Photo Credit: Canadian Coast Guard

Photo Credit: Annika Ogilvie

Combining Marine Traffic AIS Data and Ice Conditions to Understand Navigational Risk in the Canadian Arctic

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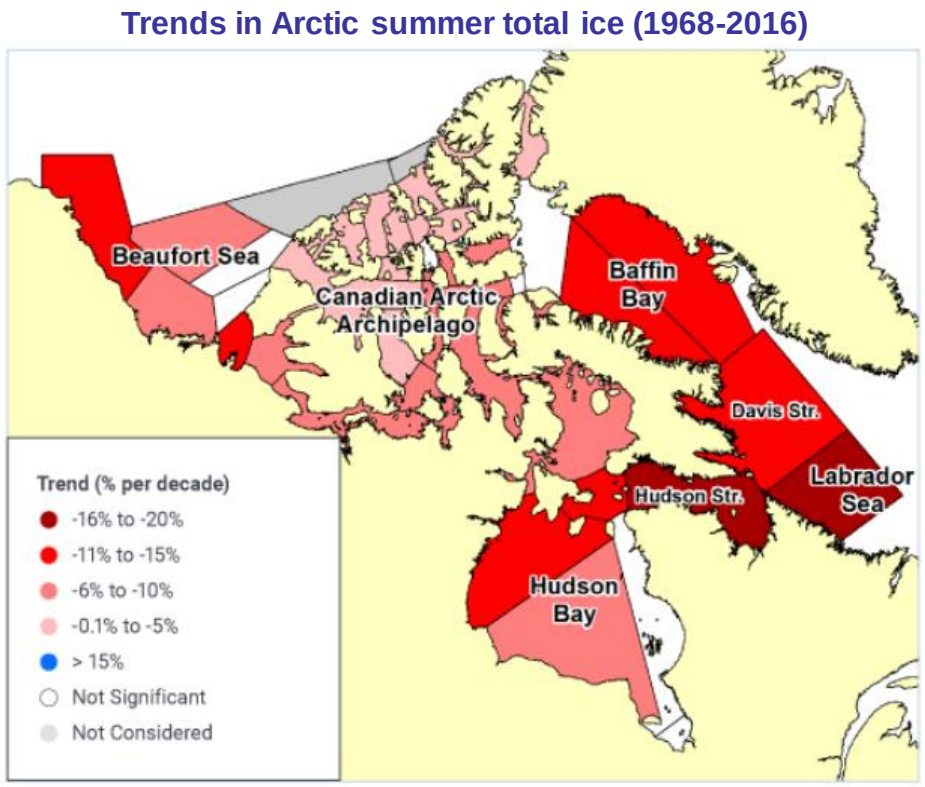
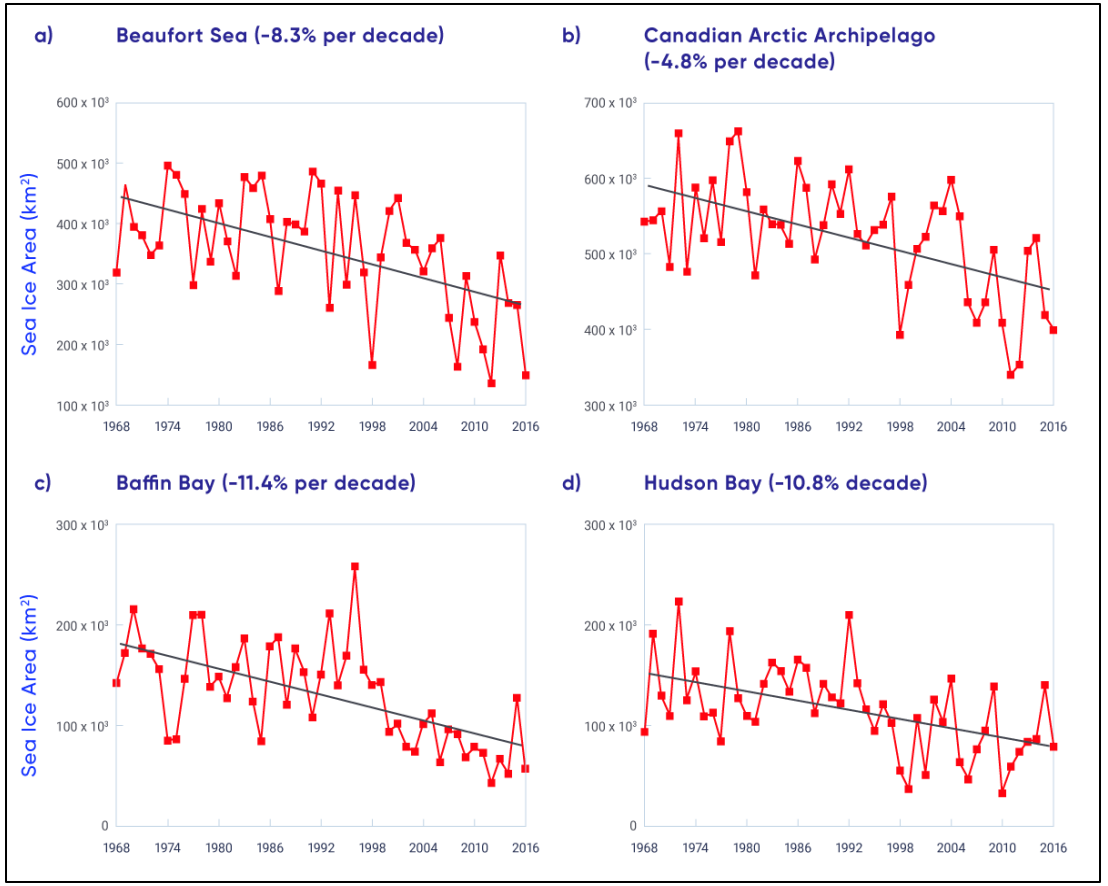
Transport Canada
Canada

- Reduction in sea ice extent and thickness



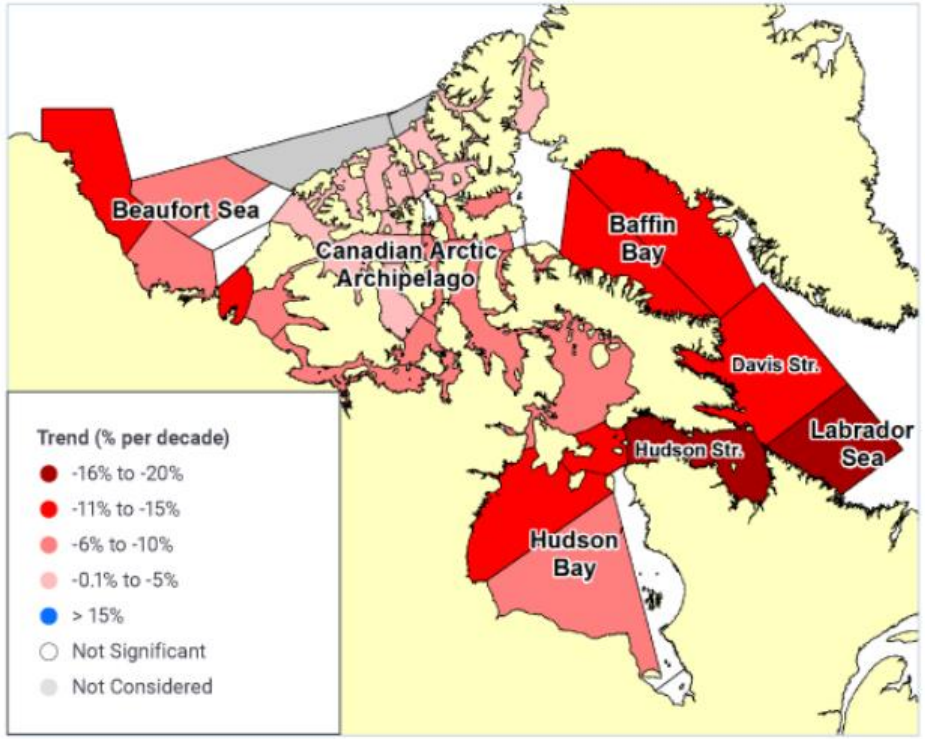
Source: Canada's Changing Climate Report (Derksen et al., 2019)



Source: Canada's Changing Climate Report (Derksen et al., 2019)

- Reduction in sea ice extent and thickness
- Increase in ice mobility and inter-annual variability

Trends in Arctic summer total ice (1968-2016)



