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Natural attenuation potential for petroleum hydrocarbons at sub-zero temperatures in the Canadian Arctic marine environment

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National Research Council Canada, Energy, Mining and Environment;
Fisheries and Oceans Canada.

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Fisheries and Oceans Canada | Pêches et Océans Canada
National Research Council Canada | Conseil national de recherches Canada
McGill
CSIRO
Canada

NRC Arctic Program

OBJECTIVE

Ensure sustainable, low-impact development of the North while increasing the quality of life for Northerners

Value proposition:

- Reducing the uncertainty in ice loads by 40%
- Reduce vessel structural damage by 50%
- Increase survivability in lifeboats (baseline: 24 hours) to a target of five days
- Increased performance of immersion suits (baseline: minimum of six hours) to a target of twelve hours
- Increase the lifetime of northern housing and infrastructure by 50%

R&D Activities

Resource Development

- Ice loads on offshore structures
- Oil spill detection, forecasting and bioremediation
- Engineering datasets for offshore regulators and industry
- Ice characterization for design

Northern Transportation

- Shipping risk assessment system
- Pack ice forecasting for operations
- Ice- and winter-roads under climate change conditions

Marine Safety

- Next generation personal protective equipment
- Next generation life-saving appliances
- Operations to support evacuation and rescue

Community Infrastructure

- Northern building standards
- Water and wastewater technologies
- Building envelope, lighting and energy efficiency
- Foundations in permafrost
- In-situ bioremediation

