

Arctic Corridors and Northern Voices: an example of a multidisciplinary approach to shipping risk assessment in the Arctic

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MEOPAR Shipping Community of Practice
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ESPG Environment, Society
and Policy Group

Shipping in Arctic Canada

➤ Rapid recent reduction in sea ice age and extent in Canadian Arctic: >-10% decline per decade

➤ But still high variability through Northwest Passage

➤ Rapid recent increase in Canadian Arctic ship traffic

➤ 364,179 km travelled in 1990

➤ 918,266 km travelled in 2015 (>250% increase)

➤ Major changes in some ship types: e.g., Pleasure Craft: 2590 km/yr 1990s vs 52,799 km/yr 2011-2015

How are shipping risks changing over time?

- Changes in ship numbers & ice class
- Changes in sea ice navigability
- Changes in seasonality of shipping

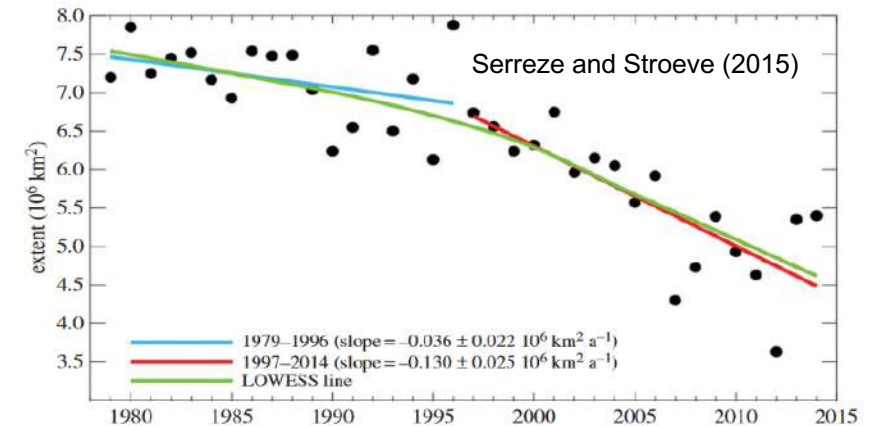
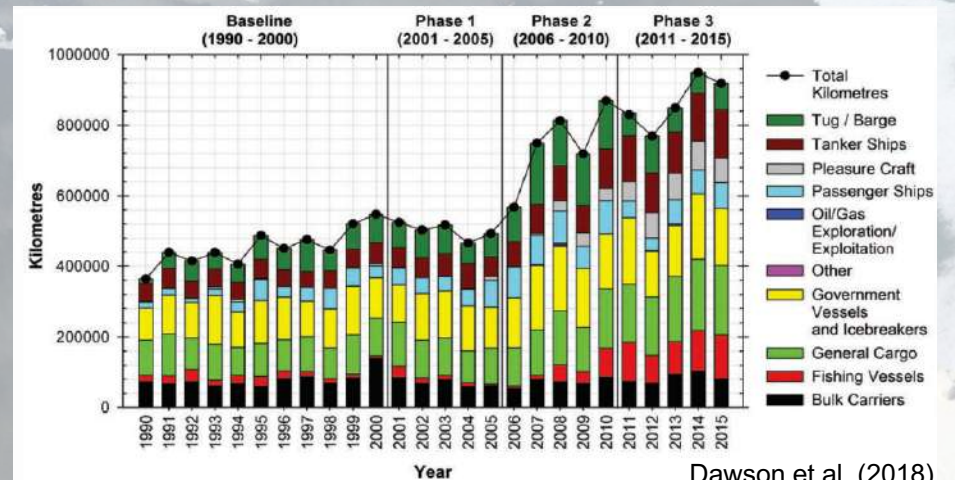
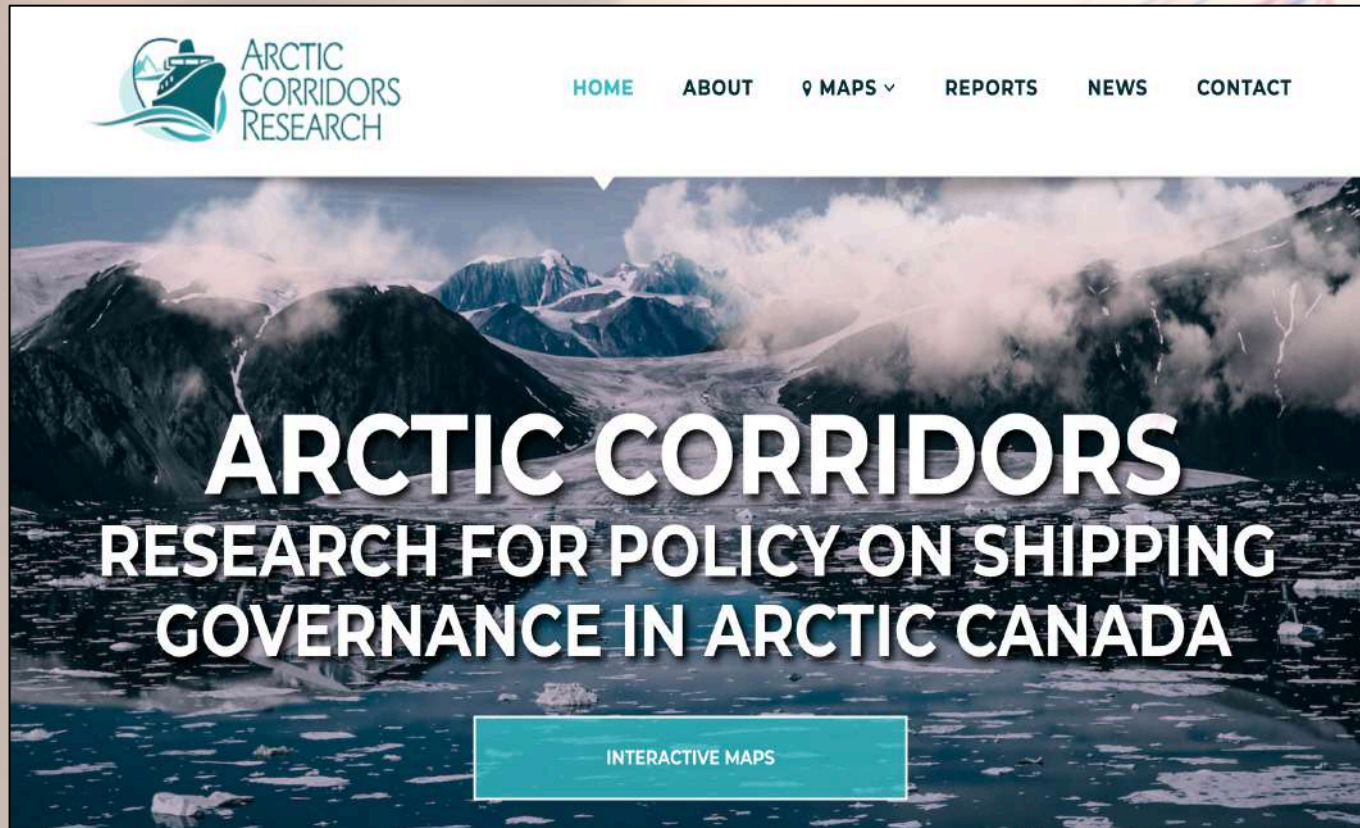


Figure 2. Comparison of linear trends in September sea ice extent for the period 1979–1996 and for 1997–2014. The smoothed nonlinear trend line is calculated using locally weighted scatterplot smoothing. Linear trends are calculated using least-squares regression.



Arctic Corridors – Northern Voices Project

www.arcticcorridors.ca



The screenshot shows the homepage of the Arctic Corridors Research website. At the top left is the logo for Arctic Corridors Research, featuring a stylized ship and waves. To the right of the logo is a navigation menu with the following items: HOME, ABOUT, MAPS (with a dropdown arrow), REPORTS, NEWS, and CONTACT. Below the navigation is a large banner image of a snowy mountain range. Overlaid on the banner is the text: **ARCTIC CORRIDORS**
RESEARCH FOR POLICY ON SHIPPING
GOVERNANCE IN ARCTIC CANADA. At the bottom center of the banner is a teal button with the text **INTERACTIVE MAPS**.