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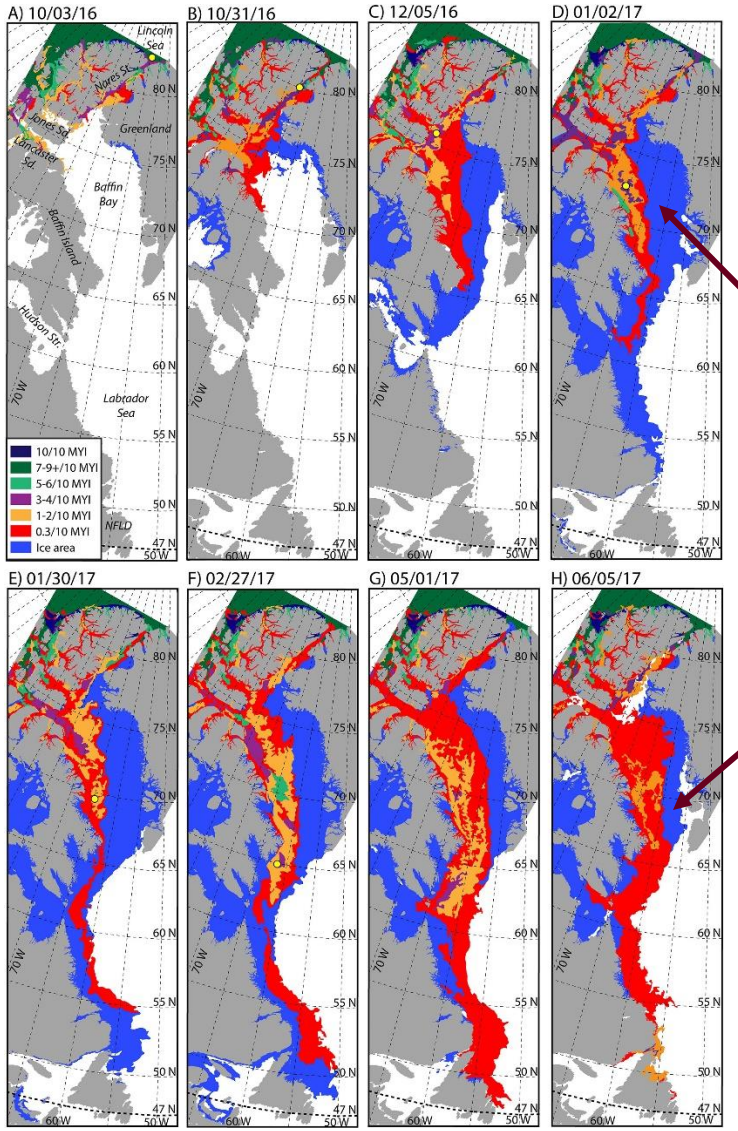
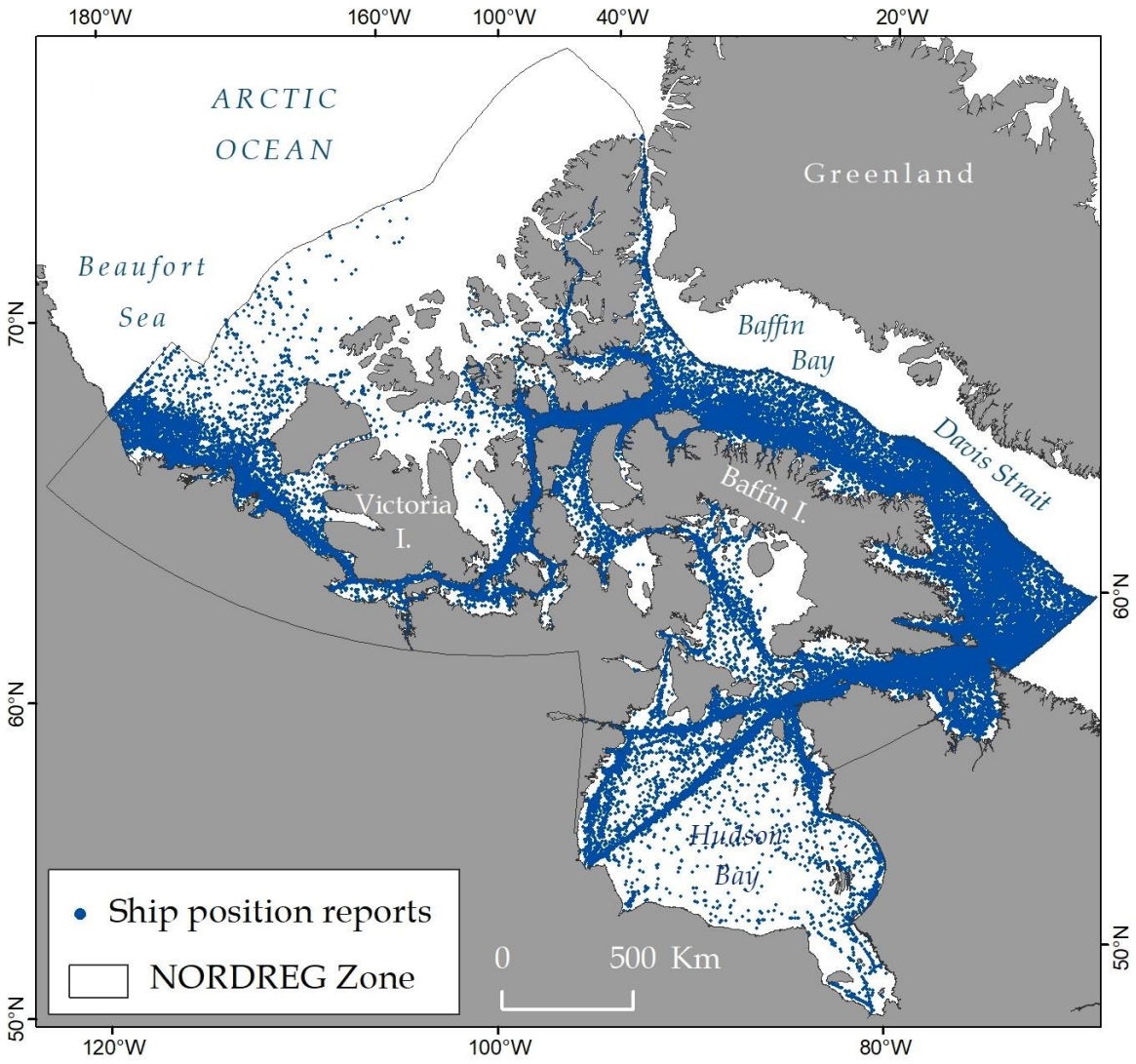


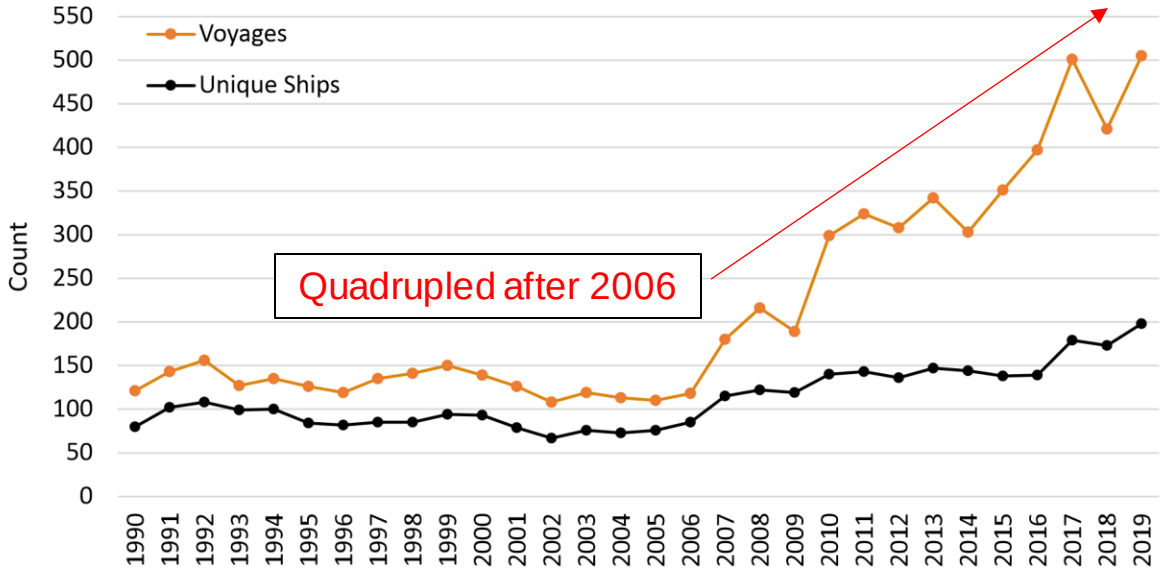
E.g. Movement of multi-year ice into Baffin Bay

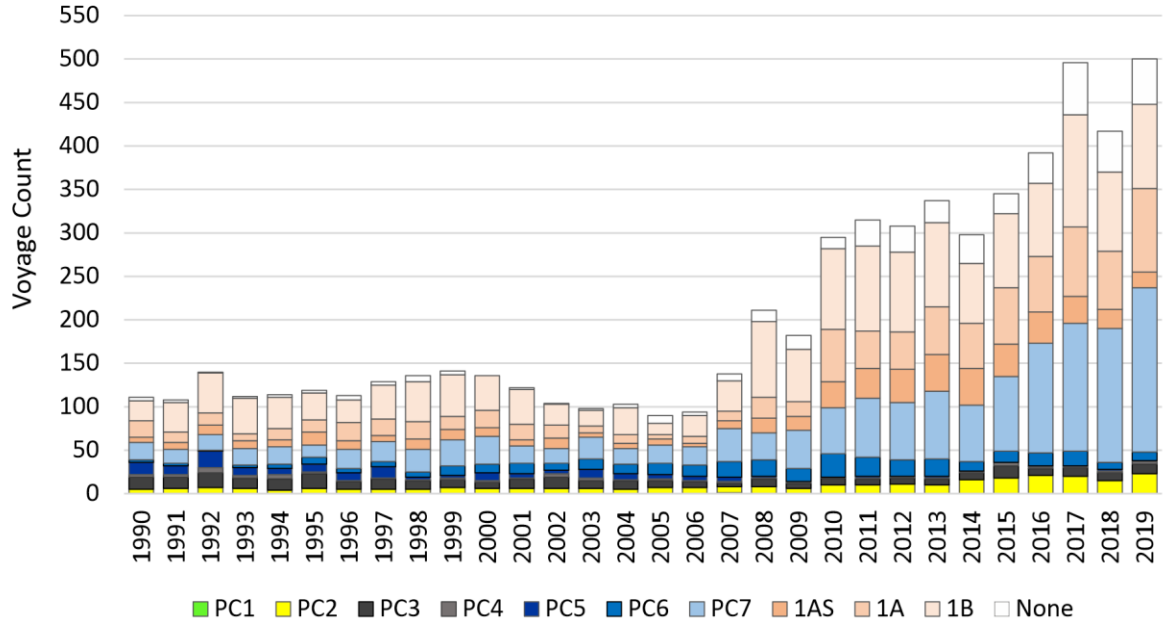
(Barber et al., 2018)

