



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

Recent multi-year ice loss in the Northwest Passage: a cautionary tale for future navigation

Stephen Howell¹, David Babb², Jack Landy³, & Mike Brady¹

¹Climate Research Division, Environment and Climate Change Canada, Toronto, Canada

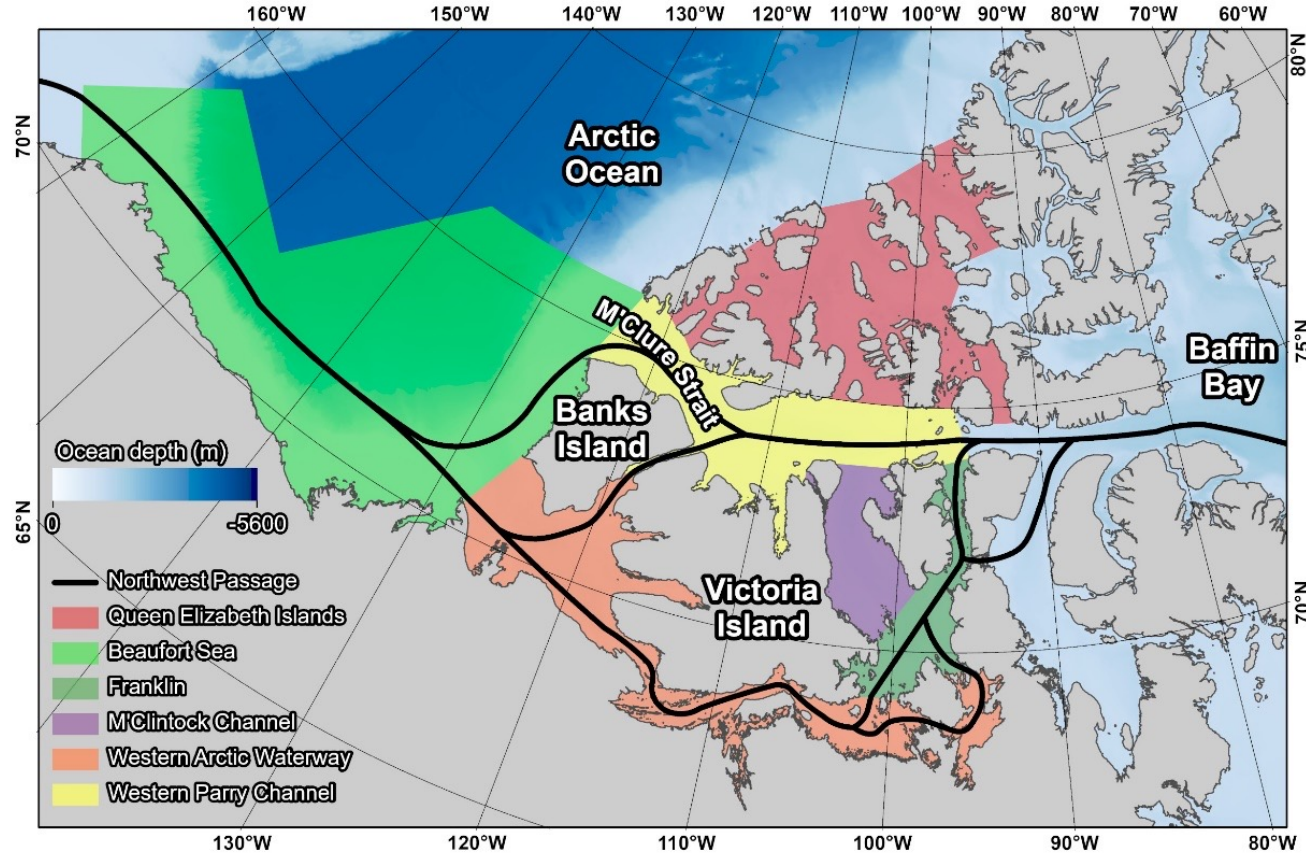
²Centre for Earth Observation Science, University of Manitoba, Winnipeg, Canada

³Department of Physics and Technology, The Arctic University of Norway, Tromsø, Norway