Multidisciplinary (spatial) Risk Assessments for Arctic Shipping

Risks to Ships

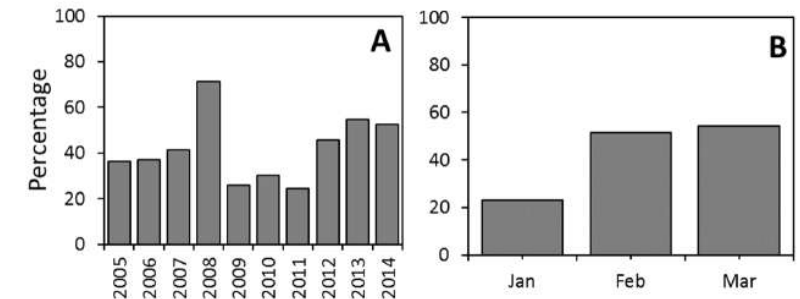
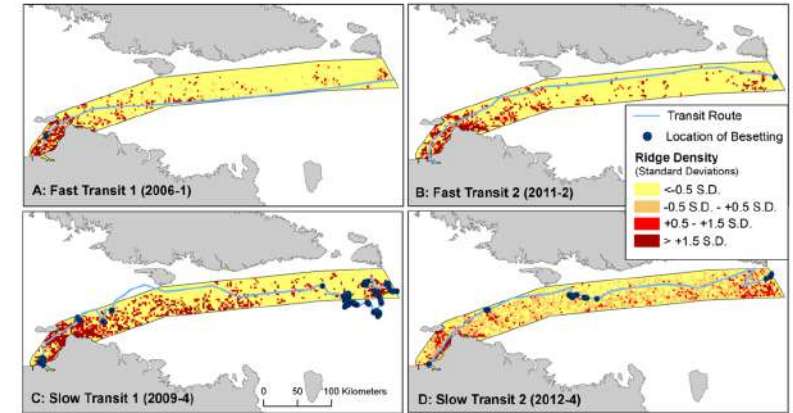
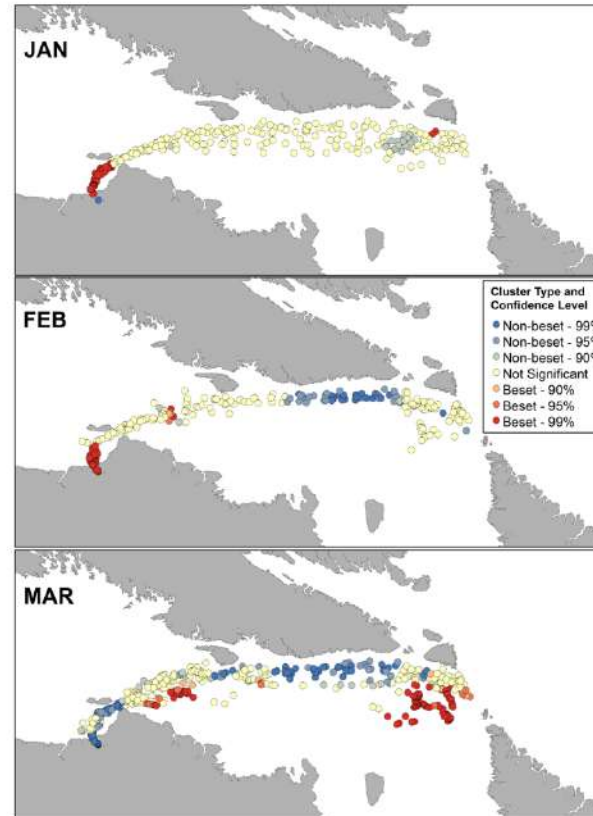
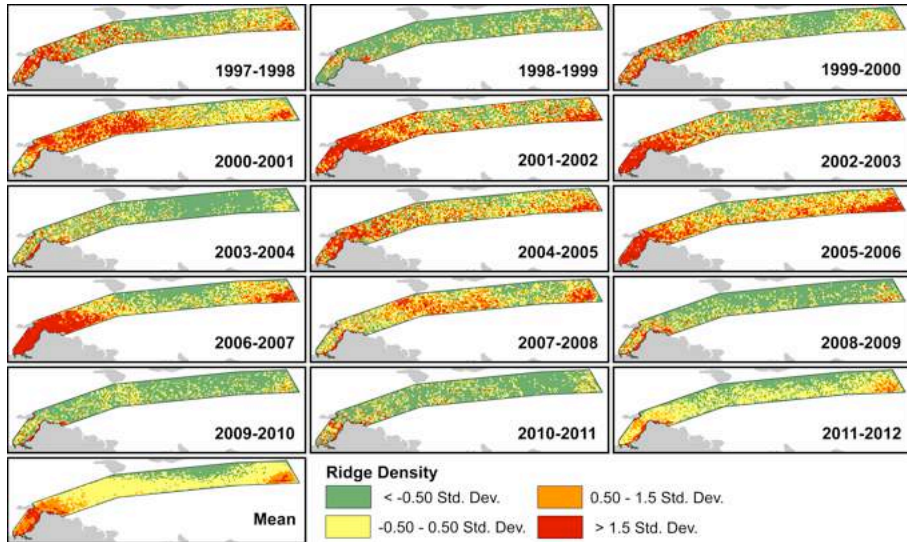
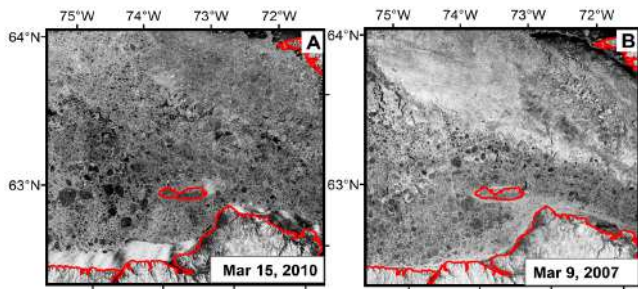
1. Pressured ice as a risk to ship navigation and safety
2. Mobile ice as a risk to ships

Risks from Ships

1. Risk from ship-source noise to marine mammals
2. Risk from ships to cultural activities and communities

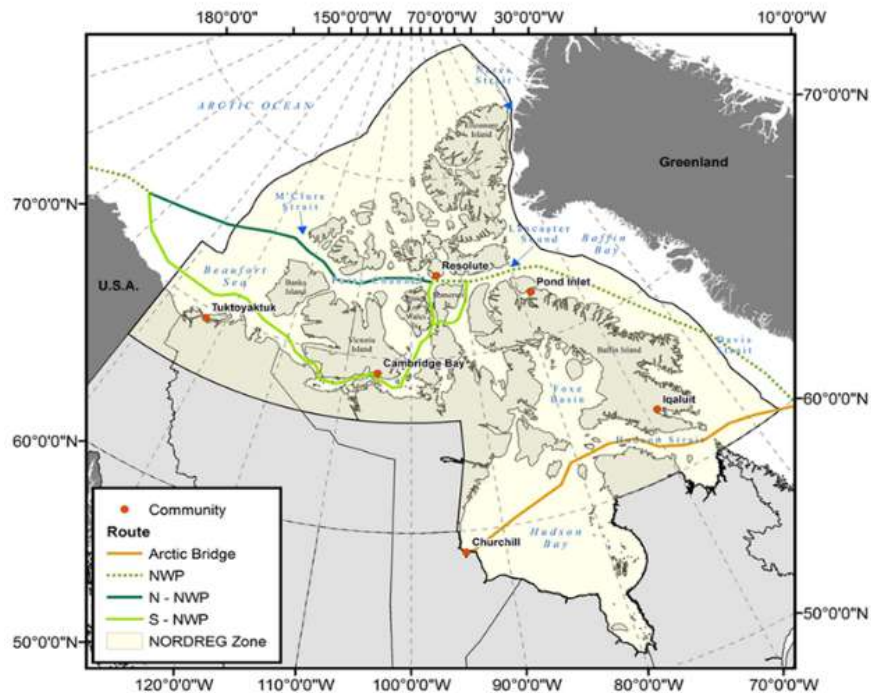
Risks TO Ships

1. Pressured ice as a risk to ship navigation and safety



Risks TO Ships

2. Mobile ice as a risk to ships



REFERENCE BOX: Ship Definitions

POLAR CLASS

- PC1:** Year-round operation in all Polar waters
- PC2:** Year-round operation in moderate multi-year ice conditions
- PC3:** Year-round operation in second-year ice which may include multi-year ice inclusions
- PC4:** Year-round operation in thick first-year ice which may include old ice inclusions
- PC5:** Year-round operation in medium first-year ice which may include old ice inclusions
- PC6:** Summer/autumn operation in medium first-year ice which may include old ice inclusions
- PC7:** Summer/autumn operation in thin first-year ice which may include old ice inclusions