Shipping trends since 1990

Dawson et al. (2022)







Shipping trends since 1990

Dawson et al. (2022)

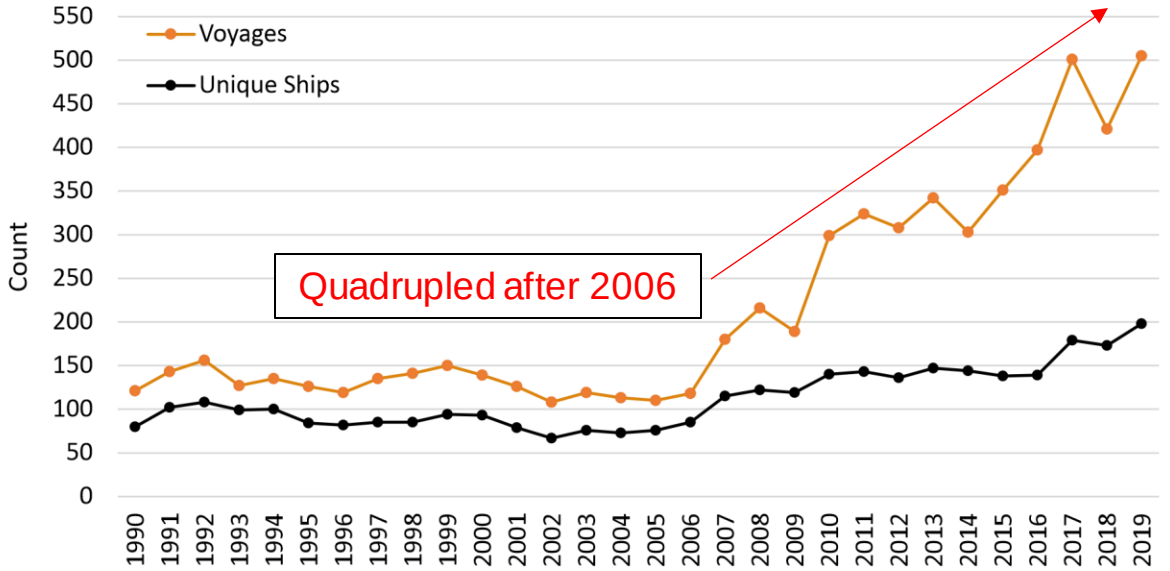
CBC

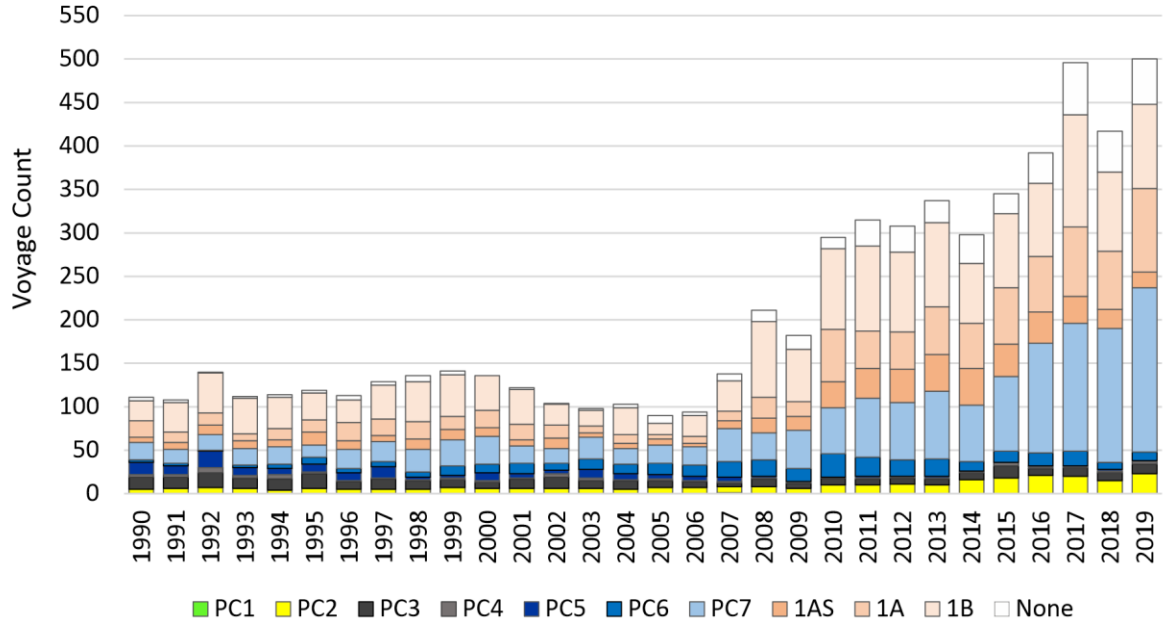
North

Fog, ice and a sinking sailboat involved in 16th Arctic-based emergency of the year

2 Argentine sailors released flares to grab the attention of emergency responders

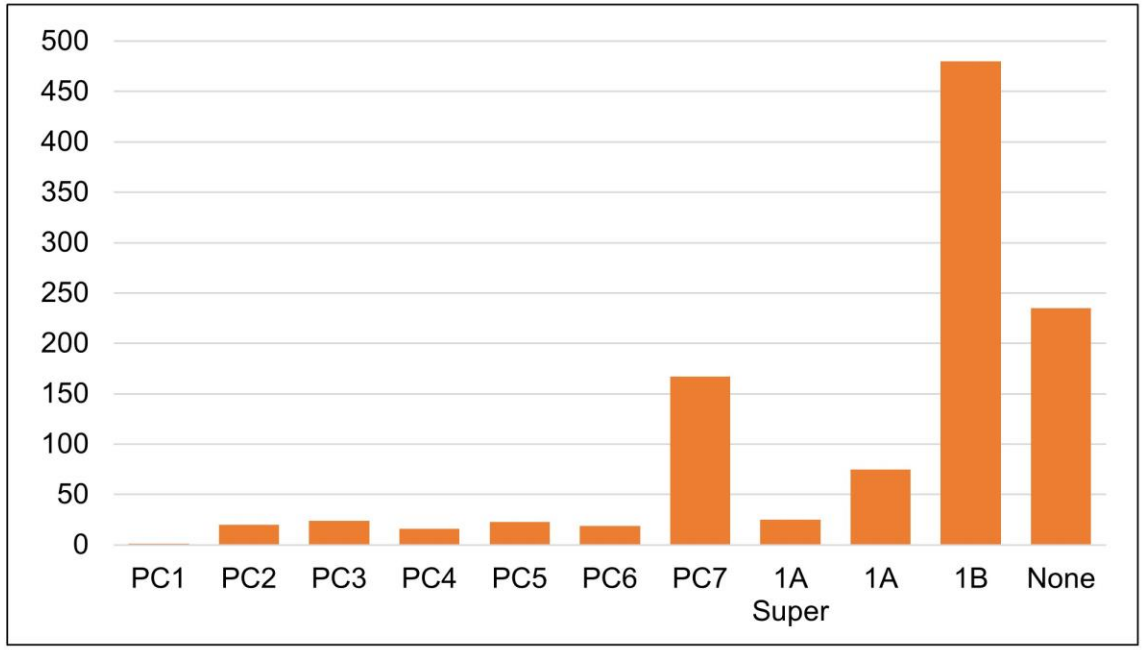
Katie Toth · CBC News · Posted: Sep 05, 2018 3:00 AM CT | Last Updated: September 5, 2018