Canada 

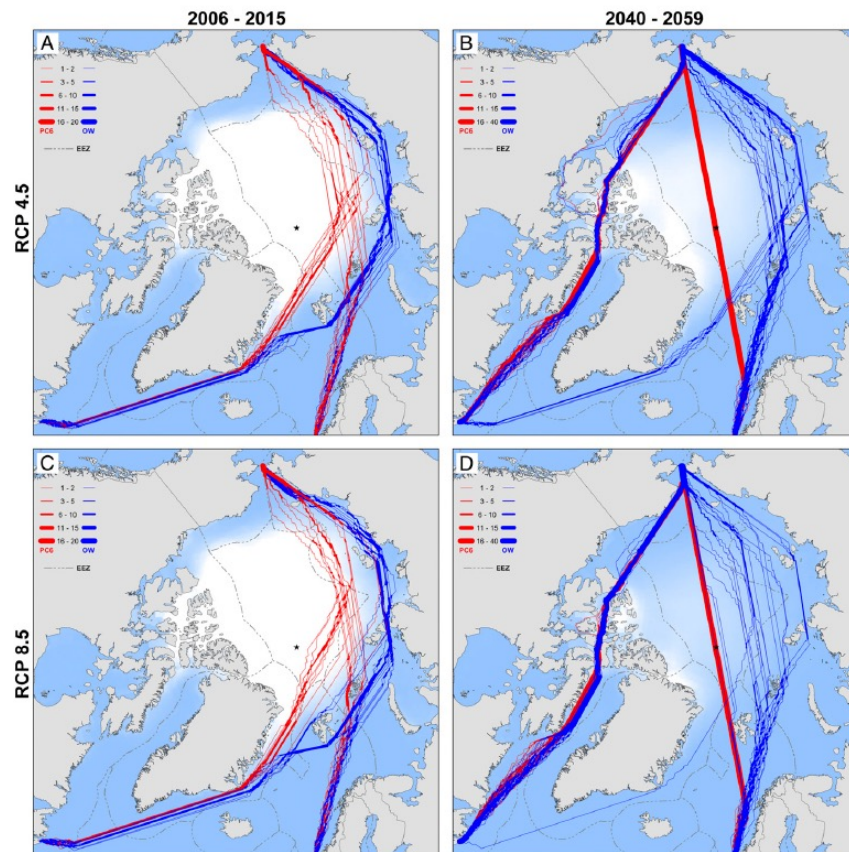
The Northwest Passage



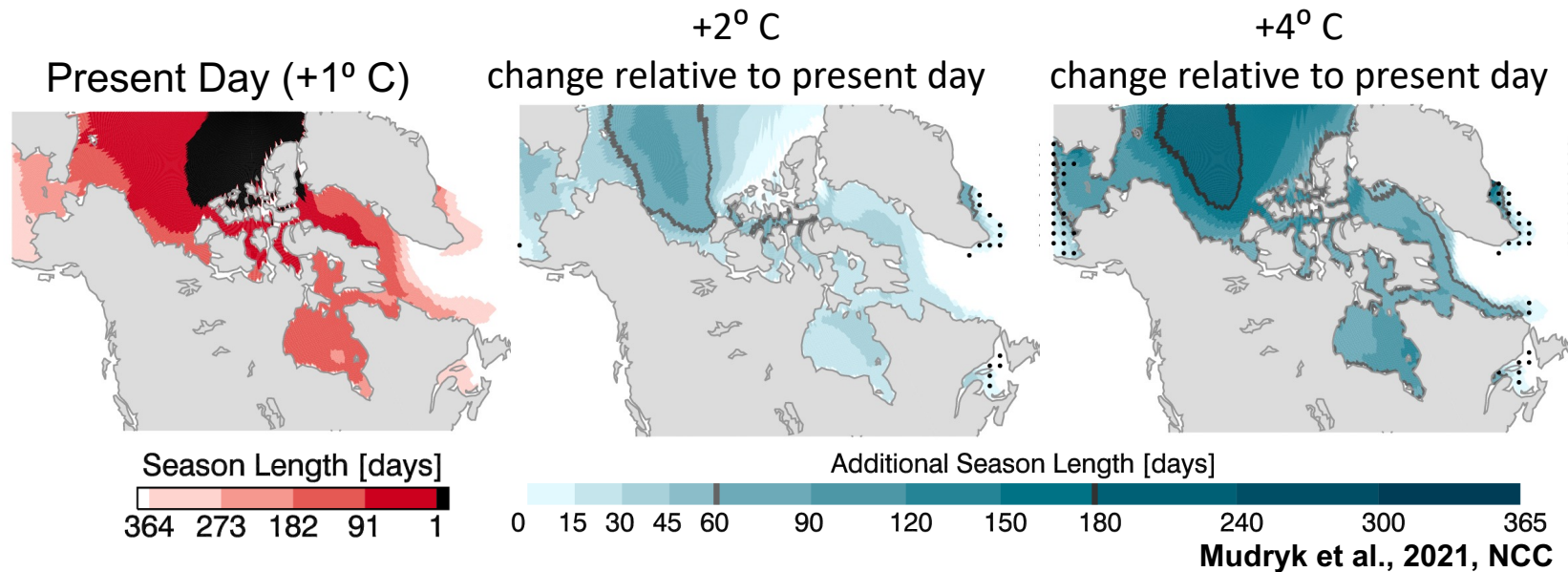
- Connects the Atlantic and Pacific Oceans through the Canadian Arctic Archipelago
- Led to the demise of the Franklin Expedition (1845-1848)
- Discovered by Sir Robert McClure (1854)
- First completely sailed by Roald Amundsen (1906)
- Ever-present sea ice has prevented its practical use
- Model projections suggest it might be more navigable under climate change induced reductions in sea ice



Projected changes in marine navigation under various scenarios/levels of global warming