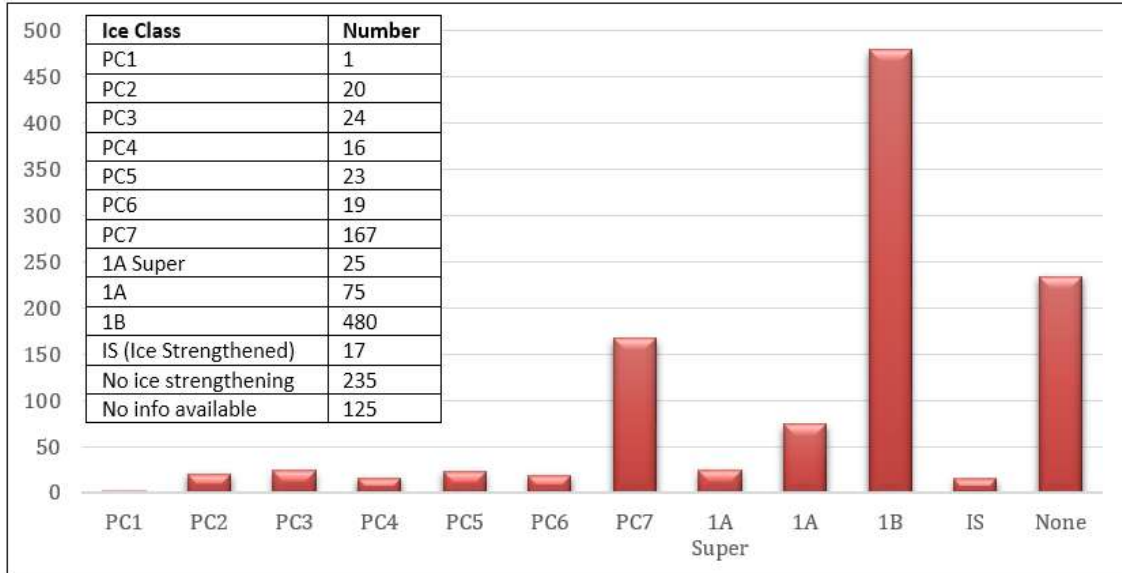
POLAR CATEGORY

- A:** Operation in Polar waters in at least medium first-year ice which may include old ice inclusions (PC1 to PC5)
- B:** Operation in Polar waters in at least thin first-year ice which may include old ice inclusions (PC6 or PC7)
- C:** Operation in open water or in ice conditions less severe than those included in Cat A or B (1A Super to 1B No ice class)

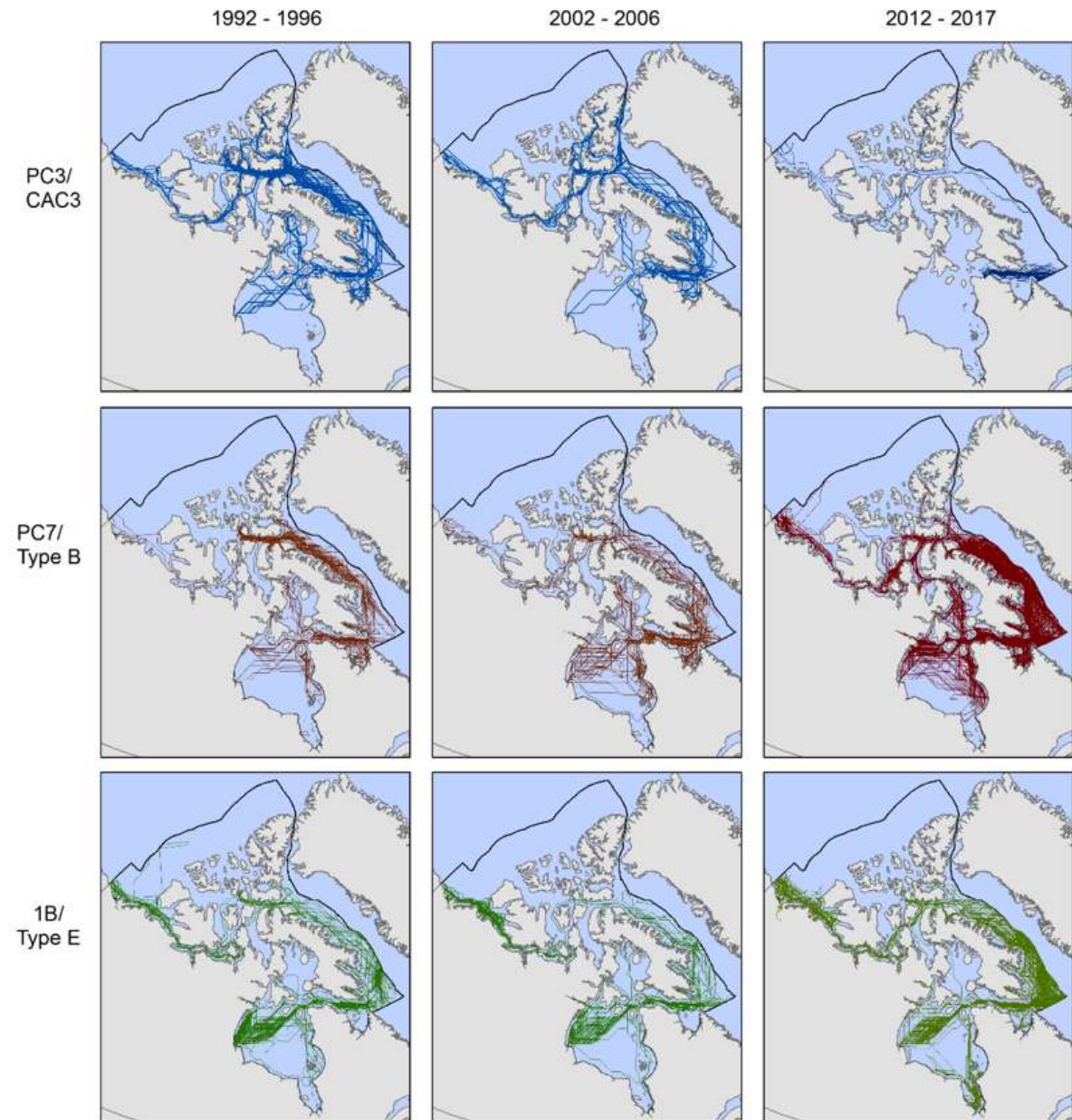
Figure 1. Examples of a: (a) Highly ice strengthened ship (CCGS Amundsen; Polar Class 3); (b) Medium ice strengthened ship (Acadia Desgagnés; Polar Class 7); (c) Little ice strengthened ship (Archimedes; Ice Class 1B). See Reference Box and Table 3 for further details.

Risks TO Ships

- Total of 1227 unique vessels reported 1990-2018
 - 21% reported no ice strengthening
 - Move towards less ice strengthening over time



Ice strengthening of vessels recorded in the NORDREG zone, 1990-2018, according to Ice Class



Changes in vessel track distribution over time for: Highly ice strengthened ships (Ice Class PC3/CAC3); Medium ice strengthened ships (Ice Class PC7/Type B); Little ice strengthened ships (Ice Class 1B/Type E).

Risks TO Ships

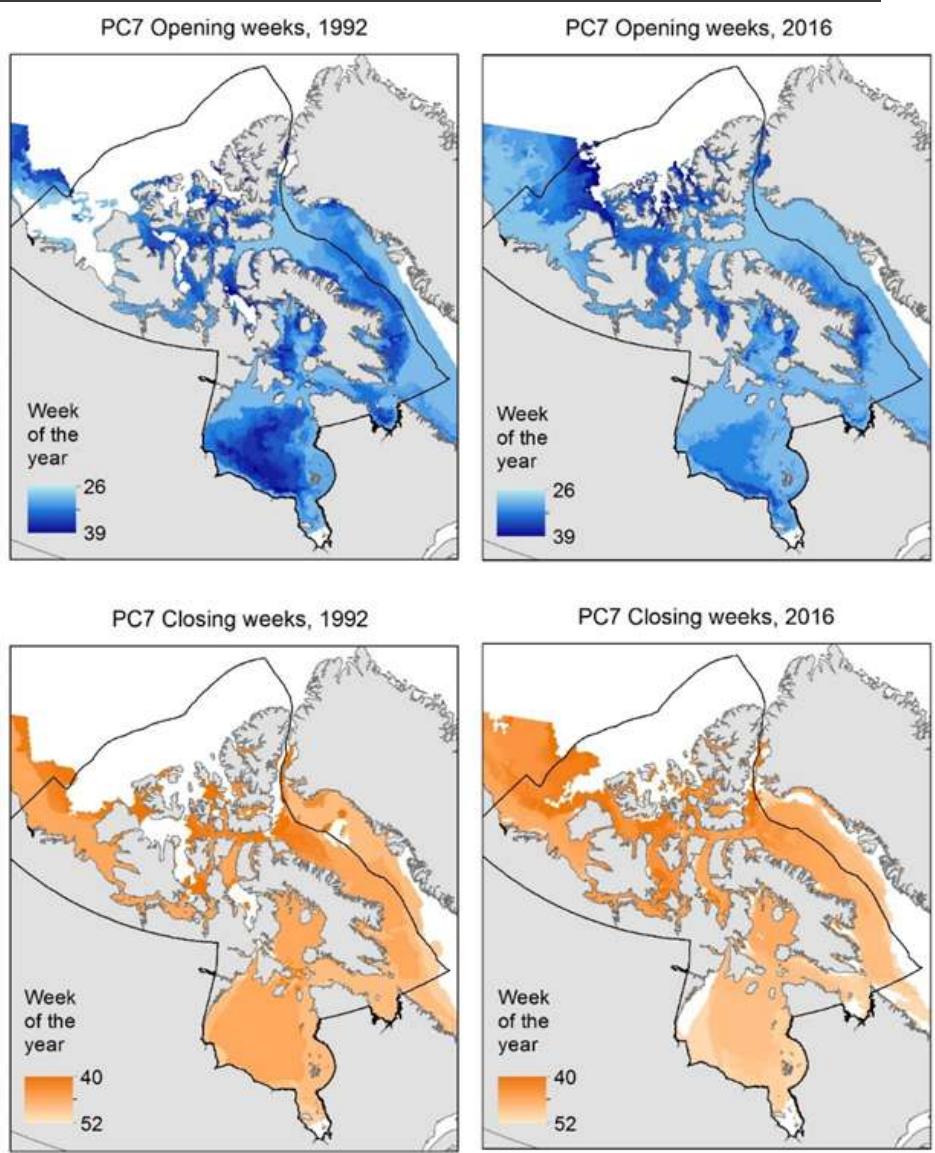
- Weekly sea ice charts from Canadian Ice Service since 1990
- Converted to Arctic Ice Regime Shipping System (AIRSS) ice numeral (IN) to indicate navigability for particular ship ice class:

$$IN = (C_a \times IM_a) + (C_b \times IM_b) + \dots$$

- C_a : Concentration (in tenths) of ice type “a”
- IM_a : Ice Multiplier for ice type “a” and ship type
- Separate map of navigability for each ship ice class
 - PC3 = CAC3; PC7 = Type B; 1B = Type E

Ice Codes	Ice Types/ Stages of Development	Ice thickness (cm)	Type E	Type D	Type C	Type B	Type A	CAC 4	CAC 3
7 • or 9 •	Old / Multi-Year Ice		-4	-4	-4	-4	-4	-3	-1
8 •	Second-Year Ice		-4	-4	-4	-4	-3	-2	1
6 • or 4 •	Thick First-Year Ice	> 120	-3	-3	-3	-2	-1	1	2
1 •	Medium First-Year Ice	70 -120	-2	-2	-2	-1	1	2	2
7	Thin First-Year Ice	30-70	-1	-1	-1	1	2	2	2
9	Thin First-Year Ice – 2 nd stage	50-70	-1	-1	-1	1	2	2	2
8	Thin First-Year Ice – 1 st stage	30-50	-1	-1	1	1	2	2	2
3 or 5	Grey-White Ice	15-30	-1	1	1	1	2	2	2
4	Grey Ice	10-15	1	2	2	2	2	2	2
2	Nilas, Ice Rind	<10	2	2	2	2	2	2	2
1	New Ice	<10	2	2	2	2	2	2	2
	Brash (ice fragments < 2m)		2	2	2	2	2	2	2
= Δ	Bergy Water		2	2	2	2	2	2	2
	Open Water		2	2	2	2	2	2	2

Weak ← → Strong

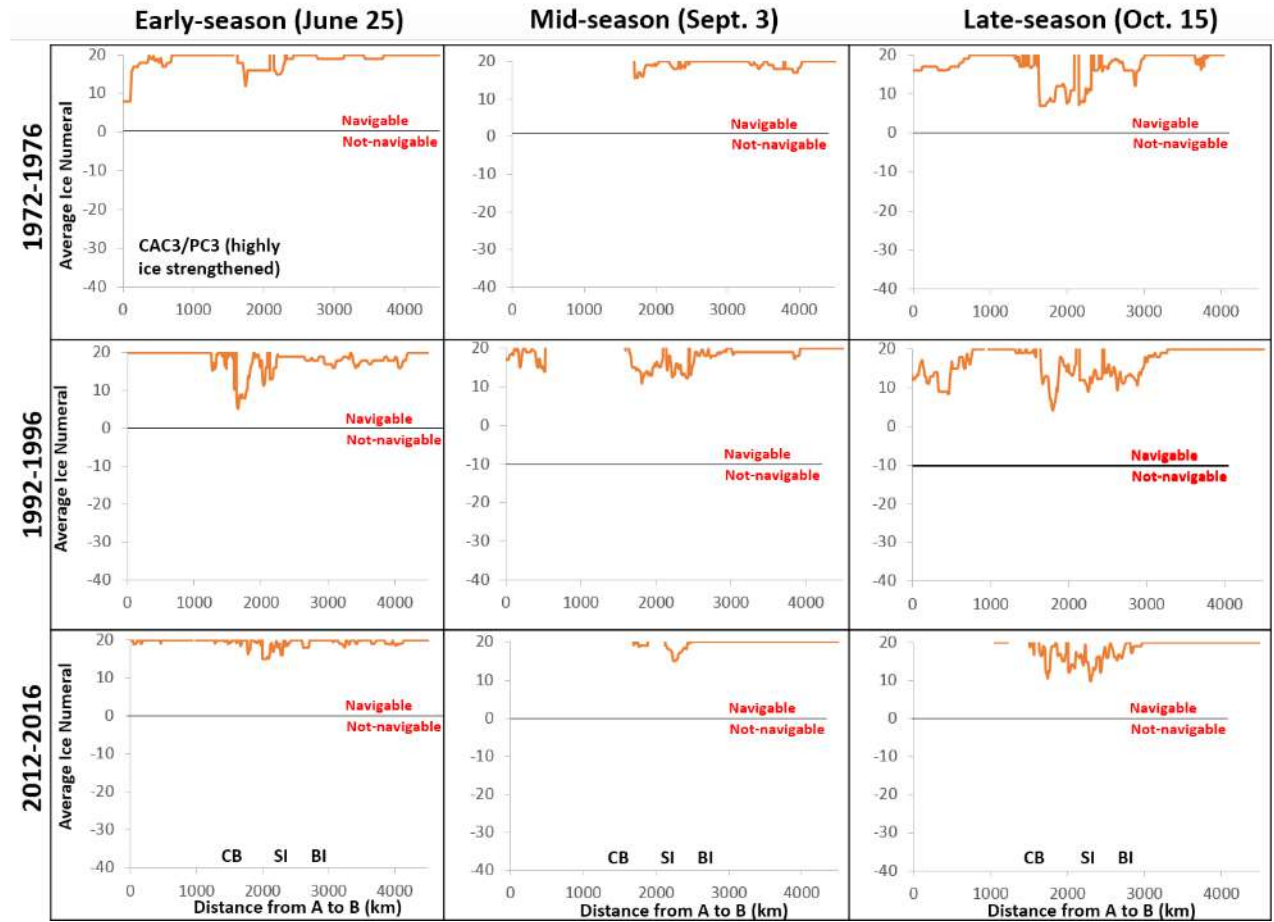


Opening and closing weeks across the NORDREG Zone for PC7 vessels (1992 vs. 2016)