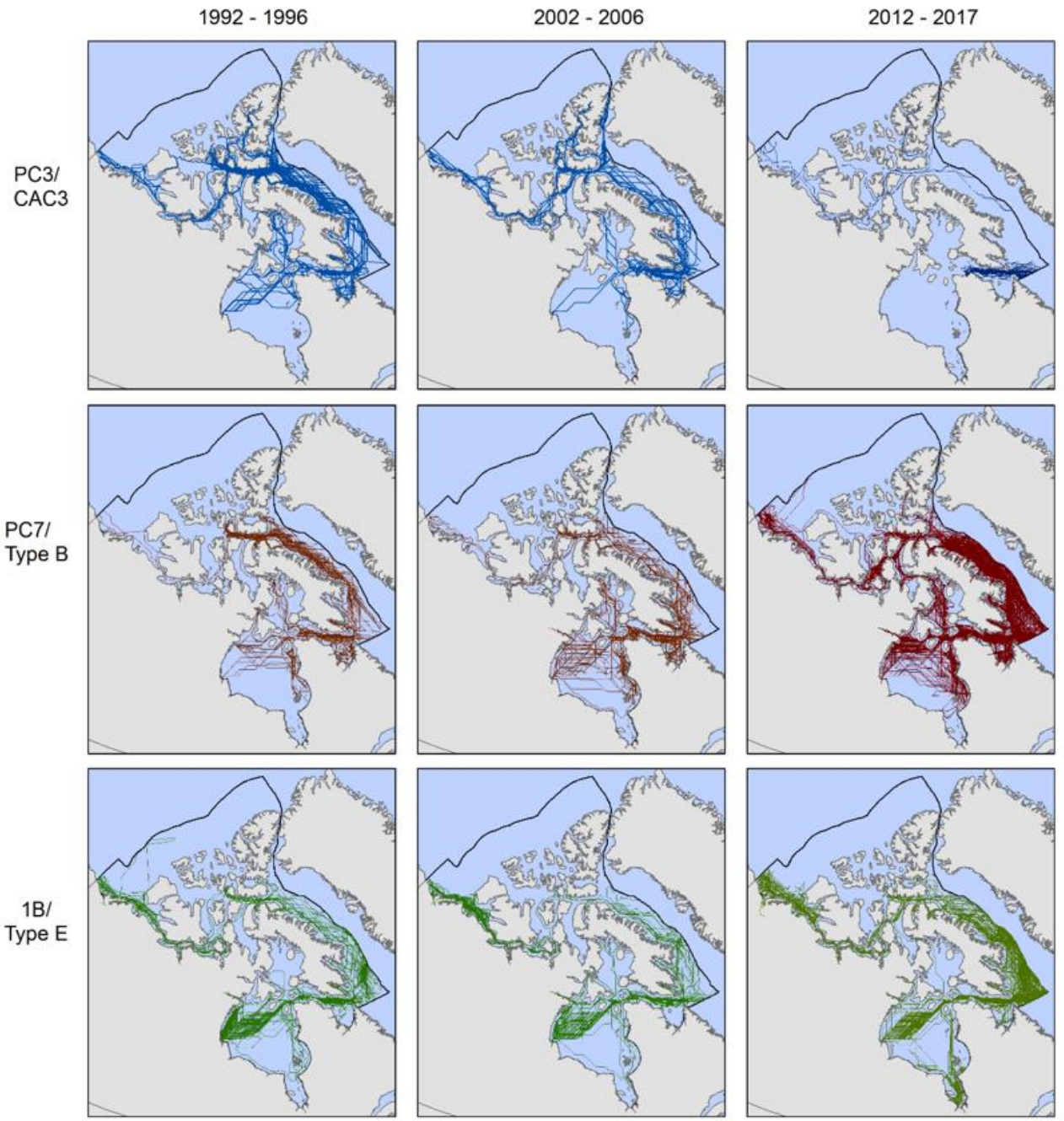




Changes in Shipping by Ship Ice Class

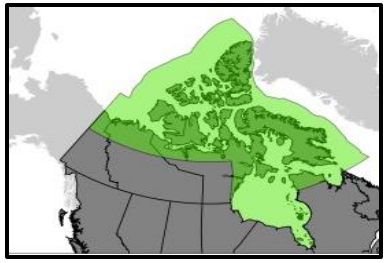
- Total of 1292 unique vessels reported 1990-2018
- 22% reported no ice strengthening
- Move towards less ice strengthening over time



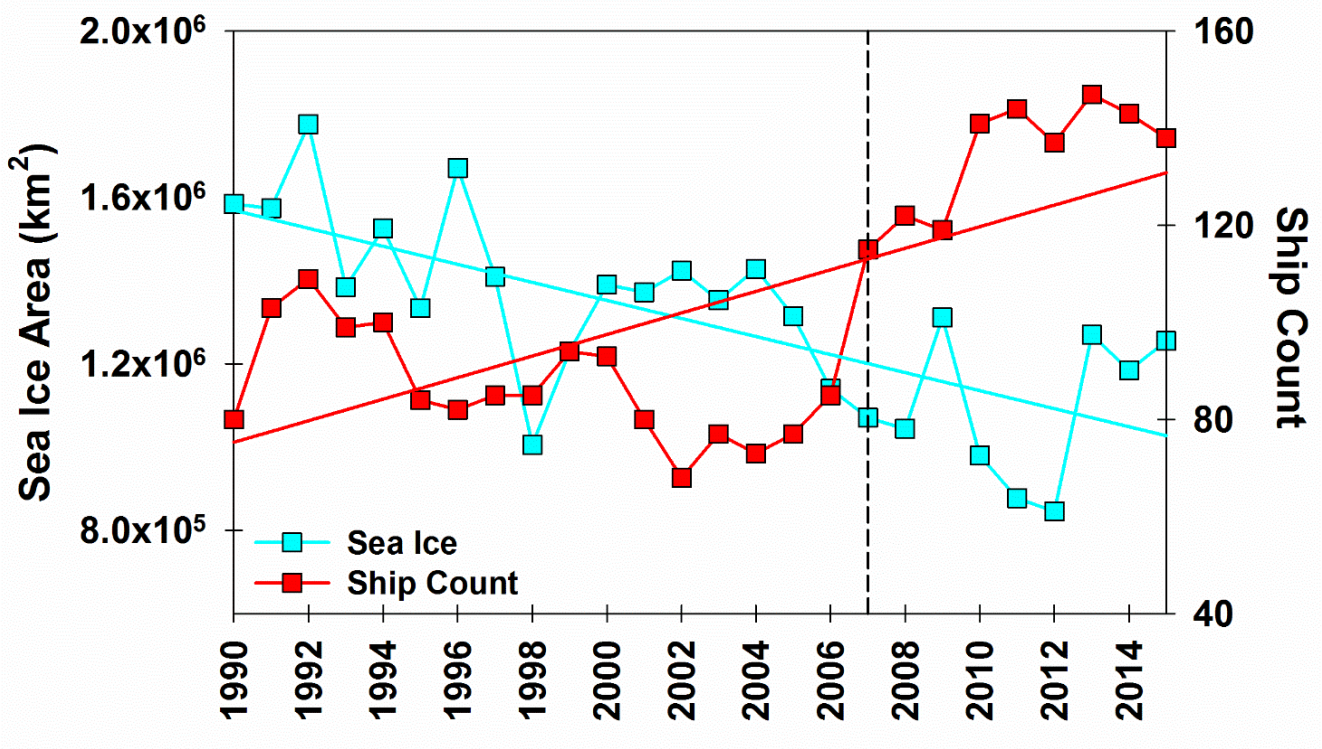


Dawson et al. (2022)

Changes in sea ice and shipping activity (1990-2015)



- Divergent trends are present for sea ice and shipping
- Significant step change in shipping activity in 2007
- De-trended correlation is low. Sea ice decline is only part of the story



Time series of total sea ice area (km^2) and unique ship count by vessel name in the Canadian Arctic sea ice domain from 1990 to 2015.

Pizzolato et al. (2016)

IS THE LEVEL OF RISK CHANGING?

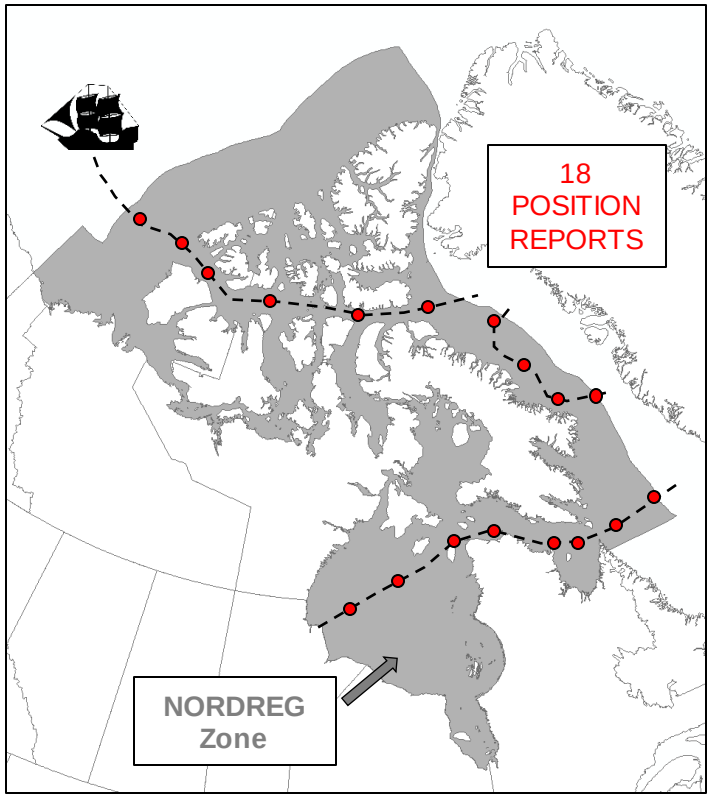
Objective: Evaluate ship activity between 1990 and 2019, detailing what ice navigational risks were encountered by vessels, including by different types of ships and with different ice strengths.

"*There's a bit of a misconception that climate changes means warming, less ice, and it's easier to navigate… In fact, it's making navigation a little riskier or more complex. For years, we could be certain that ice would be there or wouldn't be there… What we're seeing more recently is we don't know what kind of weather patterns and what kind of ice we're going to get.*"

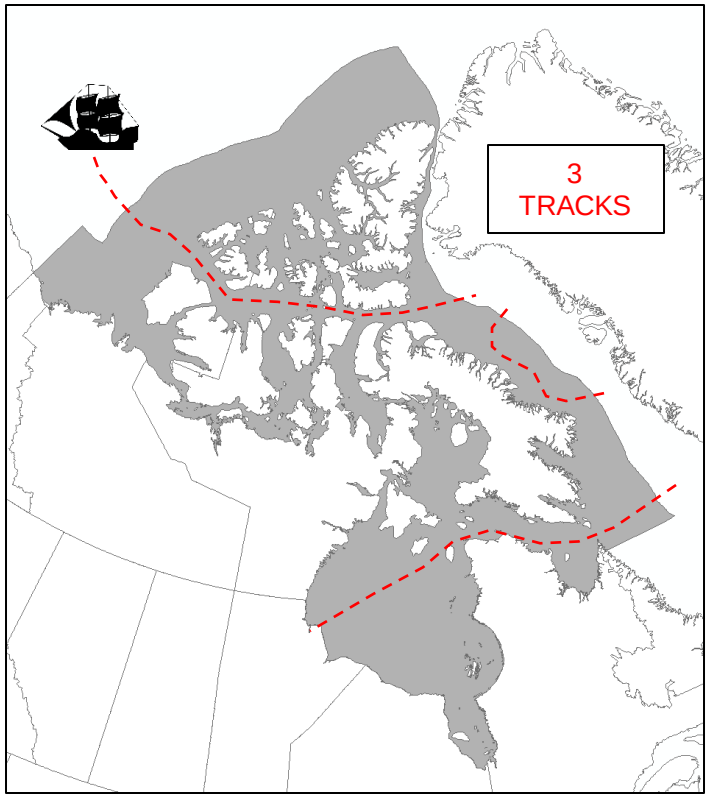
Neil O'Rourke, assistant commissioner of the Canadian Coastguard in the Arctic (Financial Post, Jan. 2, 2019)