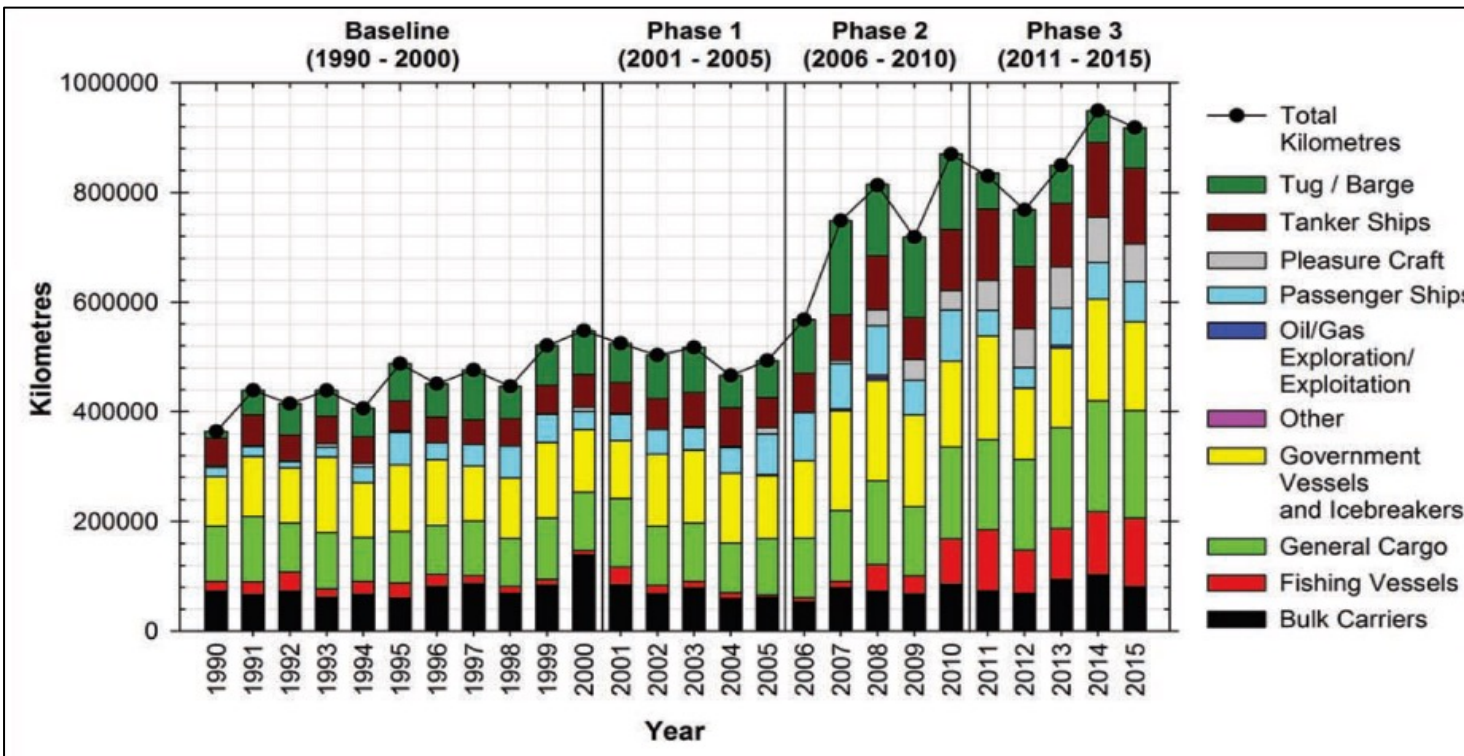
Smith and Stephenson, 2013, PNAS



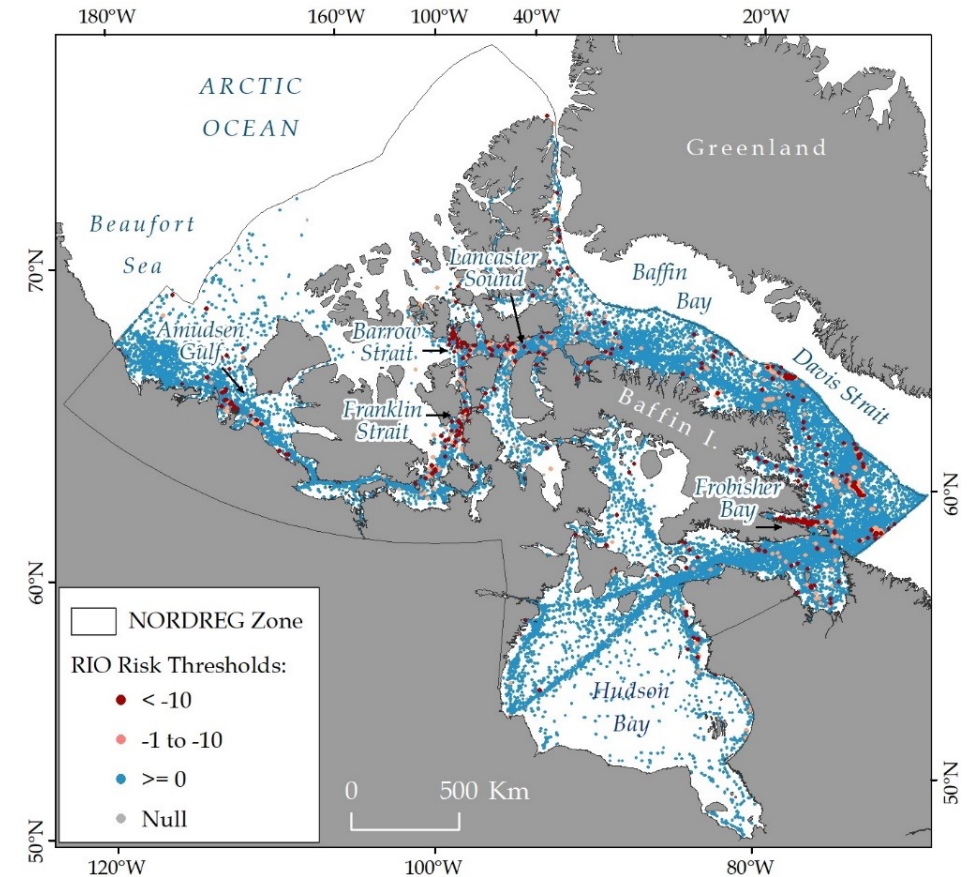
- Increased open water across the majority of the Canadian Arctic: + 1-2 months at 2° C and + 3-4 months at 4° C



Observations indicate increase in shipping activity in the Canadian Arctic



Dawson et al., 2018, Arctic



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

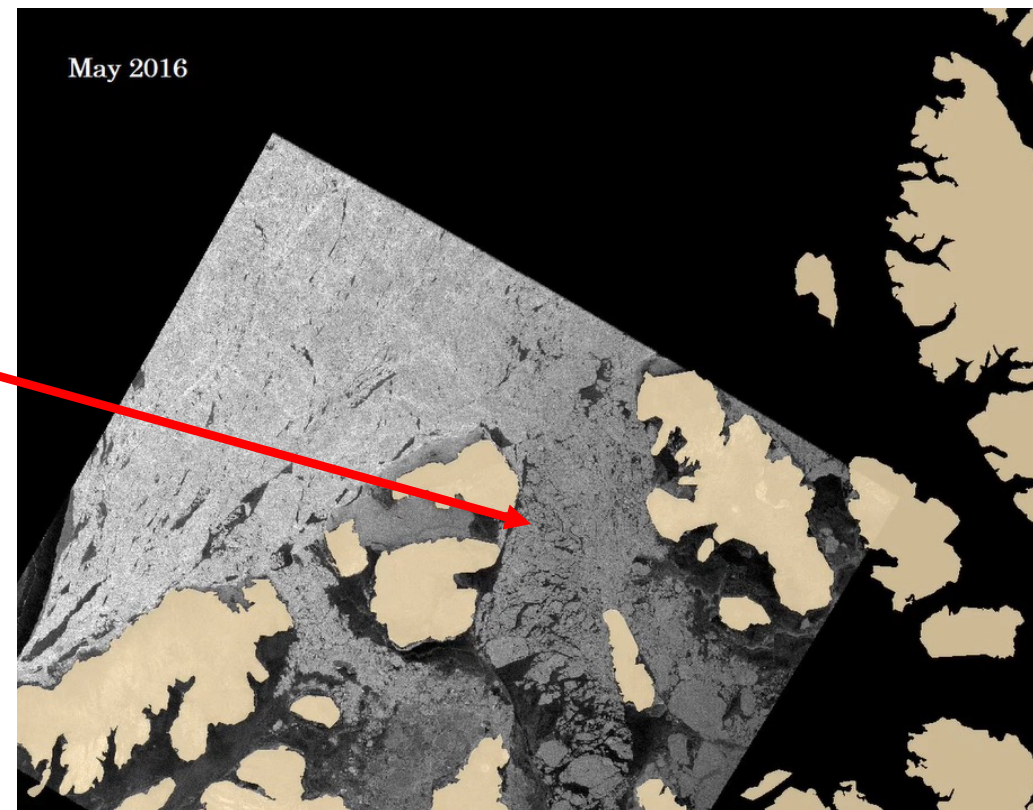
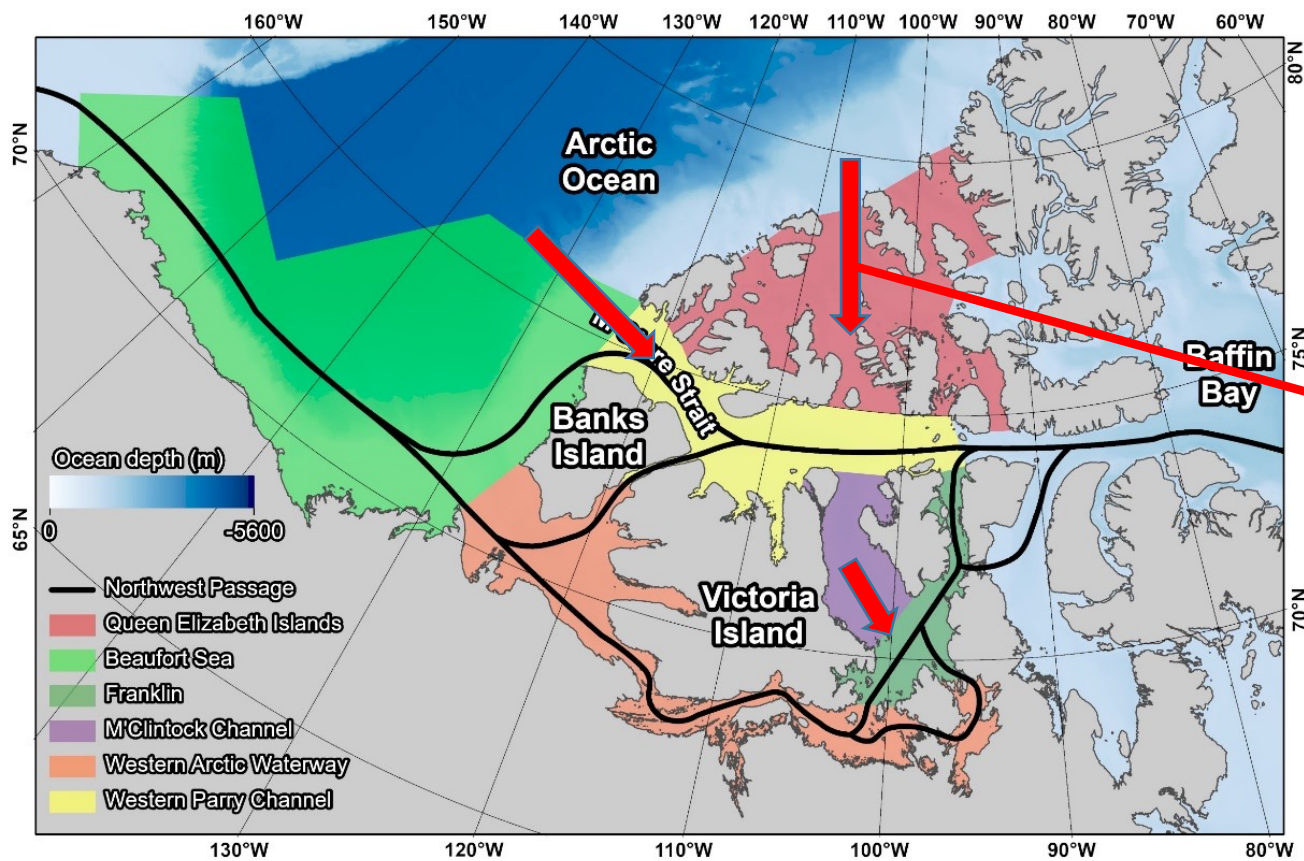
Canada