To find out more

www.nrc.gc.ca

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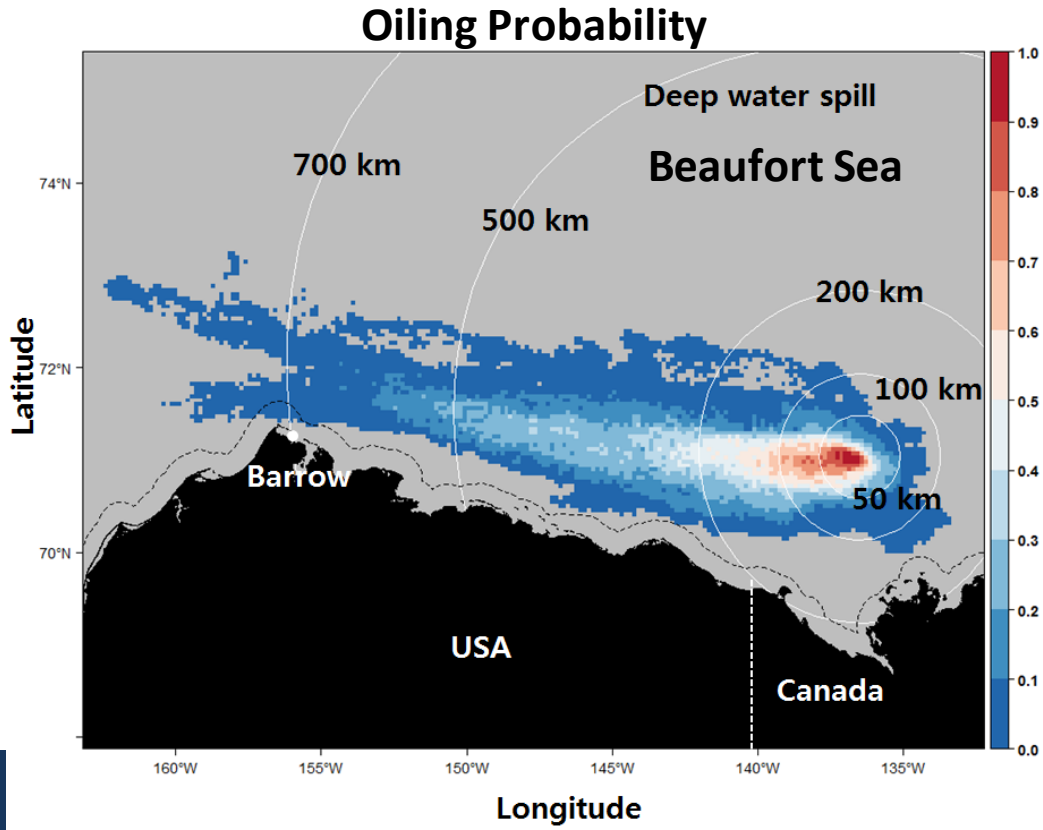
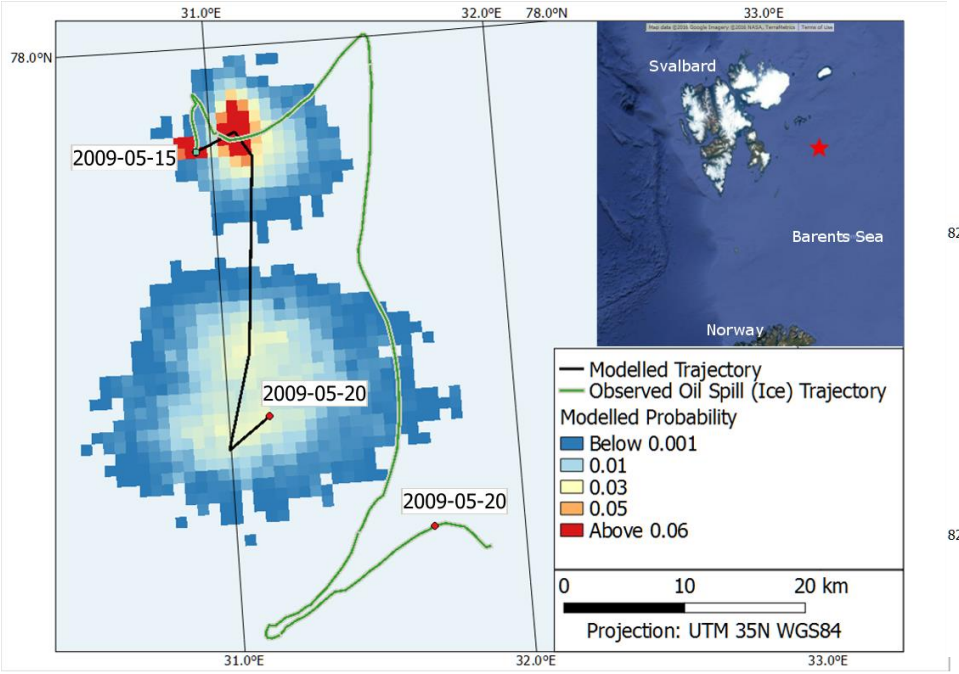
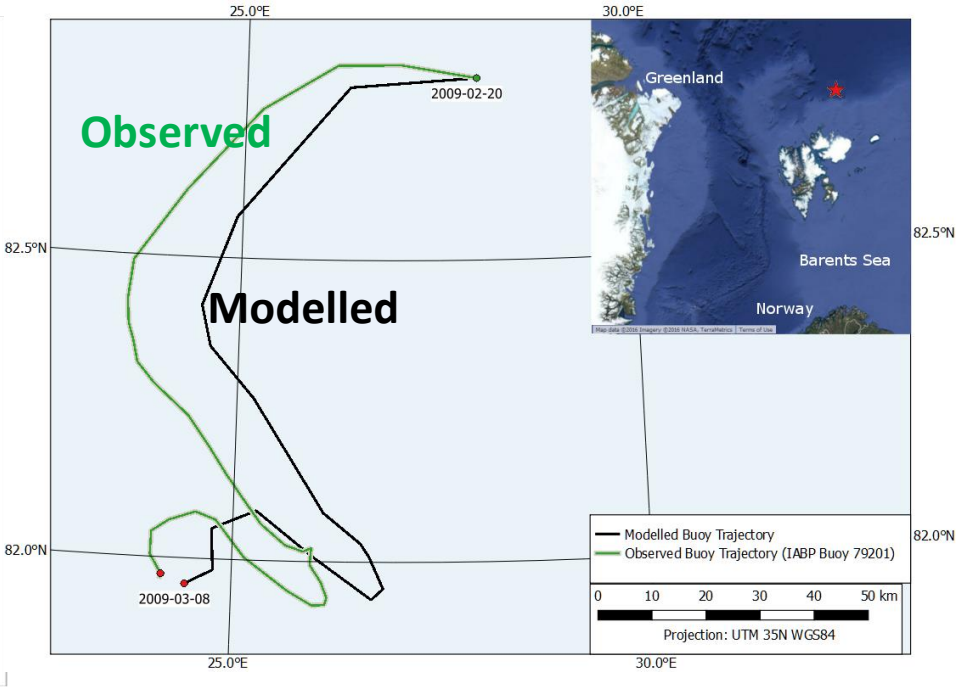
A validated and verified in-ice oil spill trajectory model, analysis and visualization tool based on satellite-derived ice drift datasets

- An in-house computer tool for the trajectory of oil spills in high ice concentrations
- Compatible with any gridded ice drift dataset produced computationally or based on satellite-derived information



Can run in both deterministic and probabilistic (based on the Monte-Carlo method) modes to estimate spill trajectory, residence time, coastline oiling probability, etc.