Data is presented in three ways:

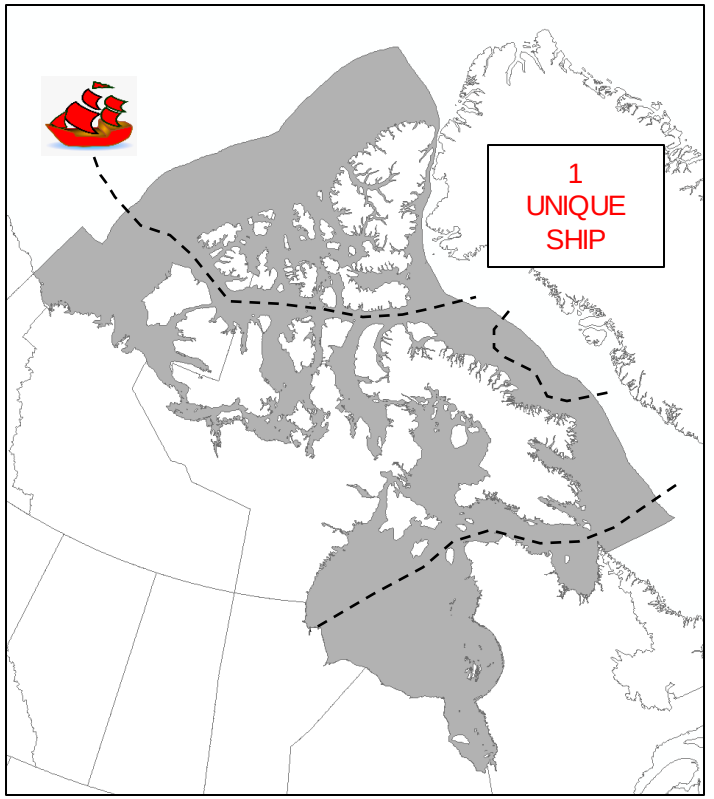
Ship Position Report



Voyage Count



Unique Ship Count



Operational risk depends on:

- Ice Class of the vessel (i.e. level of ice strengthening)

Icebreaker – Highly strengthened

CCGS Amundsen

Cargo ship – Medium strengthening

Acadia Desgagnés

Yacht – Little strengthening

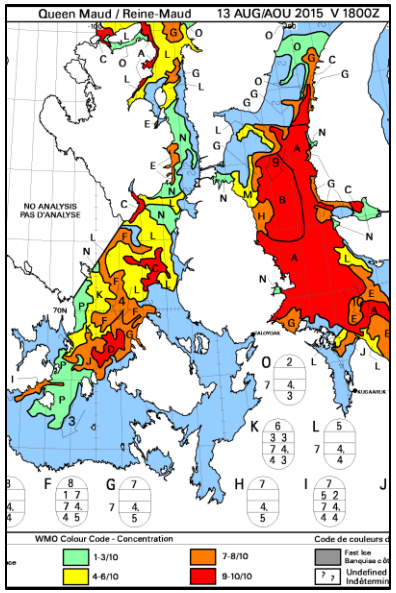
Archimedes

Operational risk depends on:

- Ice Class of the vessel (i.e. level of hull strengthening)
- Sea ice conditions in the region

RIO values assigned to **37,520 ship position reports** for 1990-2019

Ice Concentration



x

Risk Index Value (RIV)

Ice Class	Ice-Free	New Ice	Grey Ice	Grey White Ice	Thin First Year Ice 1st Stage	Thin First Year Ice 2nd Stage	Medium First Year Ice less than 1 m thick	Medium First Year Ice	Thick First Year Ice	Second Year Ice	Light Multi Year Ice, less than 2.5 m thick	Heavy Multi Year Ice
PC1	3	3	3	3	2	2	2	2	2	2	1	1
PC2	3	3	3	3	2	2	2	2	2	1	1	0
PC3	3	3	3	3	2	2	2	2	2	1	0	-1
PC4	3	3	3	3	2	2	2	2	1	0	-1	-2
PC5	3	3	3	3	2	2	1	1	0	-1	-2	-2
PC6	3	2	2	2	2	1	1	0	-1	-2	-3	-3
PC7	3	2	2	2	1	1	0	-1	-2	-3	-3	-3
IA Super	3	2	2	2	2	1	0	-1	-2	-3	-4	-4
IA	3	2	2	2	1	0	-1	-2	-3	-4	-5	-5
IB	3	2	2	1	0	-1	-2	-3	-4	-5	-6	-6
IC	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8
Not Ice Strengthened	3	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-8

Source: IMO, 2016

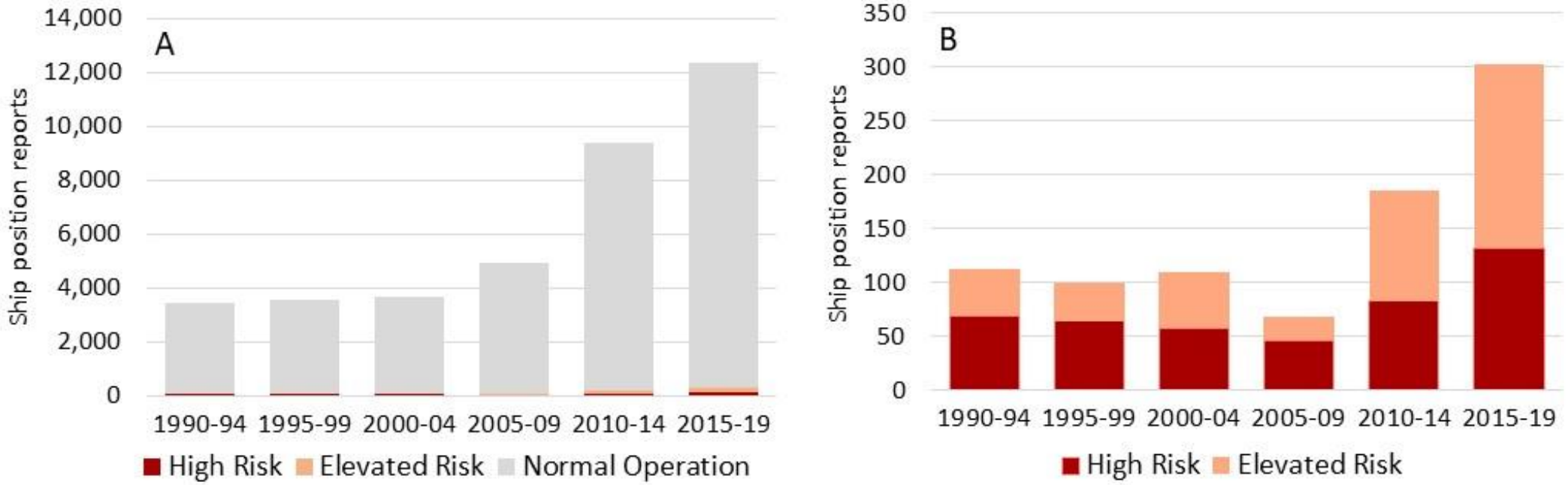
=

Risk Index Outcome (RIO)

RIO ≥ 0	Normal Operation
RIO <0 to -10	Elevated Risk
RIO < -10	High Risk

$$RIO = (C_1 \times RIV_1) + (C_2 \times RIV_2) + (C_3 \times RIV_3) + \ldots (C_n \times RIV_n)$$

- Over 96% of ships travelled in the normal operation category (RIO ≥ 0)
- Ships travelling in areas of elevated and high risk (RIO < 0) increased over time