Caution needs to be taken with respect to climate model projections in the Northwest Passage

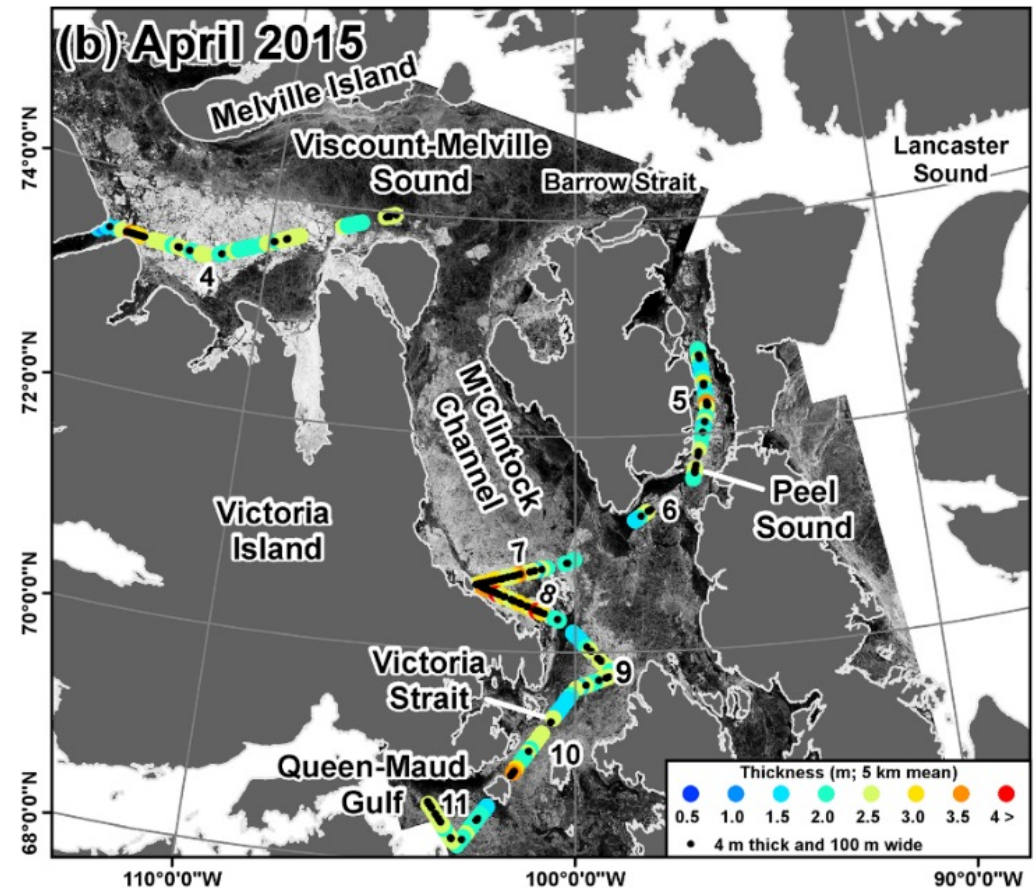
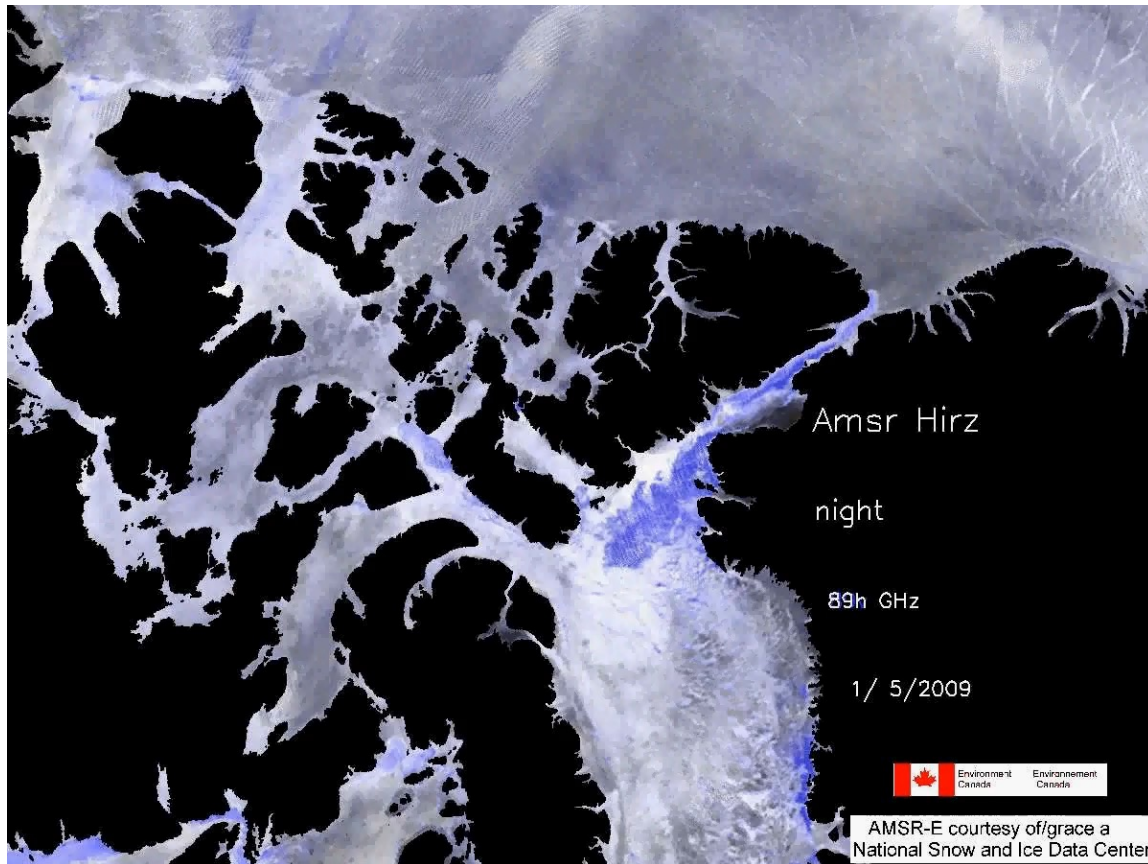
- Local scale advection processes are not well captured by coarse resolution climate models and these process pose hazardous conditions to transiting ships operating within the Canadian Arctic
- The **problem** is the drain-trap mechanism that operates within the Canadian Arctic Archipelago
- This mechanism facilitates the continuous southward transport of multi-year ice (MYI) from the Arctic Ocean into the shipping lanes of the Northwest Passage and maintains MYI in high concentration