Risks TO Ships

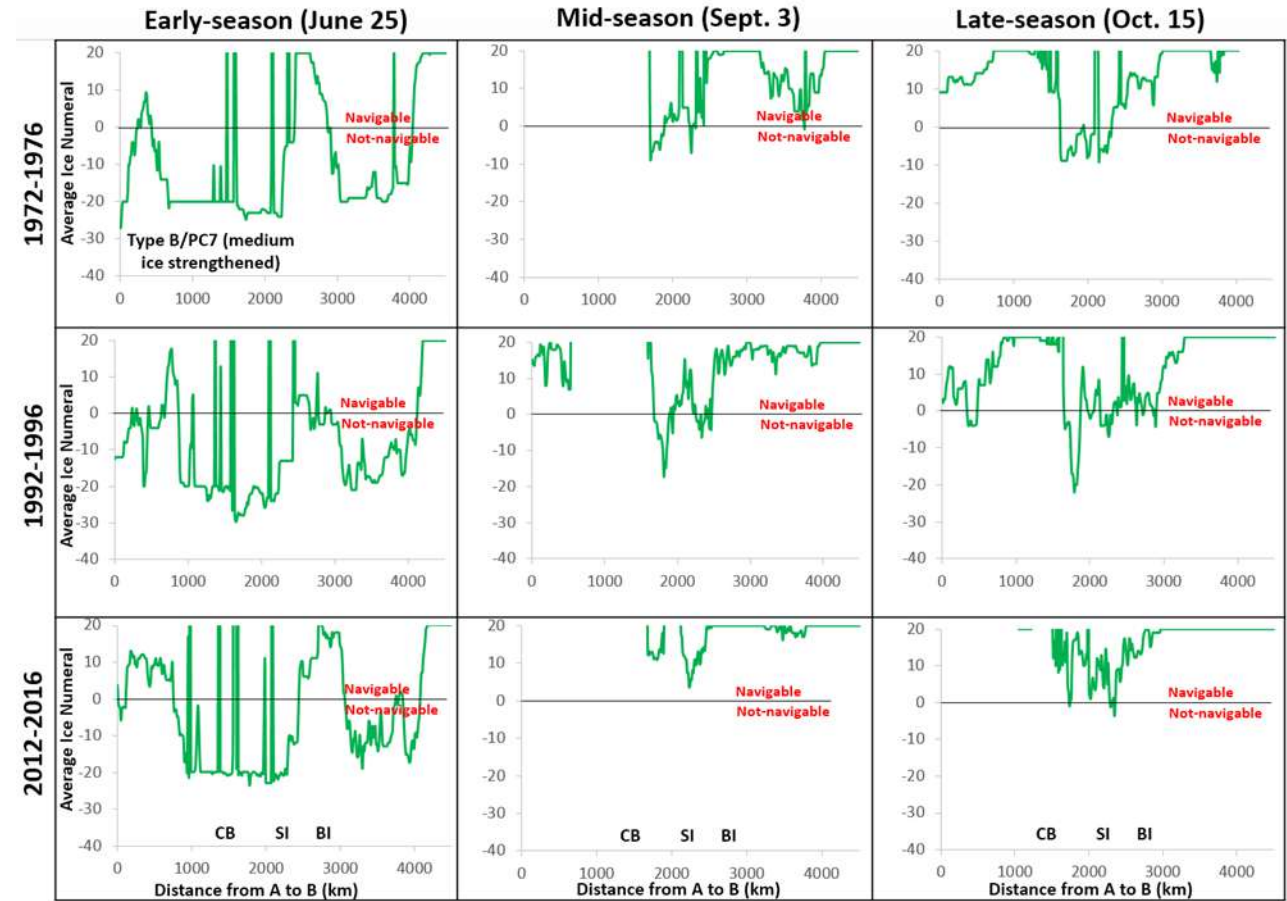


Map of the Northwest Passage primary shipping route (A to B) through the NORDREG zone, with 100 km markers, used to produce graphs of AIRSS values with distance.



Changes in ice navigability over time along the primary Northwest Passage route for ships of Ice Class CAC3/PC3 (highly ice strengthened)

Risks TO Ships



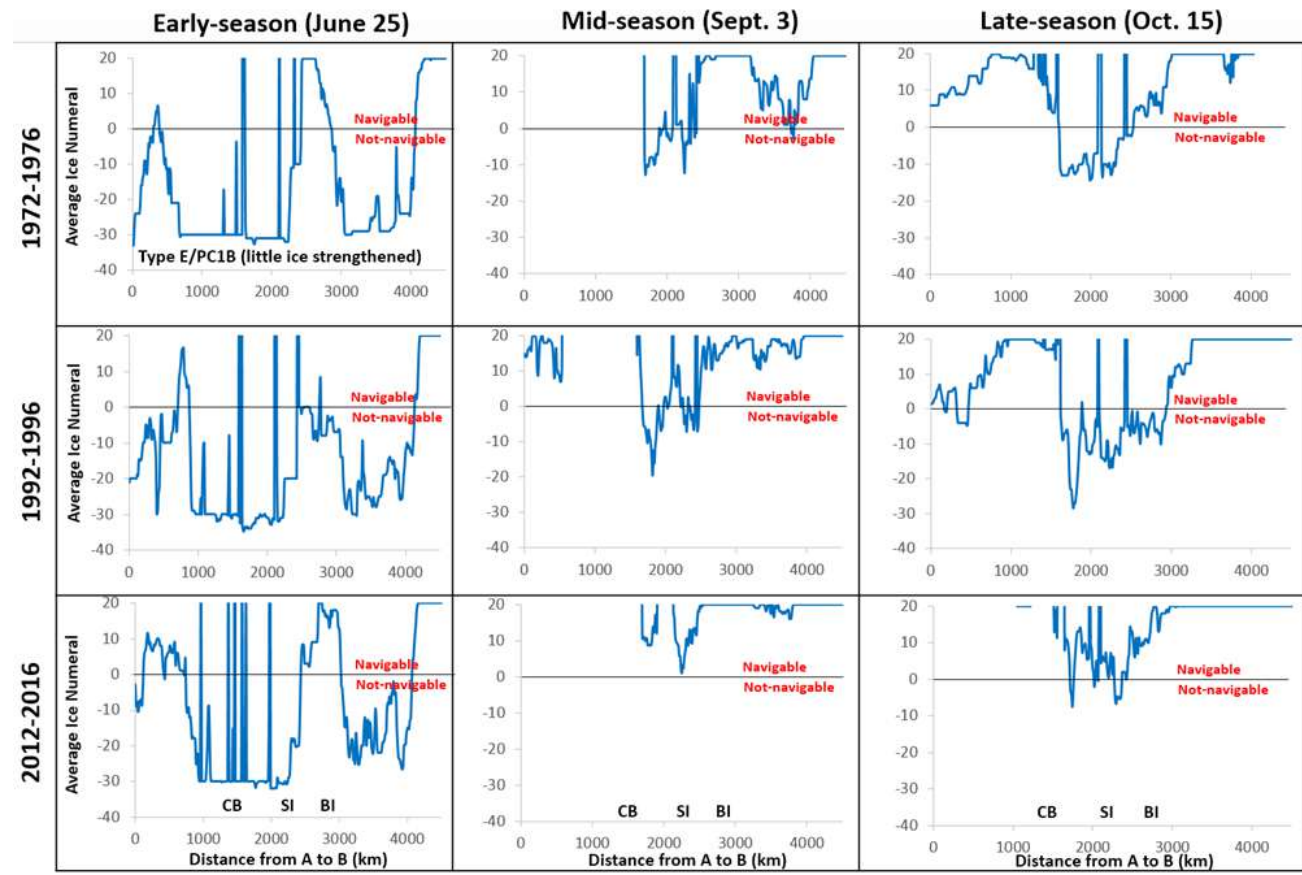
Map of the Northwest Passage primary shipping route (A to B) through the NORDREG zone, with 100 km markers, used to produce graphs of AIRSS values with distance.

Changes in ice navigability over time along the primary Northwest Passage route for ships of Ice Class B/PC7 (medium ice strengthened)

Risks TO Ships



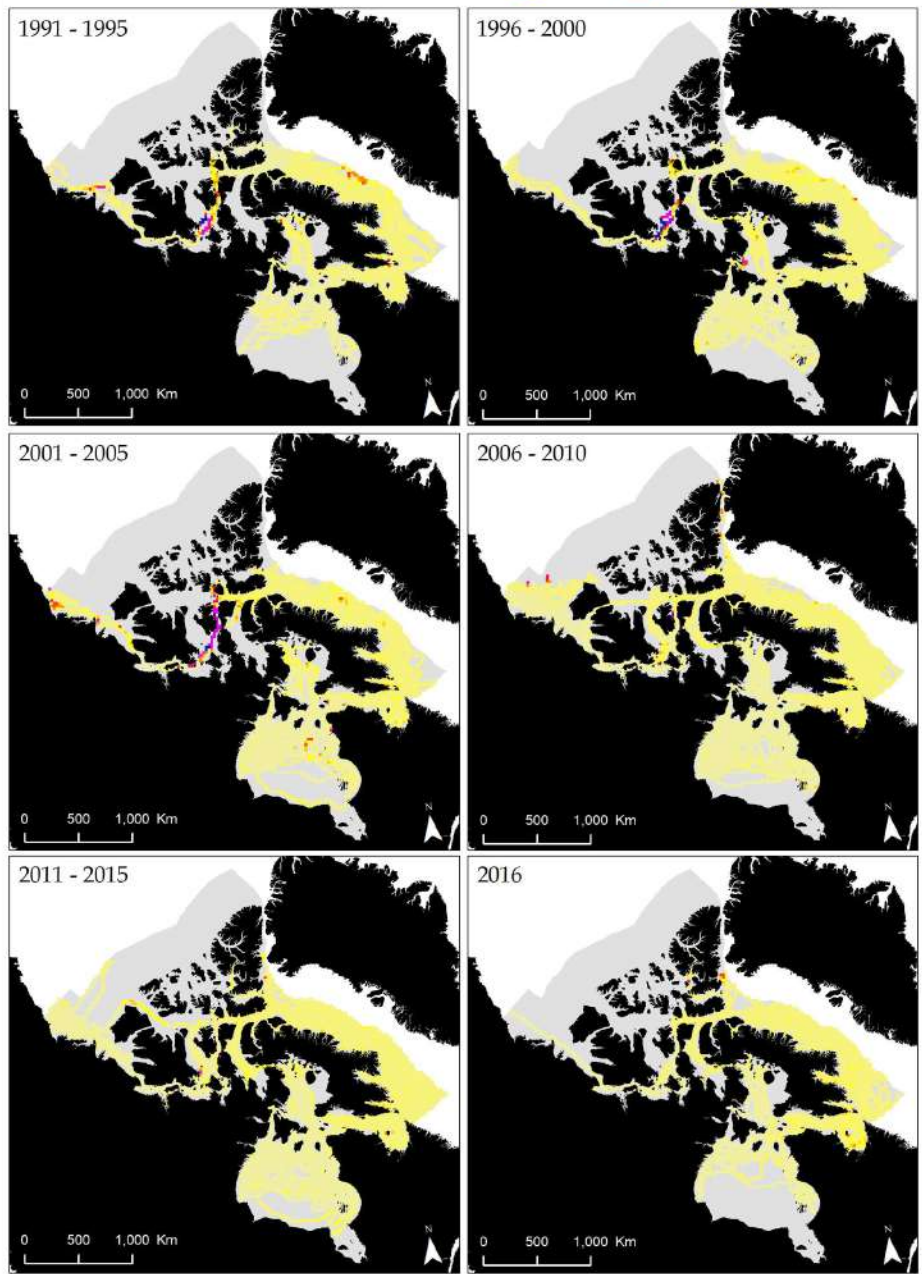
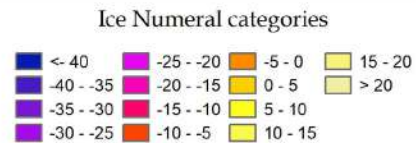
Map of the Northwest Passage primary shipping route (A to B) through the NORDREG zone, with 100 km markers, used to produce graphs of AIRSS values with distance.