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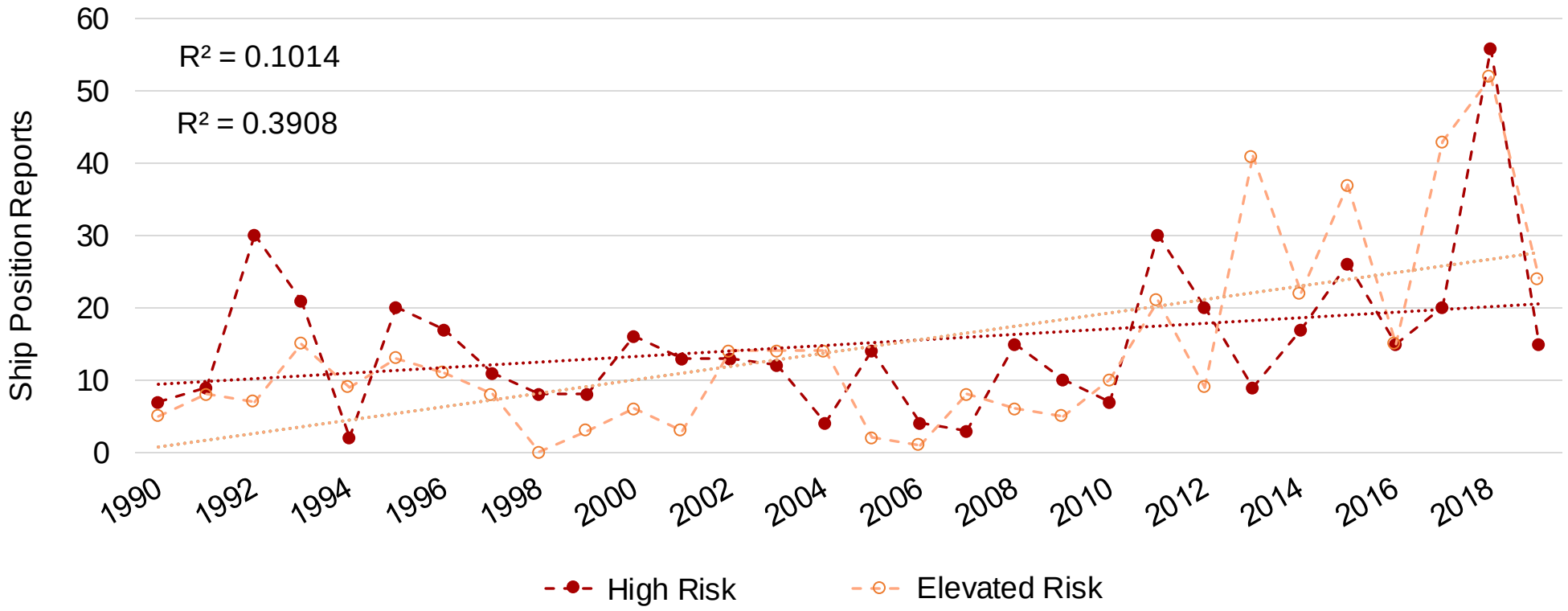
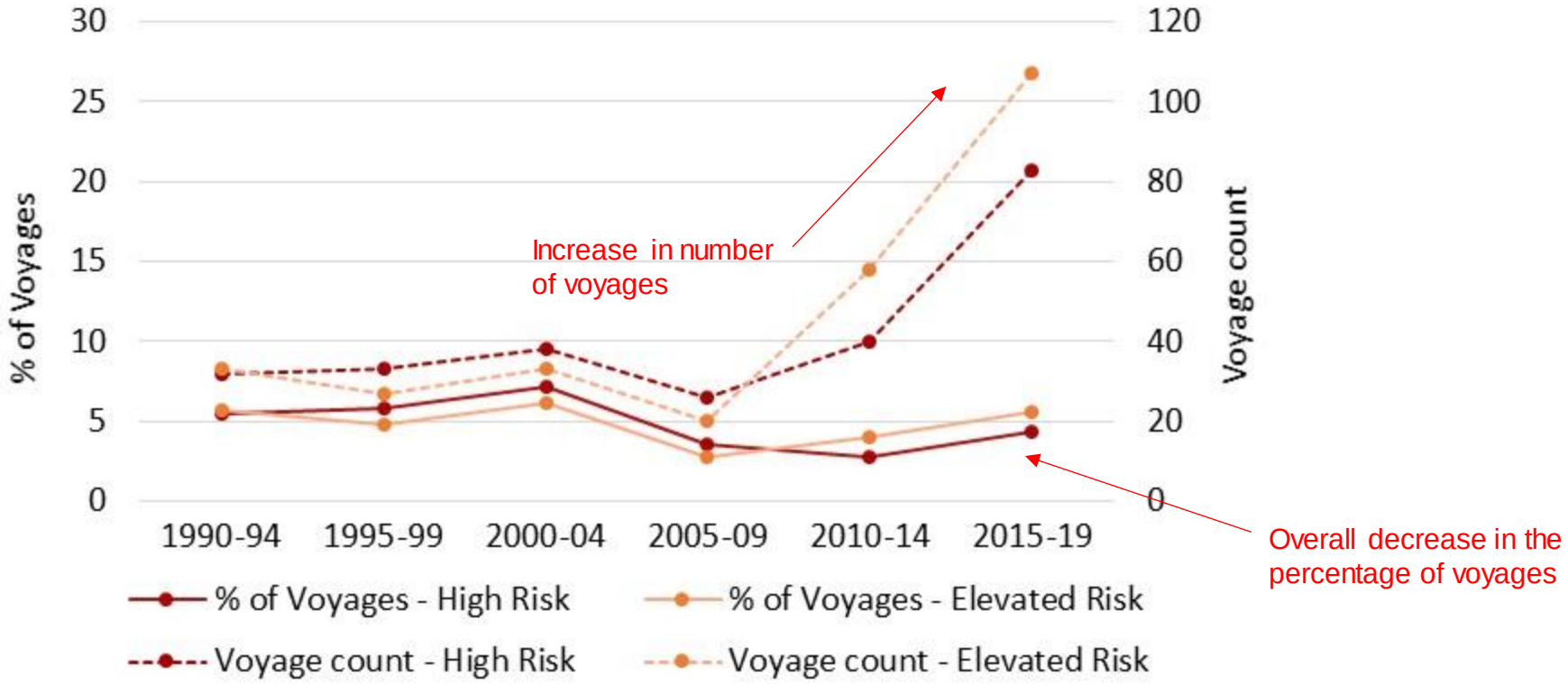
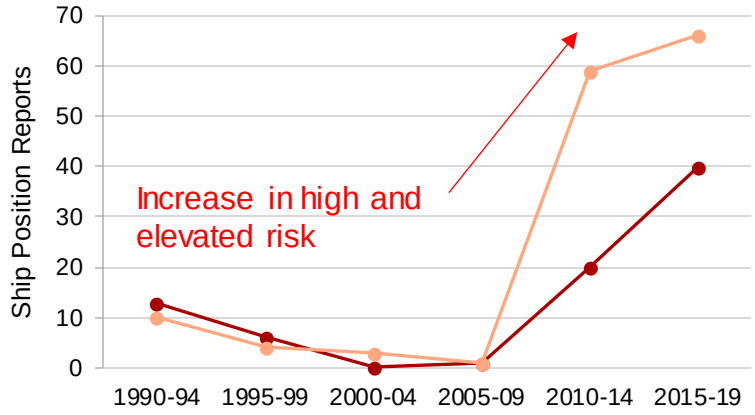
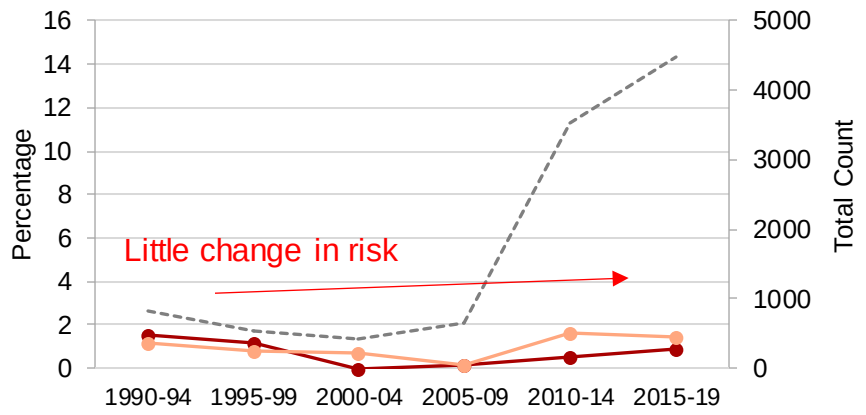


- Increase in the number of voyages with elevated and high risk conditions
- Decrease in the percentage of total voyages with elevated and high risk conditions



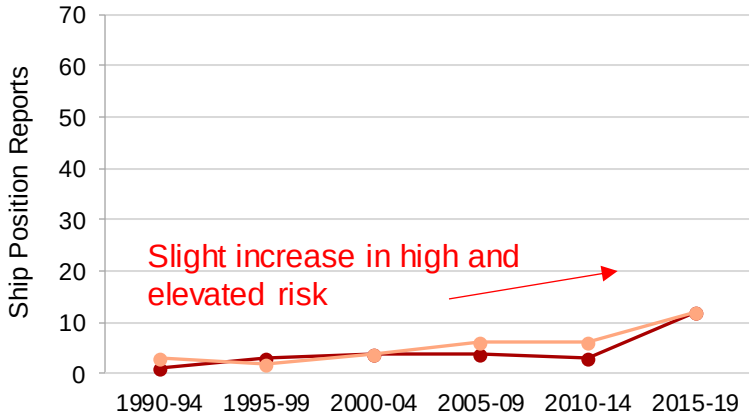
Fishing Vessel

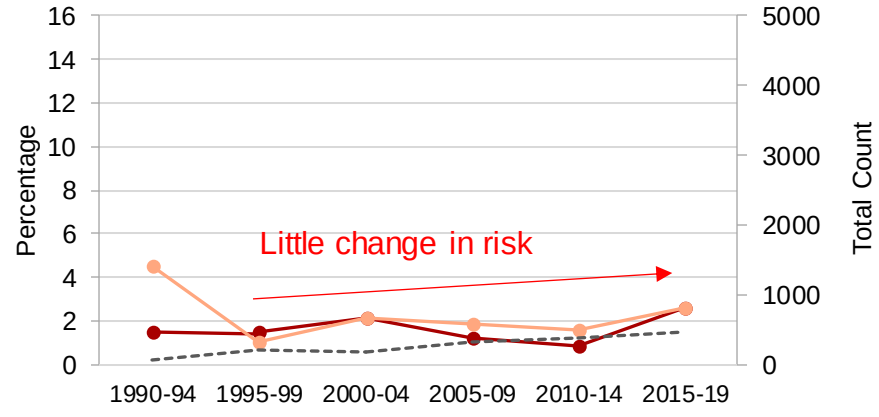




Fishing vessels, **pleasure craft**, and **passenger vessels** showed the largest <u>increases in number</u> of position reports in both risk categories.