The Drain-Trap Mechanism



The Drain-Trap Mechanism



Haas and Howell, 2015, GRL

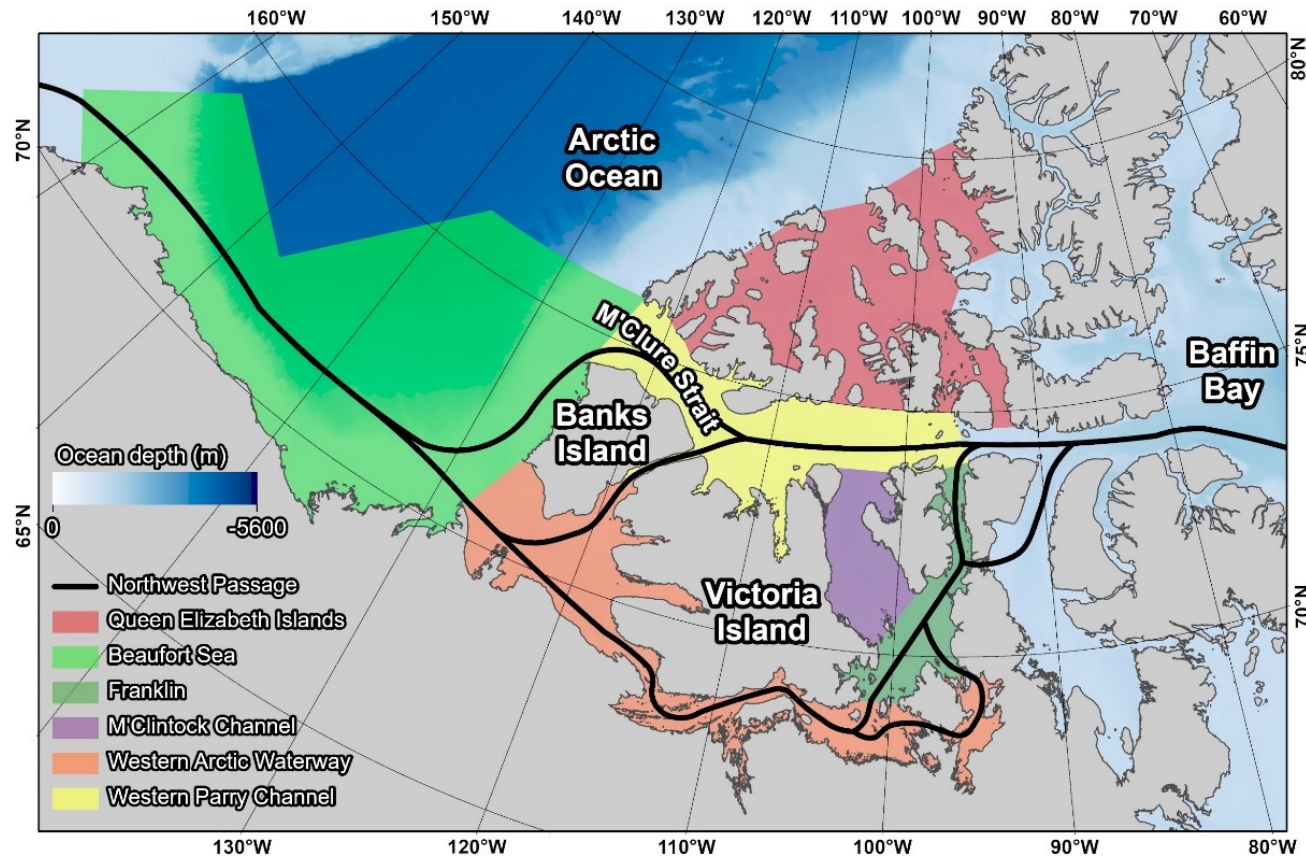


Environment and
Climate Change Canada

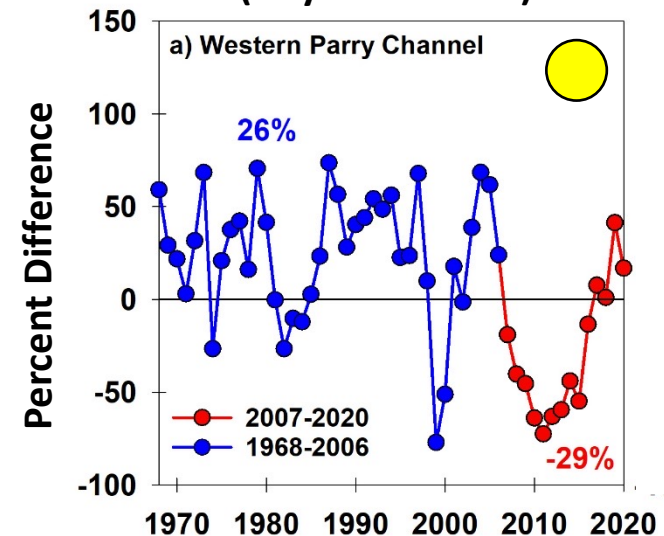
Environnement et
Changement climatique Canada