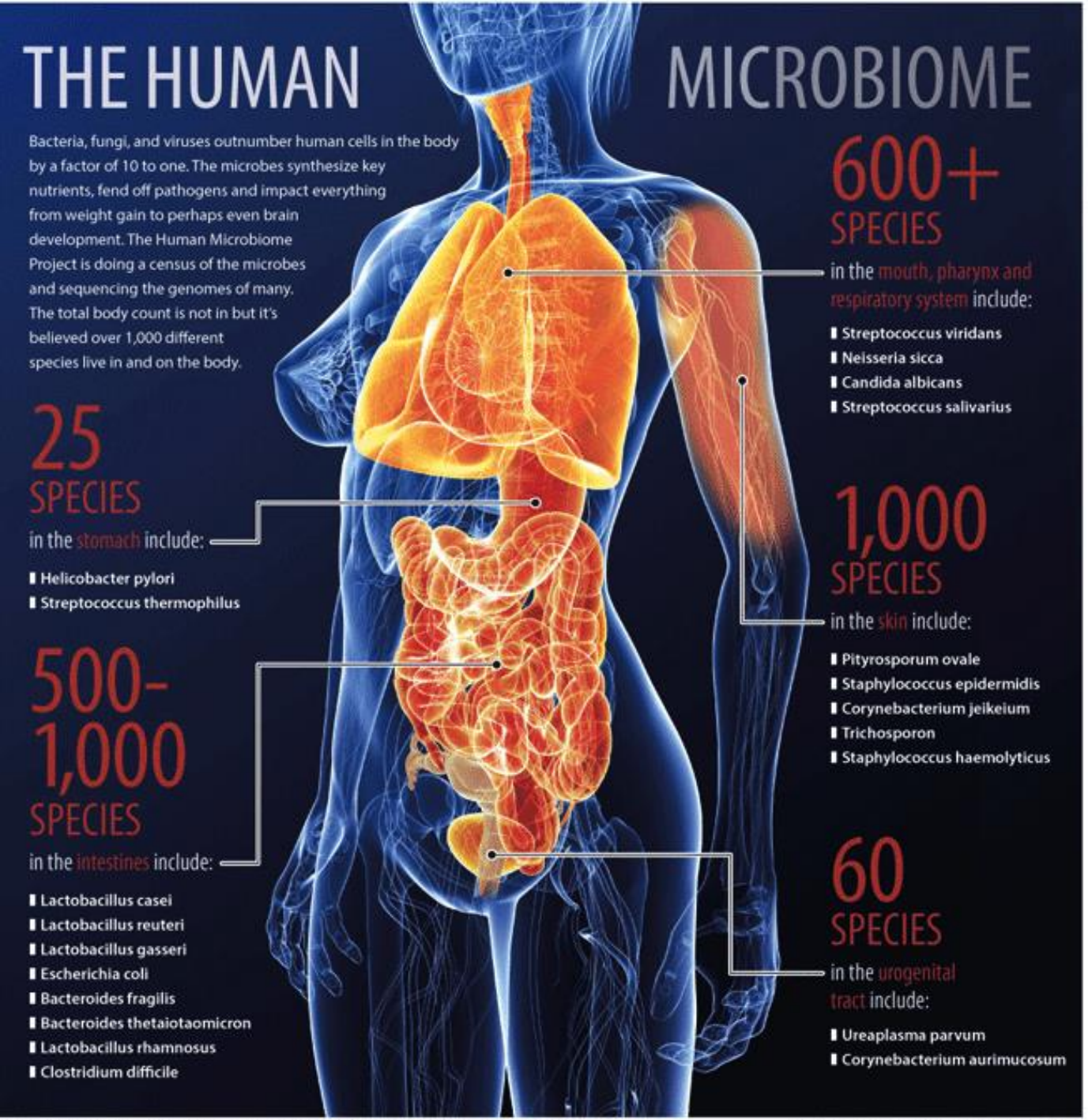




Validated with real-life in-ice oil spill trajectory in Barents Sea and verified with in-ice buoy trajectories in the Arctic Ocean and Beaufort Sea