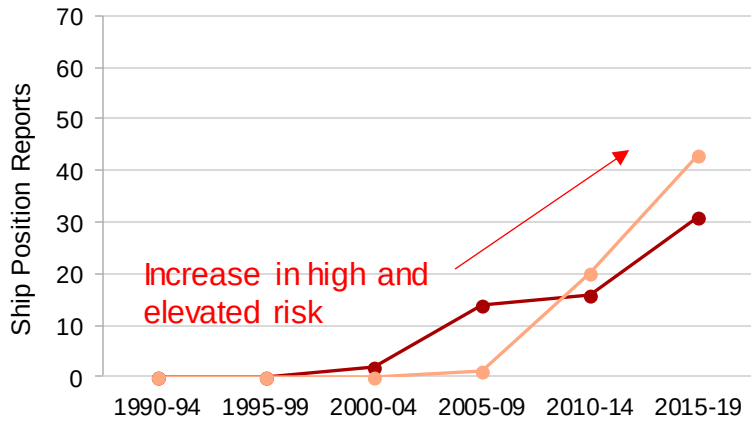
Passenger Vessels

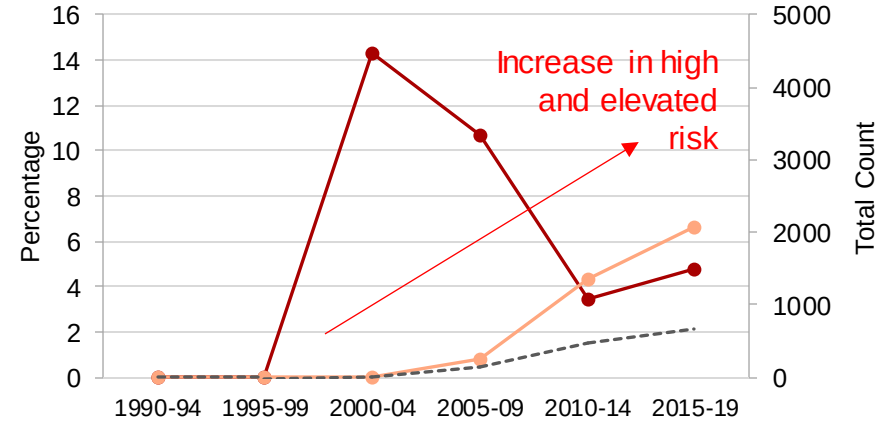




<u>Very little change in percentage</u> of total position reports in the both risk categories for **fishing vessels** and **passenger vessels.**

Pleasure Craft





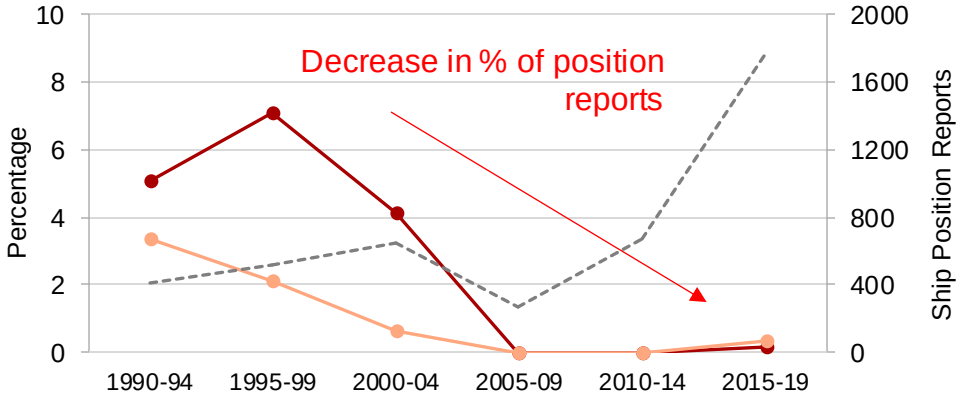
<u>Increases in percentage</u> of total position reports in the both risk categories for **pleasure craft.**

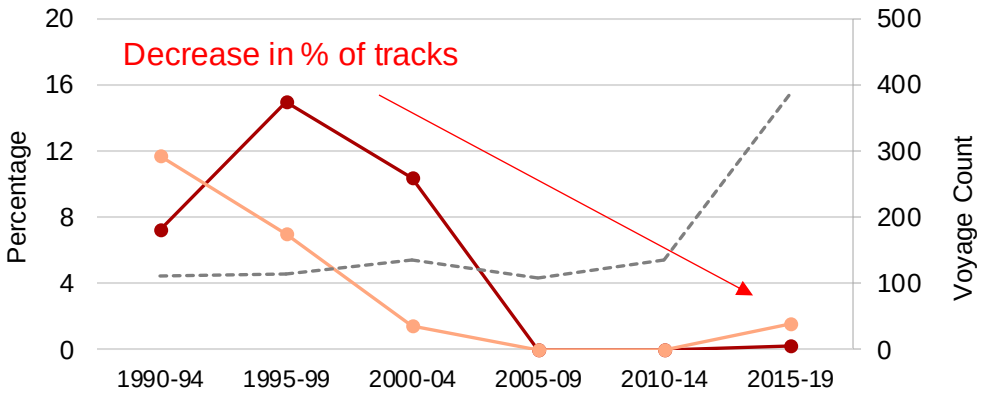
High Risk Elevated Risk Total Ship Position Reports

(Dawson et al., in prep)

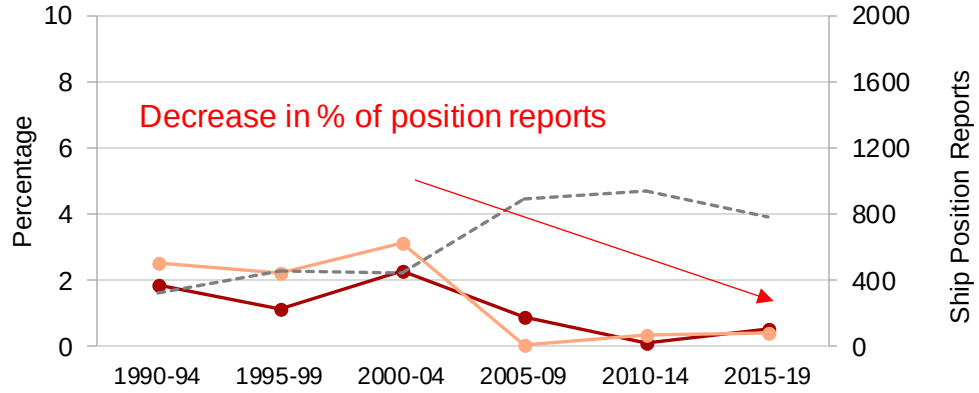
- Decrease in risk for bulk carriers and tugs/barges