Canada

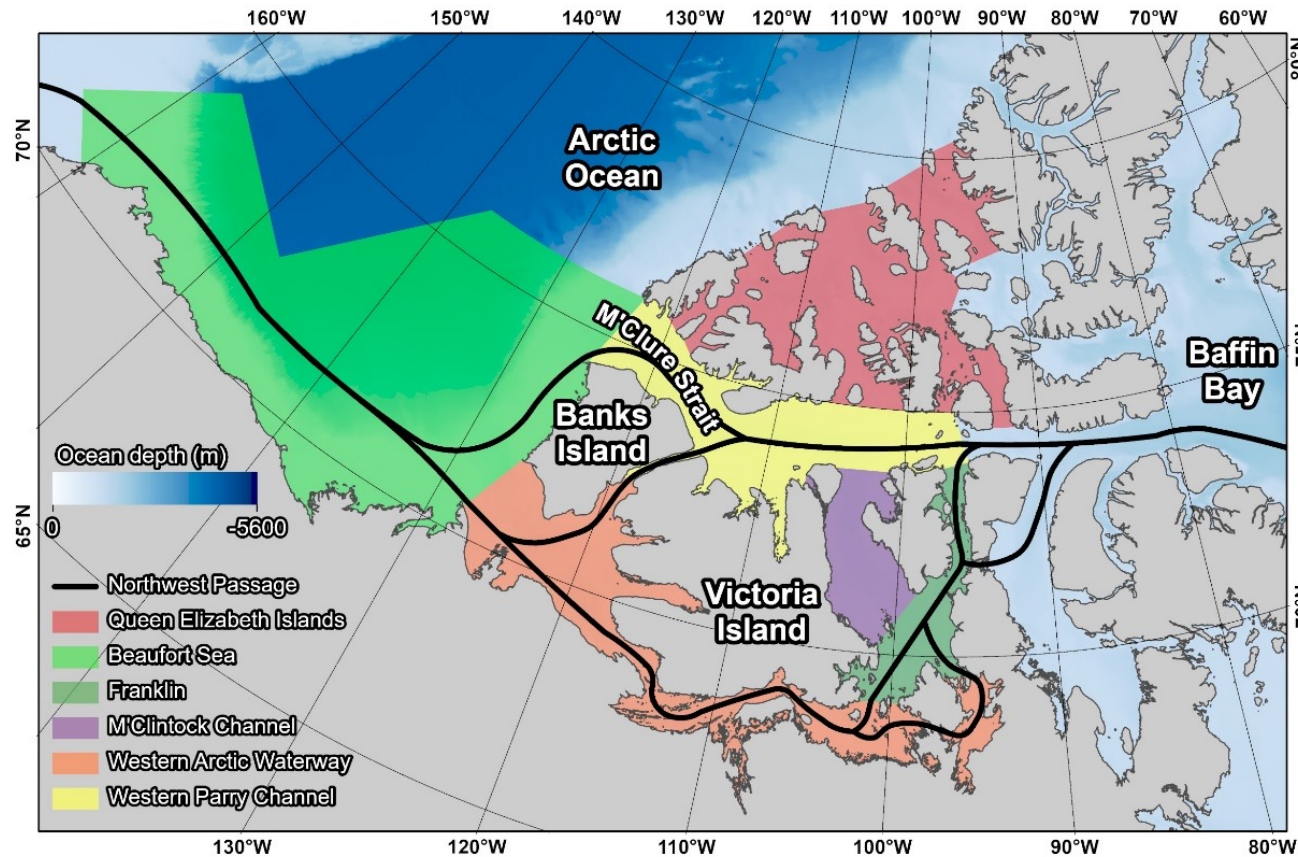
Observed multi-year ice conditions in the Northwest Passage Northern Route: 1968-2006 vs 2007-2020



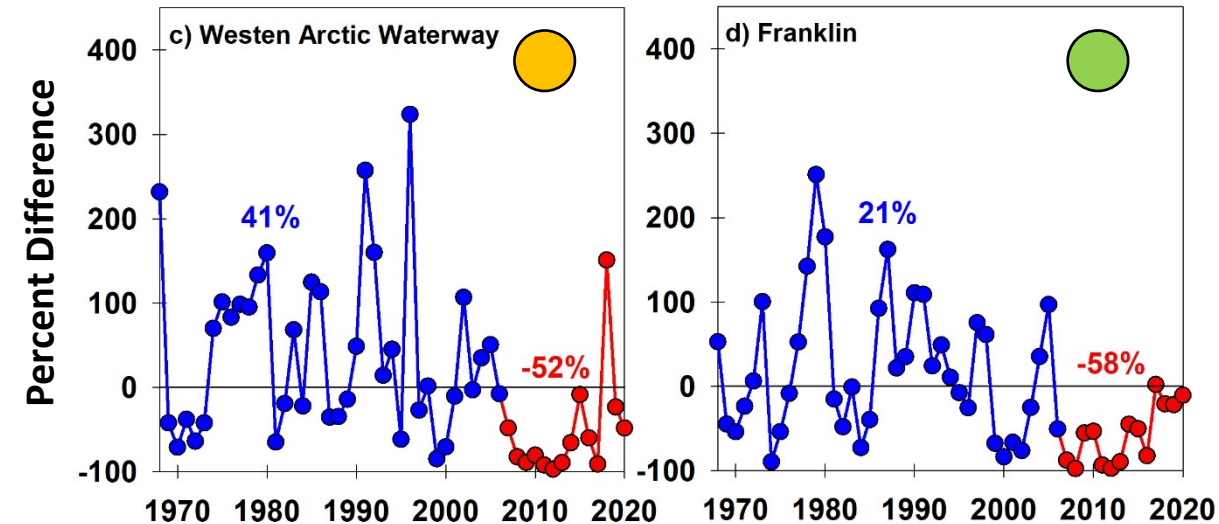
Average MYI Area During the Shipping Season
(July to October)