For more information, contact: Hossein.Babaei@nrc-cnrc.gc.ca

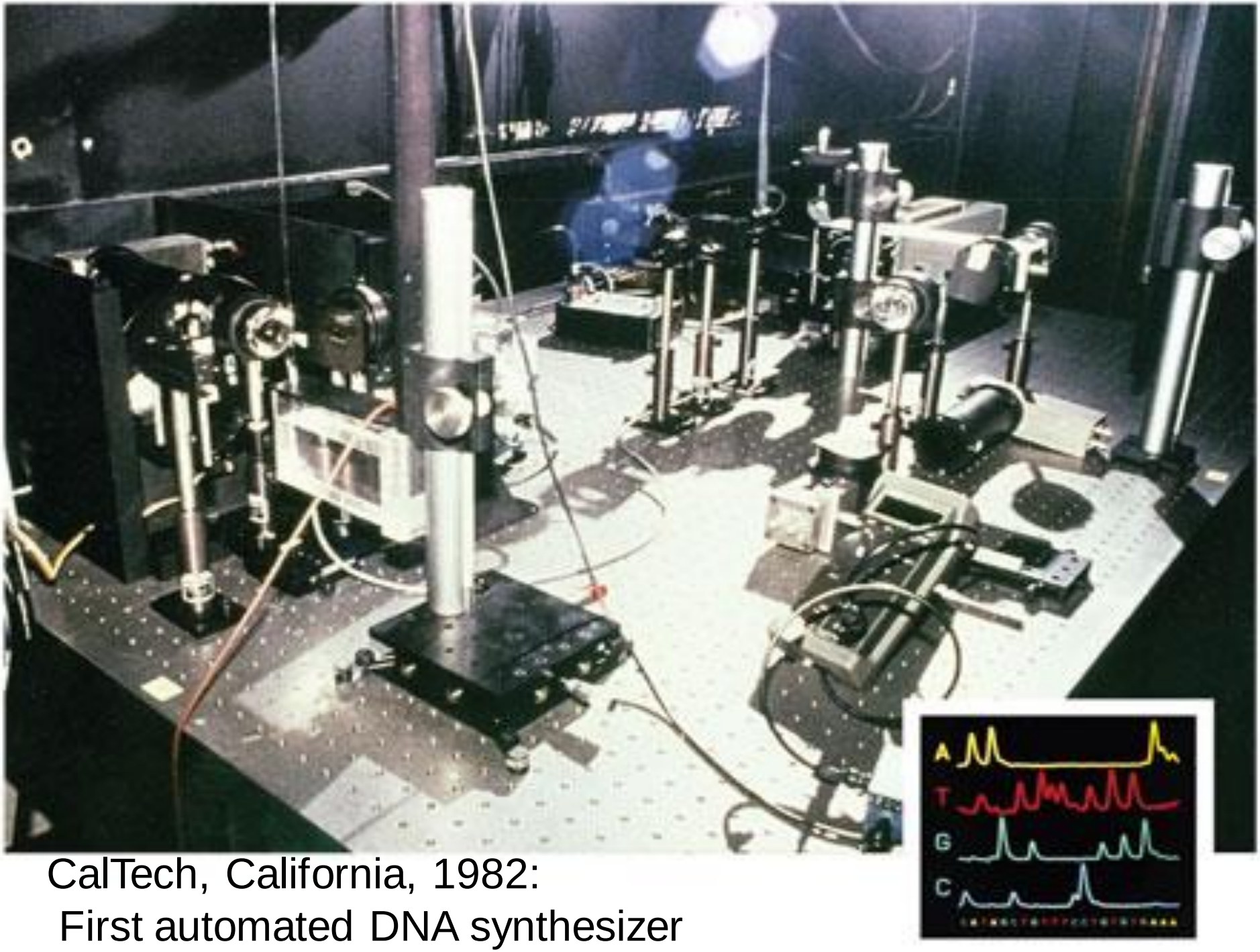
The Role of Microbiomes



Adult cells outnumbered 10:1

Microbial cells play important role in:

digestion,
disease/health
immunity,
obesity,
vitamin synthesis,
etc.

