ca  
709-772-0223



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