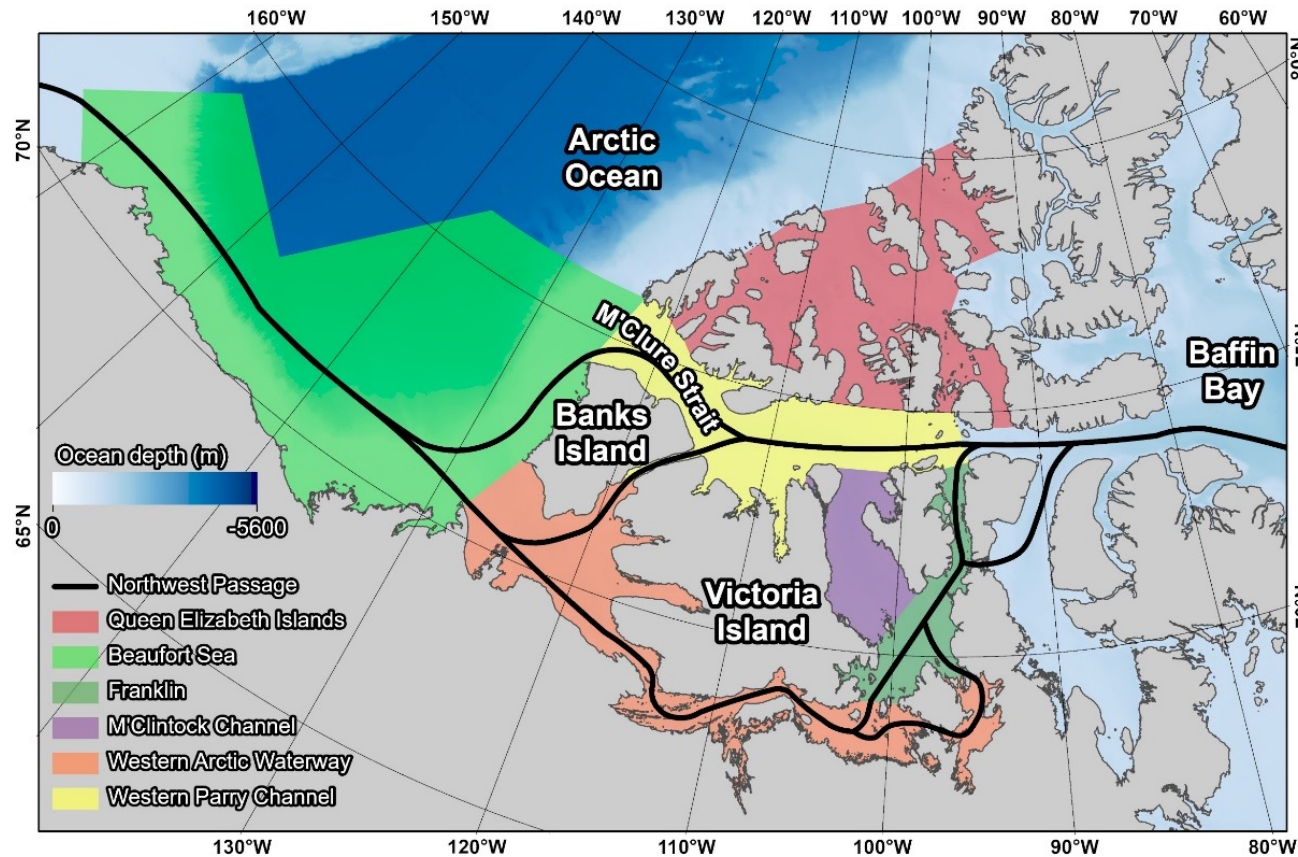
Observed multi-year ice conditions in the Northwest Passage Southern Route: 1968-2006 vs 2007-2020



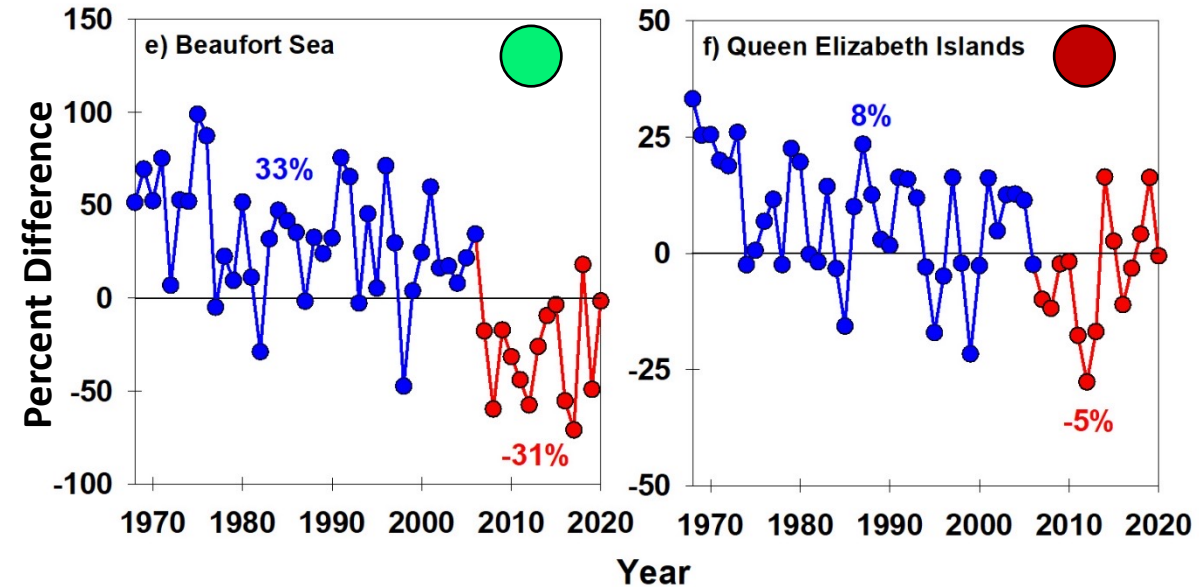
Average MYI Area During the Shipping Season (July to October)



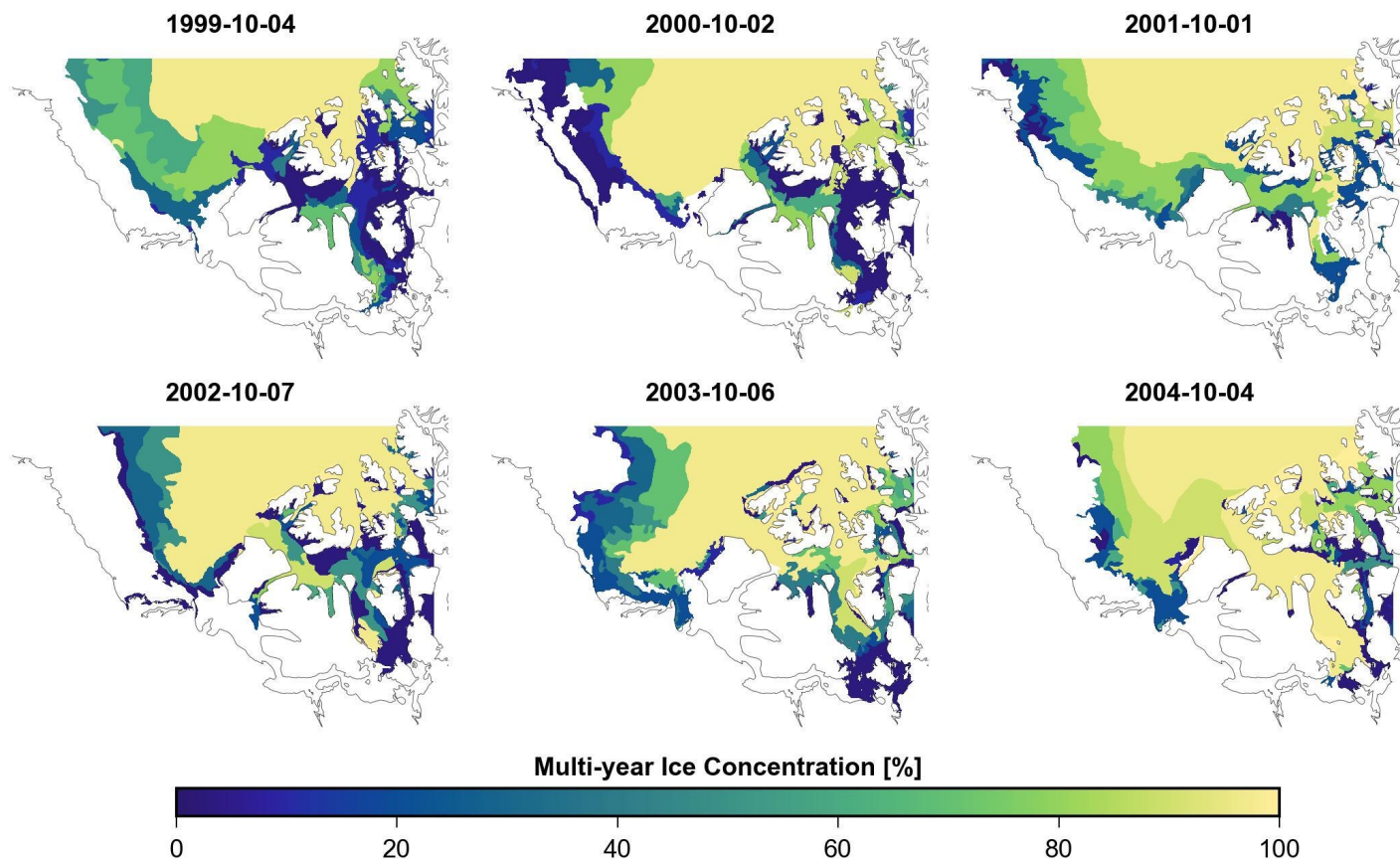
Observed multi-year ice conditions outside the shipping lanes: 1968-2006 vs 2007-2020