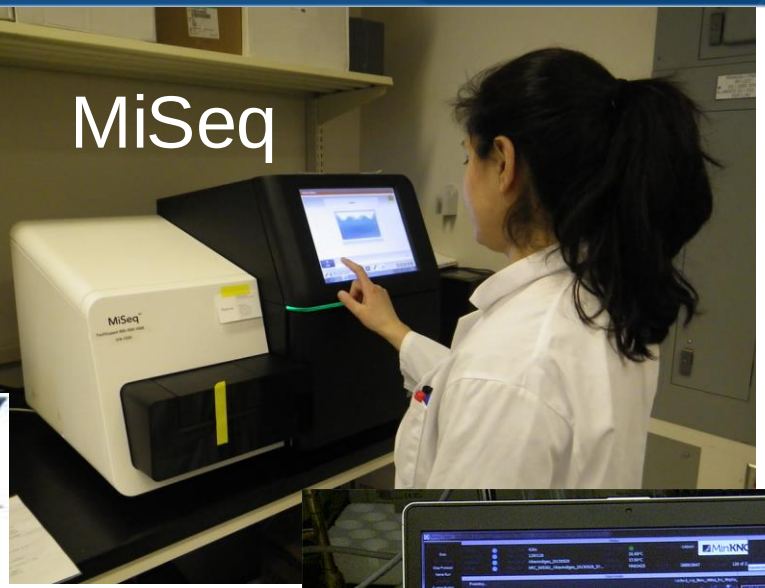


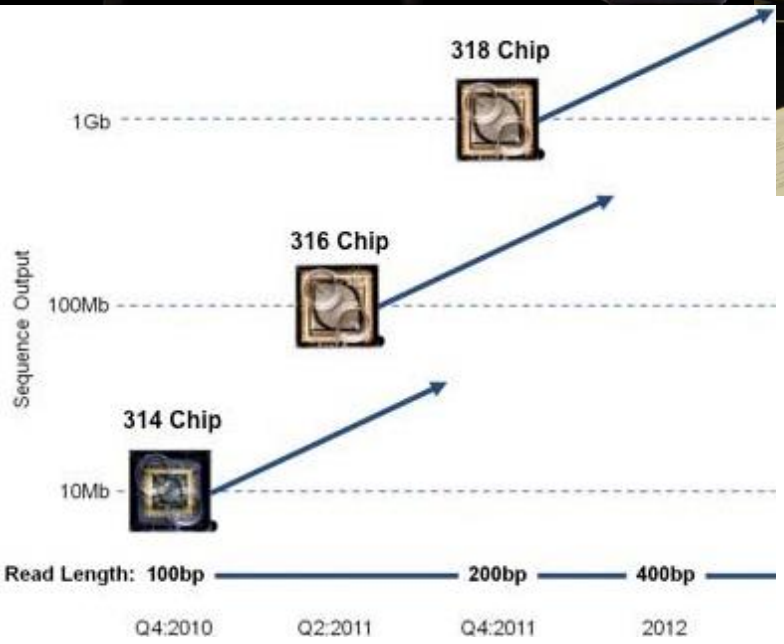
CalTech, California, 1982:
First automated DNA synthesizer

Human Genome Project

Next-Generation Sequencing Platforms

Ion Torrent - PGM





What's next!

MinION

What can sequence data tell us?