Changes in ice navigability over time along the primary Northwest Passage route for ships of Ice Class E/1B (little ice strengthened).

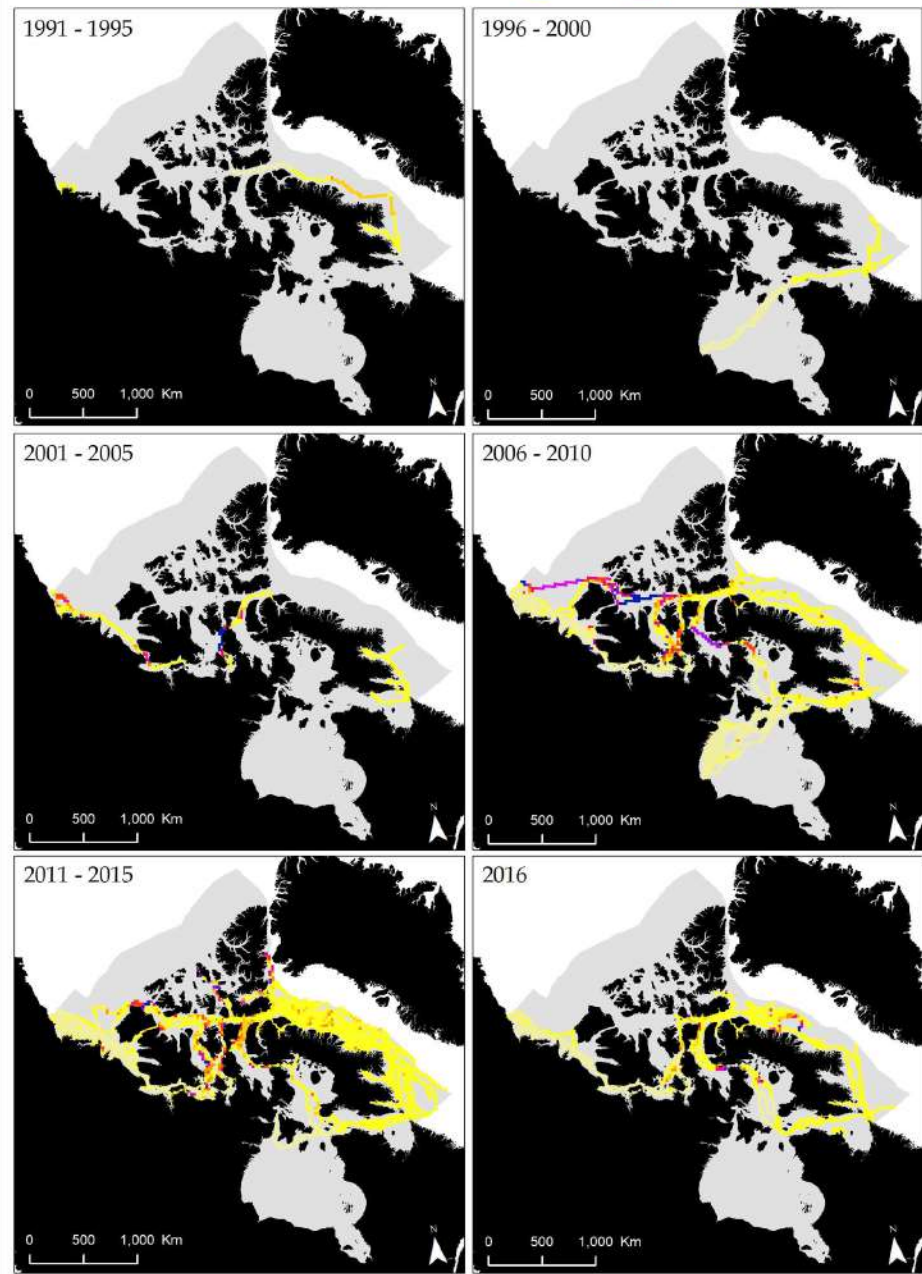
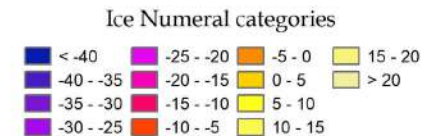
Ships with Ice Class PC7:

Mean Ice Numerals for
PC7 Polar Code



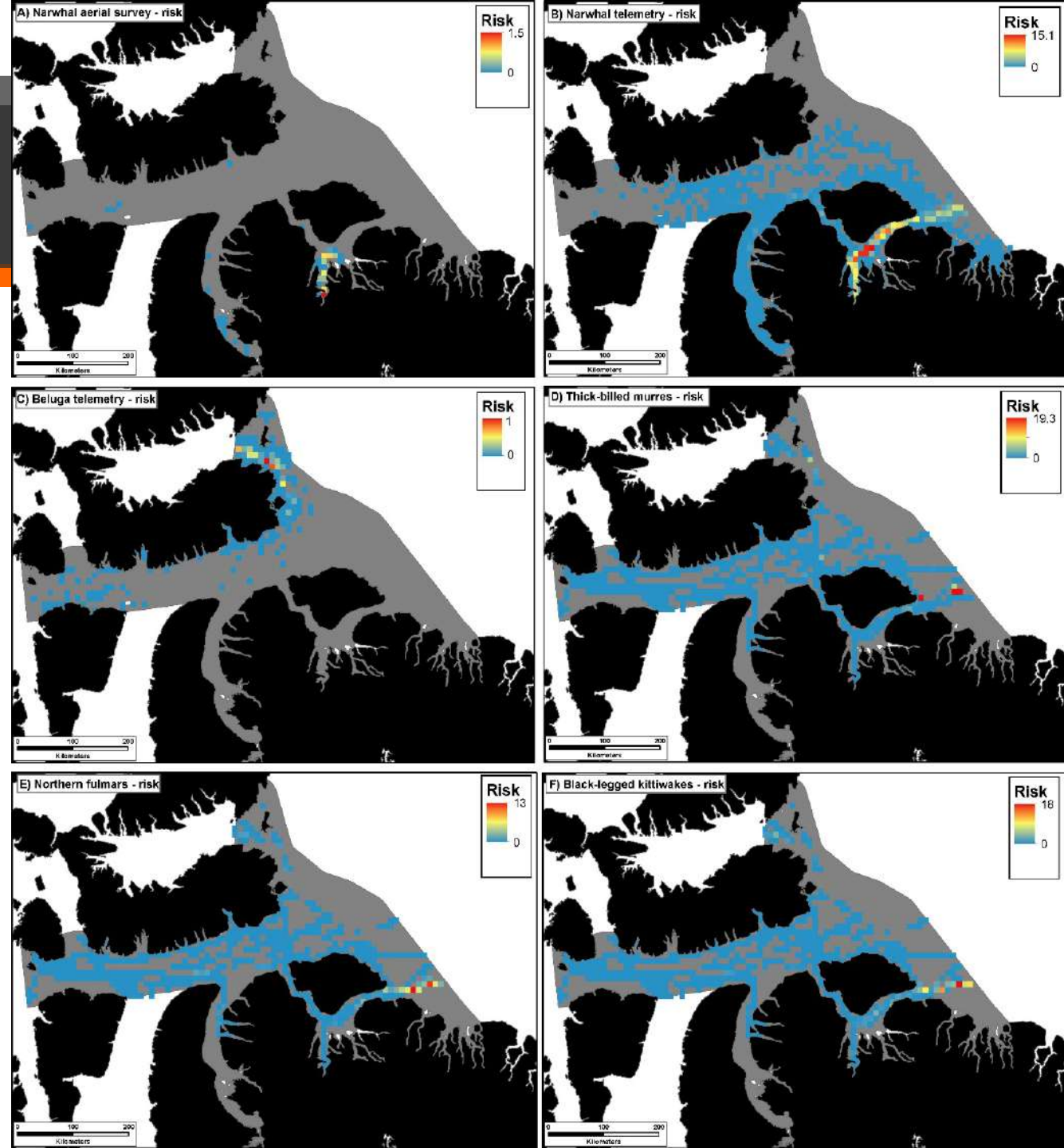
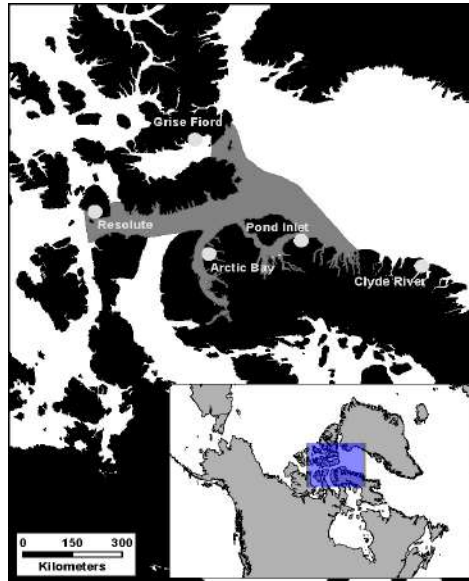
Ships with No Ice Strengthening:

Mean Ice Numerals for
'No ice strength' Polar Code



Risks FROM Ships

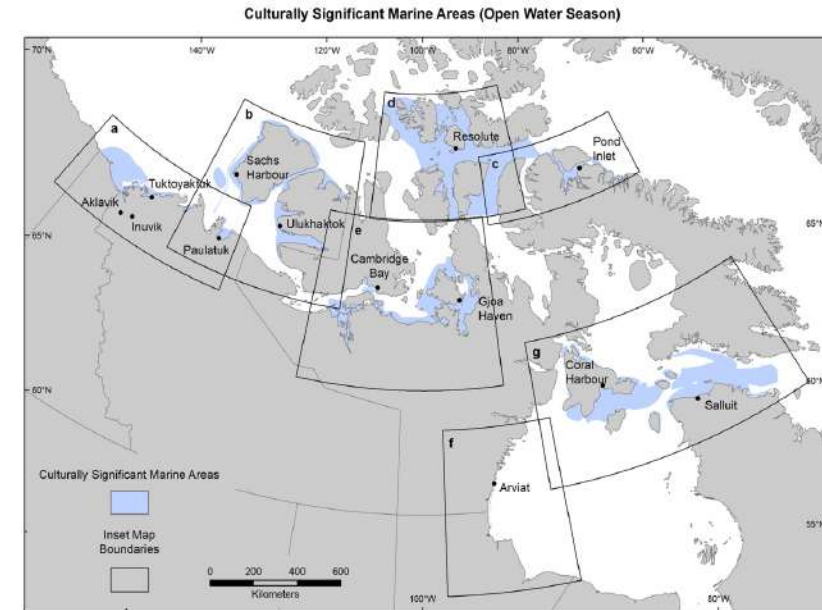
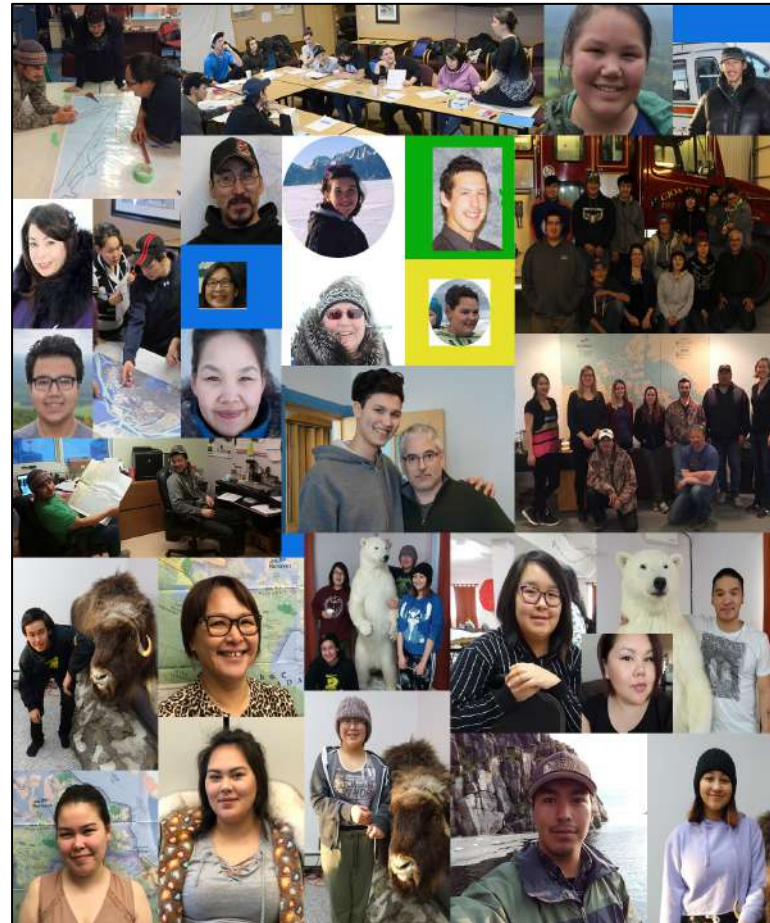
1. Risk from ship-source noise to marine mammals



Level of risk to high noise exposure ($\geq 120\text{dB}$) for narwhal (A and B), beluga whales (C), thick-billed murre (D), northern fulmars (E) and black-legged kittiwakes (F) in the Tallurutiup Imanga National Marine Conservation Area (TI NMCA).