Average MYI Area During the Shipping Season
(July to October)



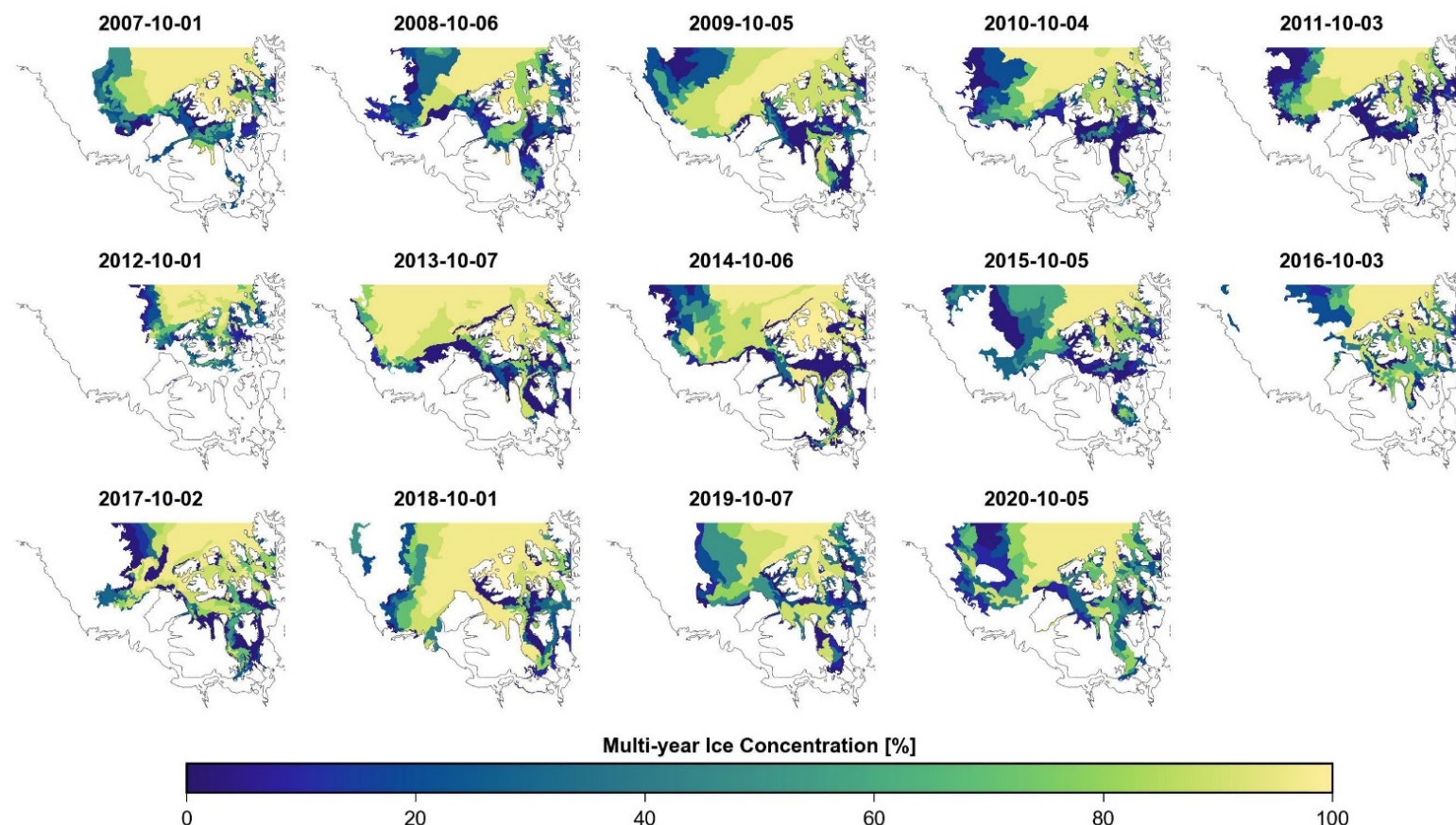
Multi-year ice recovery: 1999-2004



- Strong MYI recovery after the anomalously light ice year of 1998
- The drain-trap mechanism gradually replenished MYI in these regions of the Northwest Passage



Multi-year ice recovery: 2007-2020



- MYI is still being transported southward into the shipping lanes but in reduced amounts and less accumulation after the melt season
- MYI from the Arctic Ocean thinner and weak and more vulnerable to warming
- No observational evidence to suggest the drain-trap will stop



Summary and conclusions

- Sea ice in the Arctic is decreasing and in turn shipping activity is also increasing
- MYI conditions during 2007-2020 in the Northwest Passage were marked by unprecedented extreme negative MYI anomalies, but the drain-trap mechanism continued to operate albeit at reduced magnitude and facilitate the presence of MYI in these regions
- As Arctic Ocean MYI continues to decline in thickness, MYI recovery within the Northwest Passage will also decline MYI but it still will remain a considerable hazard to the practical usage of the Northwest Passage as long as MYI remains north of the Canadian Arctic Archipelago and Greenland (i.e. the Last Ice Area)
- Overall, the drain-trap mechanism presents a reality check for studies that propose regular sea ice-free shipping opportunities through the Northwest Passage in the near future



Thank You!



- This presentation is dedicated to David Barber who was a giant of sea ice research in Canada and passed away on April 15, 2022.



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

Canada