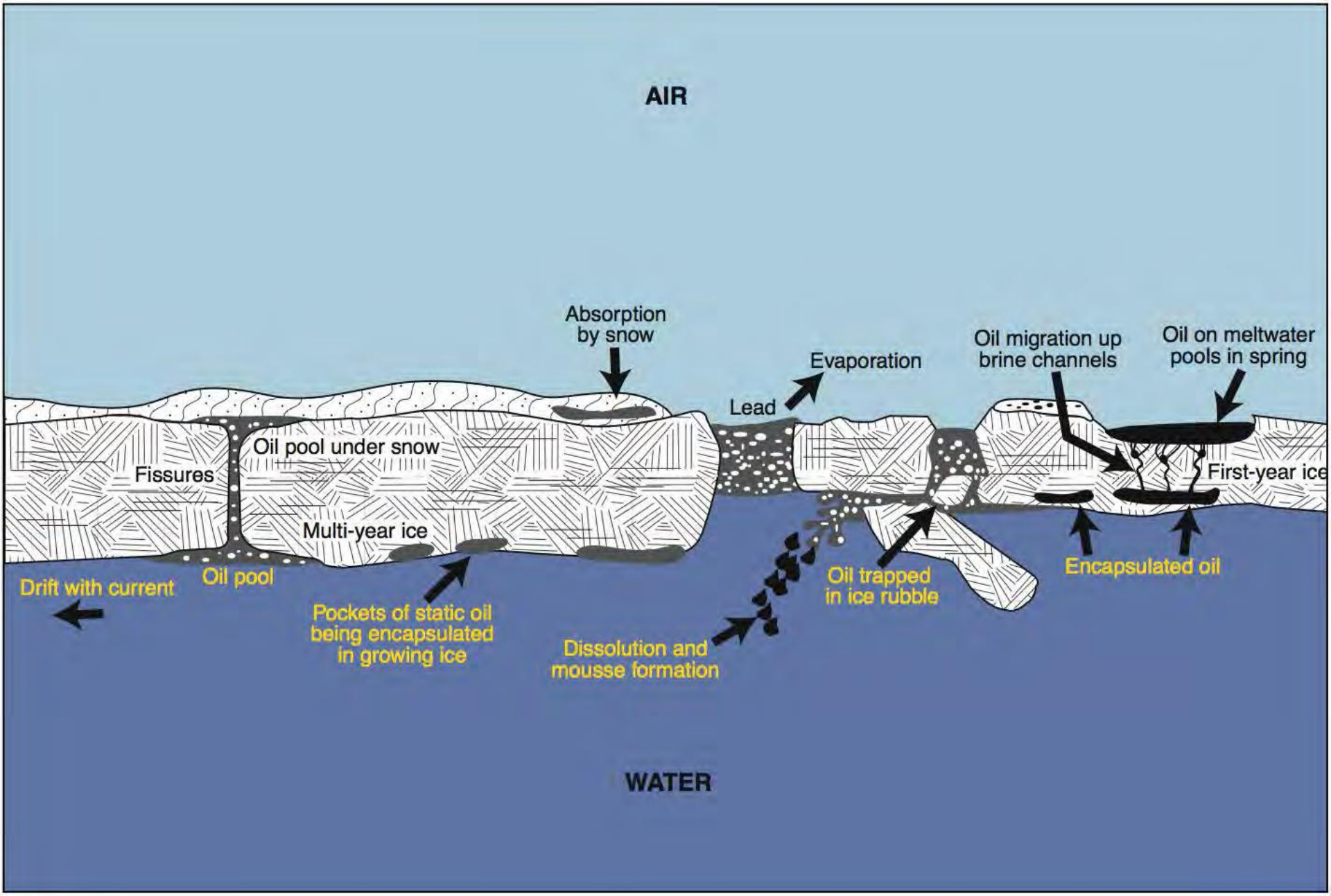
- In depth characterization of microbial diversity
  (who's present and how many)

- Profiling dynamics in microbial diversity due to change (e.g. time, distance, stress, stimulation)
  (how populations and individuals respond to change)

- Monitoring gene expression in response to change
  (how activities/functions of populations and individuals respond to change, who's responsible)

Overall Objectives

- Perform a comprehensive sampling campaign of Canada's marine environments including sea ice and underlying seawater in various Arctic areas (e.g. Resolute, Alert)
- Perform a baseline genomics characterization of the structural and functional diversity of microbial communities in marine environments
- Perform microcosm and mesocosm studies under ambient conditions to examine the effects of oil and dispersant on the ability of microbial communities to degrade oil
- Determine the potential for natural attenuation of oil under ambient conditions, including Arctic conditions, and identify parameters that could improve performance.