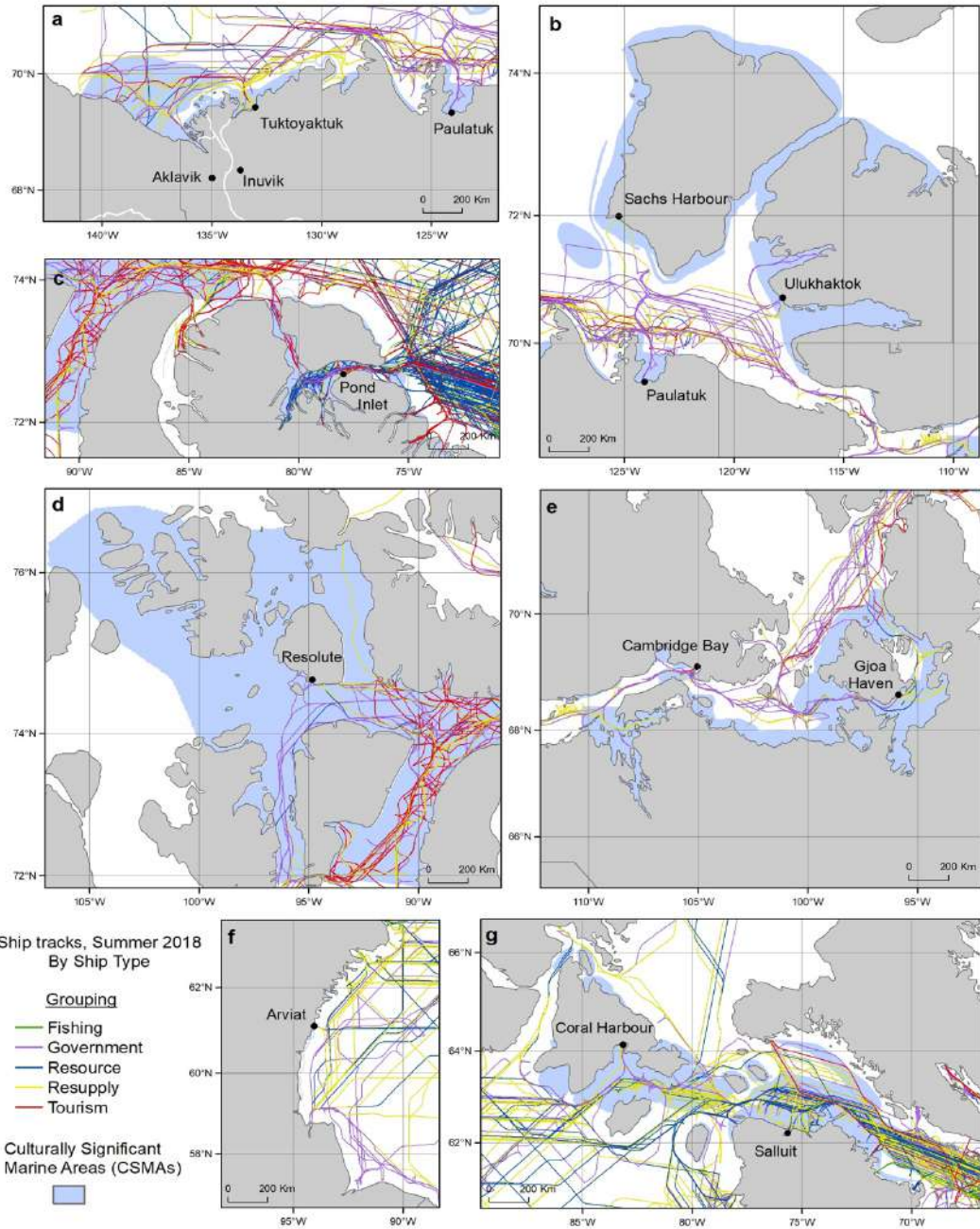
Risks FROM Ships

2. Risk from ships to cultural activities and communities



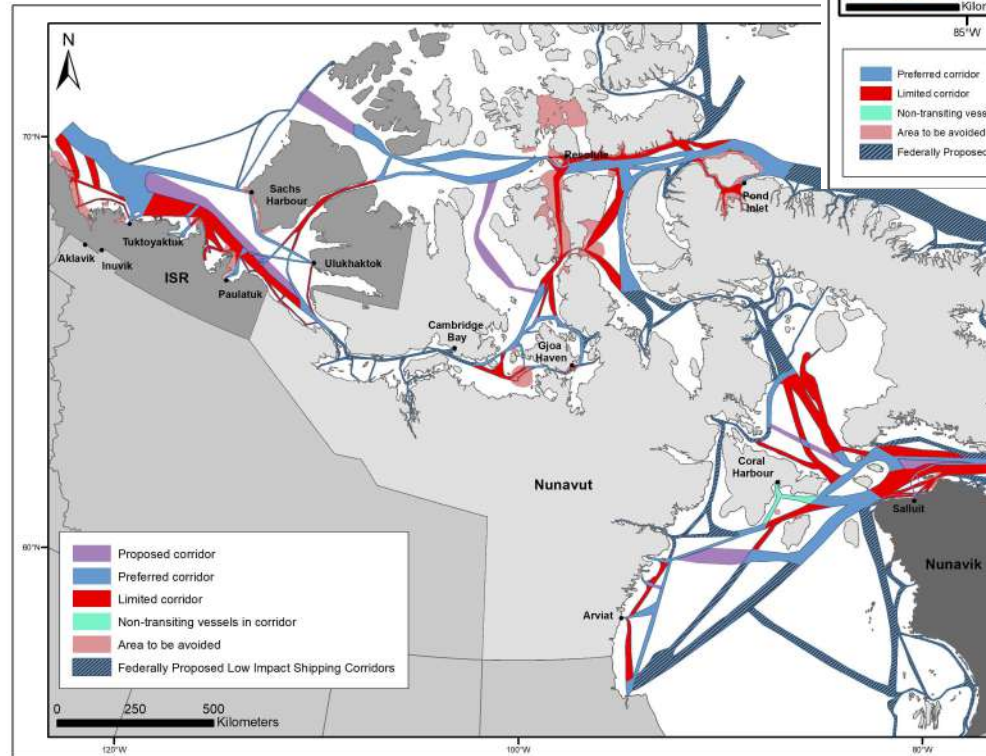
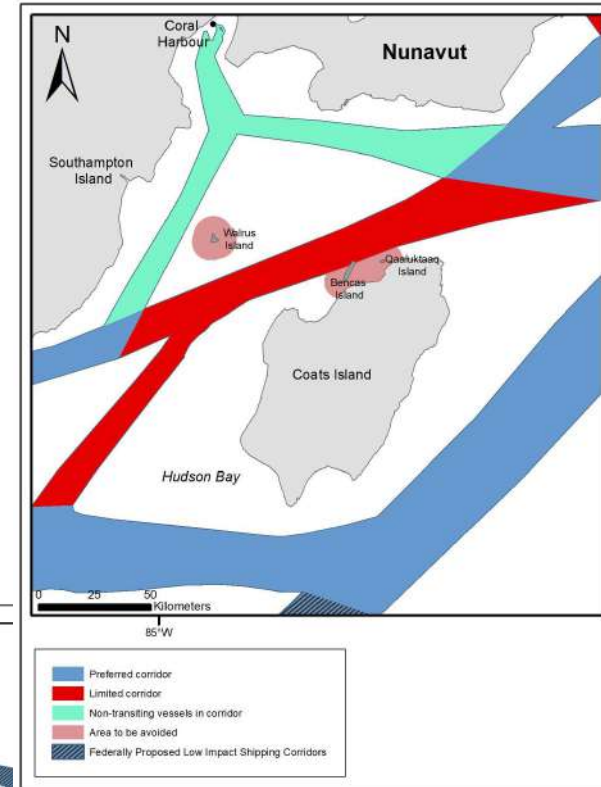
Dr. Natalie Carter

CSMAs and Ship Tracks (by Ship Type), Open Water Season, 2018

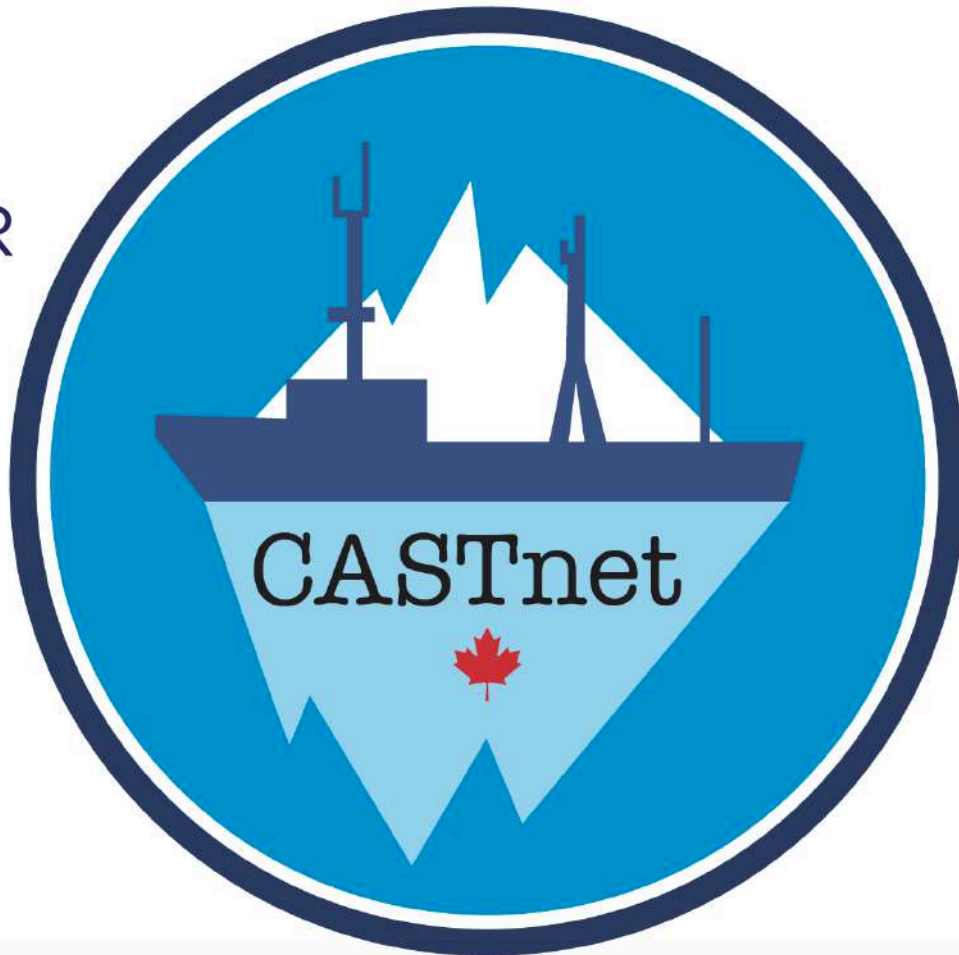


Risk Reduction Recommendation Maps

- No-go zones
- Slow-go zones
- No anchoring
- Spill equipment needed
- No ice breaking area



Next Step – university research coordination



Canadian (Circumpolar) Arctic Shipping and Transportation Research Network

Natural Science: weather and climate, ocean chemistry, sea ice

Social Science: geopolitics, history, community impacts

Law and Policy: national implications of international changes

**Science for ships!
Science off of ships!**

Thank you & Questions



Department of Fisheries and Oceans, Canadian Coast Guard, Transport Canada, Parks Canada, Nunavut Arctic College, World Wildlife Fund, Oceans North, SSHRC, NSERC, Nunavut General Monitoring Program, PEW, Adventure Canada, Canadian Ice Service, Indigenous and Northern Affairs Canada, Environment and Climate Change Canada, Polar Knowledge Canada, Students for Canada's North, University of Ottawa, Nunavut Research Institute.

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