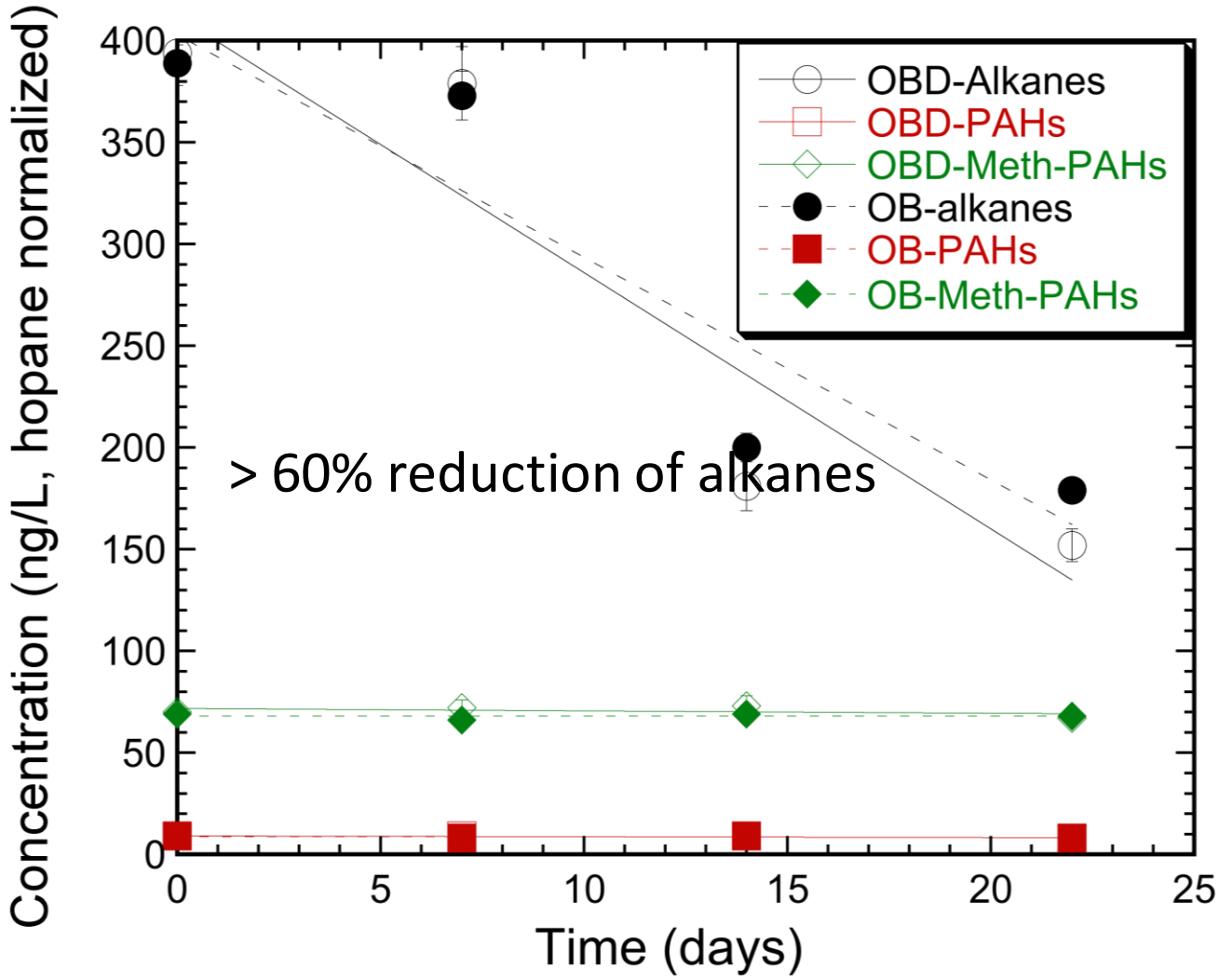


from Allen, A. 2008. In *Alaska Forum on the Environment, Anchorage, Alaska*. February, 2008

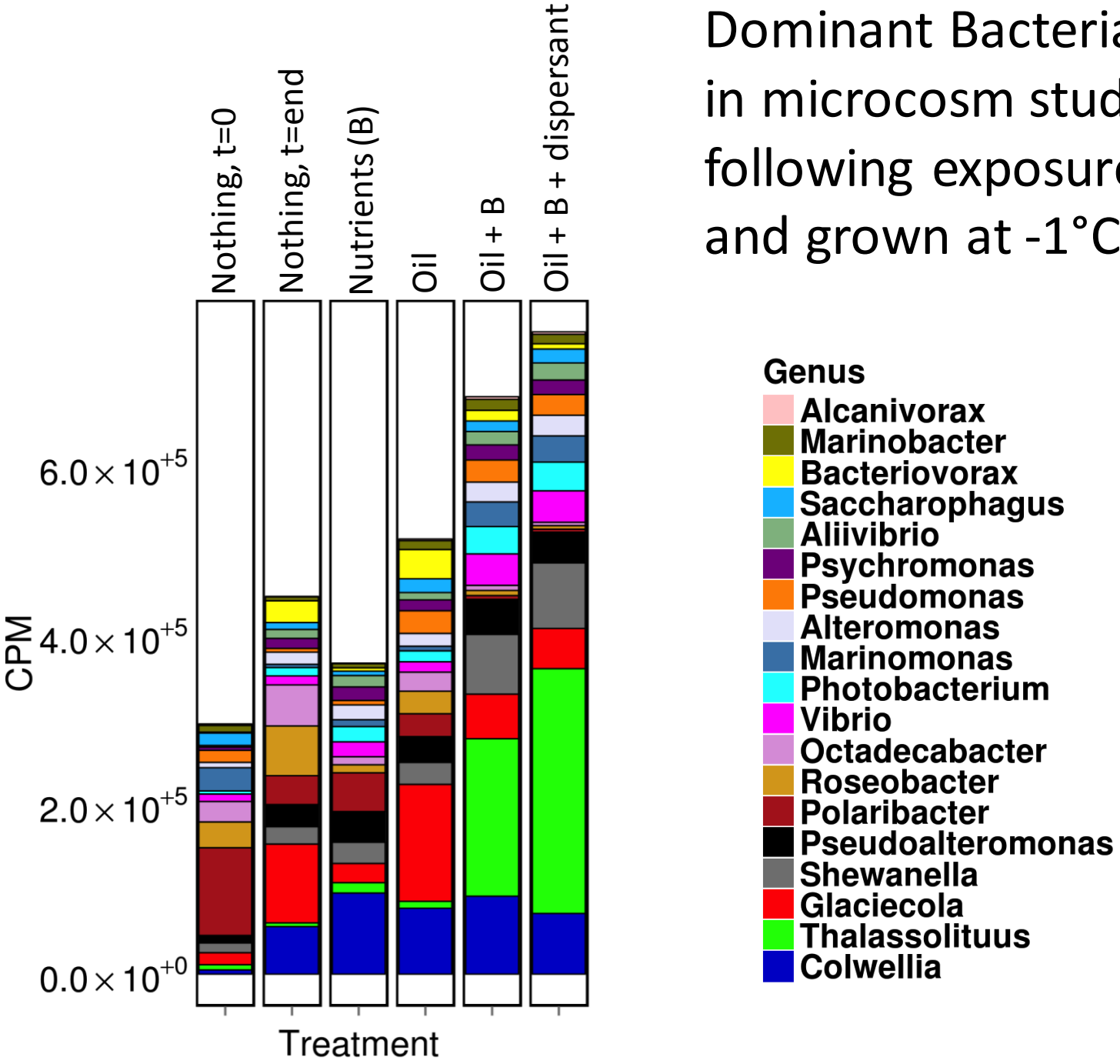
Natural Bacterial Communities in North American Oceans: Oil-degrading Potential

Mesocosm Chamber

Oil Degradation in Microcosms at -1°C: Fall seawater from Resolute in 2014



Dominant Bacterial Genera in microcosm studies following exposure to oil and grown at -1°C




Alteromonadales
Colwellia
Marinobacter
Oceanospirillales
Oleispira
Thalassolituus
Flavobacteriales
Polaribacter
Arctic Ocean
Baffin Bay
Northwestern Passages
Greenland
Hudson Bay
Canada
United States
Mexico
Gulf of Mexico
North Atlantic Ocean
Alteromonadales
Marinobacter
Oceanospirillales
Alcanivorax
Thalassolituus
Flavobacteriales
Alteromonadales
Marinobacter
Oceanospirillales
Alcanivorax
Thalassolituus
Oleispira
Oceanospirillales
Alteromonadales

Summary

- Advances in technology, especially DNA sequencing, is enabling a better understanding of the importance, the complexity and the role of microorganisms in many ecosystem processes. With this knowledge comes the opportunity to adjust natural systems to perform more effectively towards beneficial outcomes.

- Microbial communities throughout Canada's oceans have well known hydrocarbon-degrading bacterial species that are initially present at low levels, but respond positively to the presence of oil.

- Petroleum hydrocarbon degradation was quite rapid at in situ temperatures, even at ≤ -1°C, especially for saturates (half-life in days to a few weeks).

- Determining factors that can optimize degradation activity will contribute to the development of more effective oil spill remediation strategies, including under ambient Arctic conditions.

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