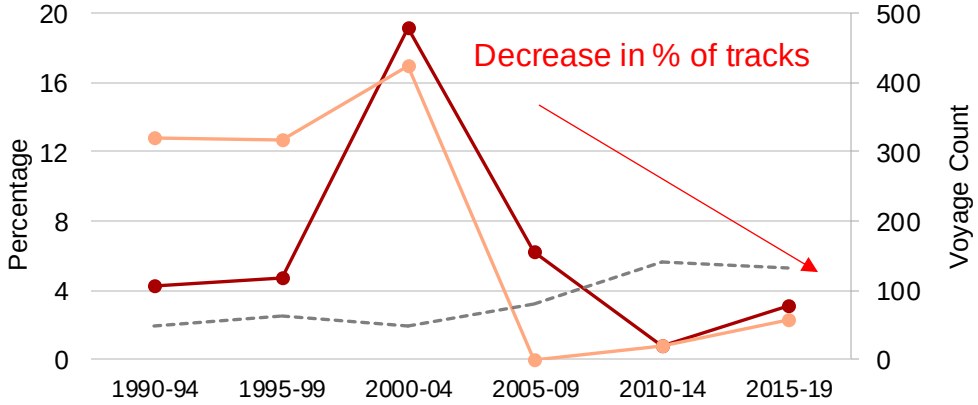
Bulk Carrier



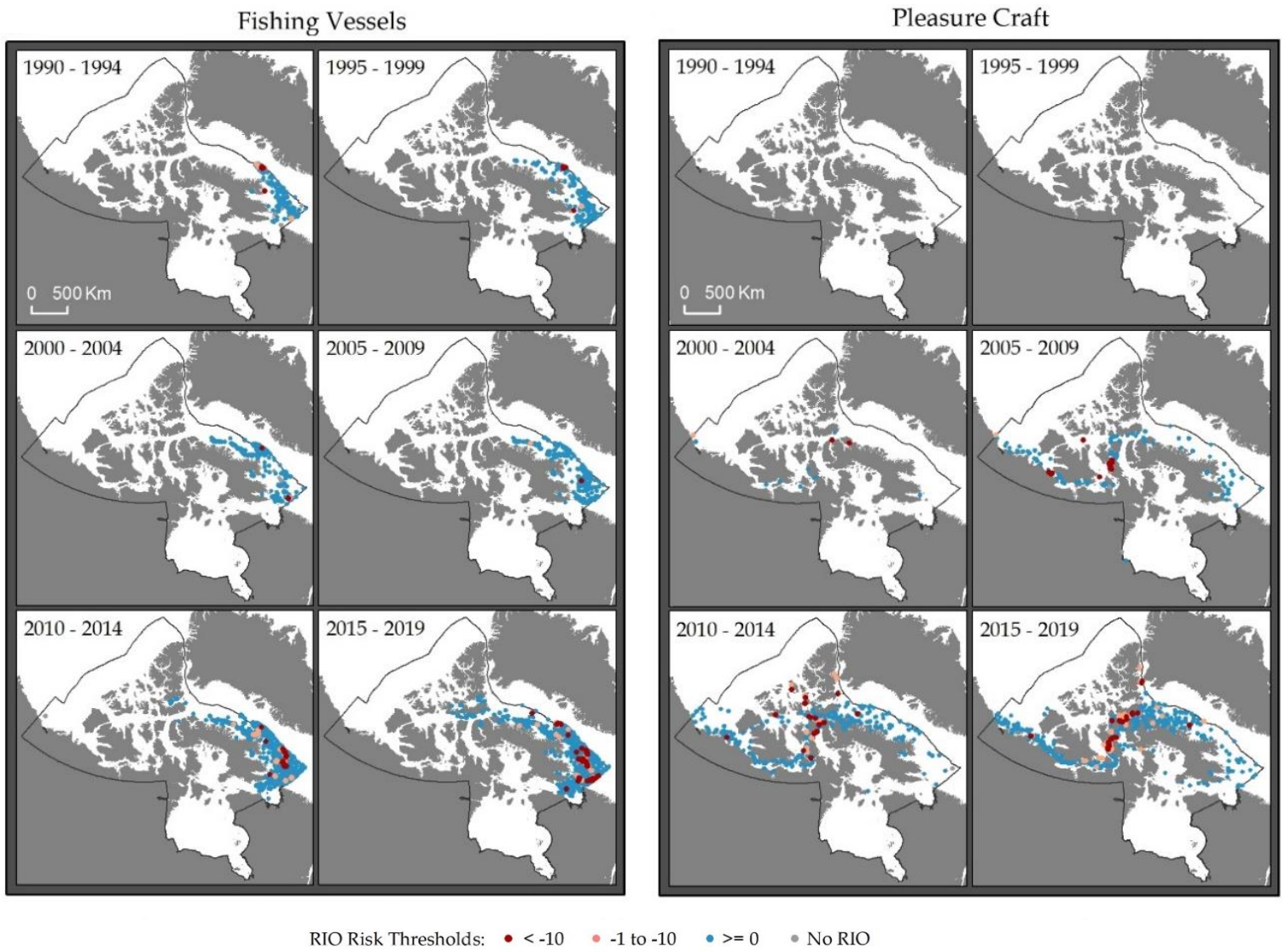


Tug/Barge



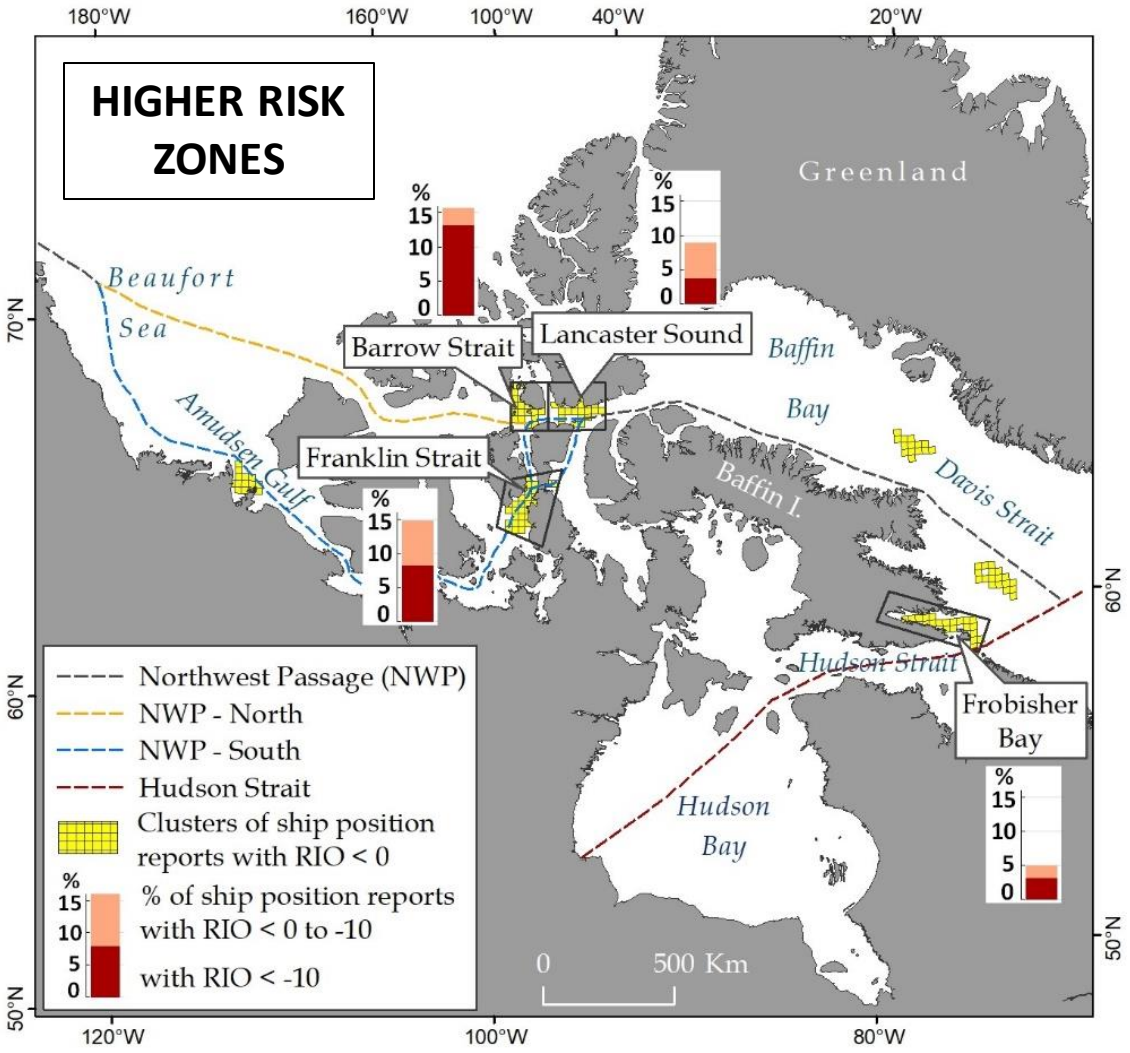


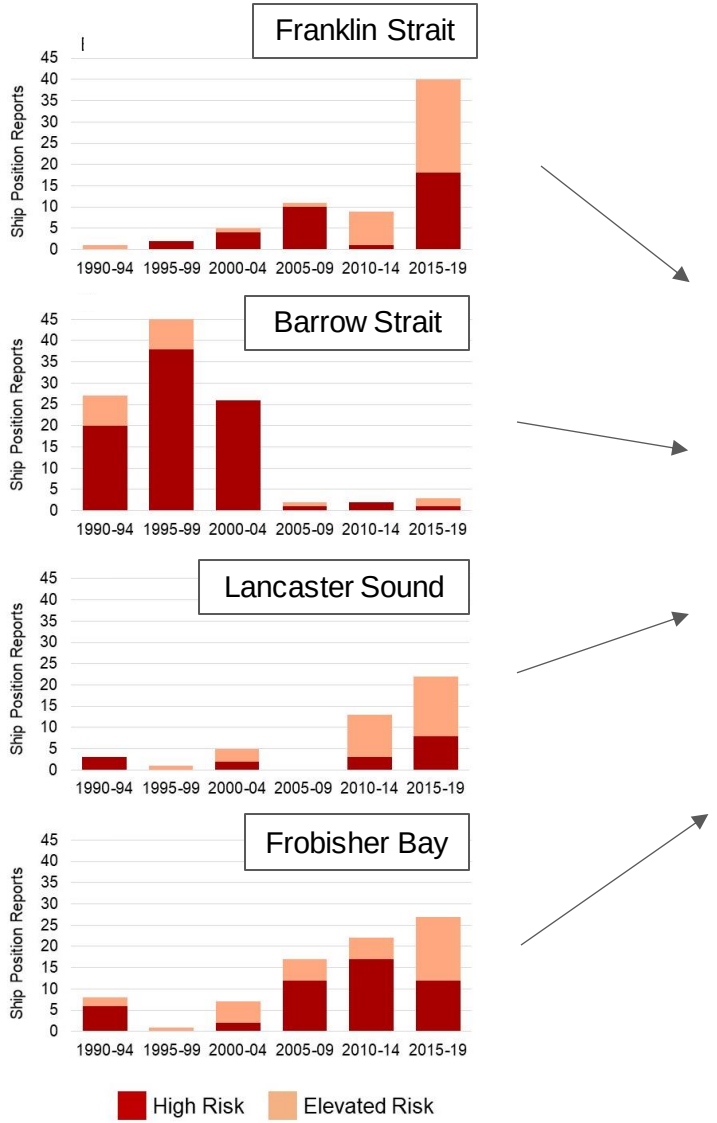
High Risk Elevated Risk Total Ship Position Reports



Increased risk from **fishing vessels** in Baffin Bay and Davis Strait.

Increased risk from **pleasure craft** mostly along the Northwest Passage after 2005, with a dramatic increase between 2010 and 2019 in Lancaster Sound and Franklin Strait.





Increase in risk over time in the four zones

CONCLUSIONS

- Increase in ship activity (position reports, voyages, unique ships)
- Most (>96%) ships operate in the "normal" category
- Ships regularly travelled under conditions of increased risk (RIO<0)
- Percentage of ships taking risks varies by ship type
- Pleasure craft experiencing the largest growth in risk, bulk carriers the greatest decrease
- Zones of high risk are Franklin Strait, Barrow Strait, Lancaster Sound, and Frobisher Bay
- Expected to continue to increase in the future

Photo Credit: Canadian Coast Guard

ACKNOWLEDGEMENTS

- Transport Canada
- NSERC
- SSHRC
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- MEOPAR
- Irving Shipbuilding
- Clear Seas
- Nunavut General Monitoring Plan
- Canada Research Chairs Program
- University of Ottawa
- Frances Delaney, Adrienne Tivy, and the Canadian Ice Service
- Will Kochtitzky

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Questions? Email me at jhollowa@uottawa.ca!

Photo Credit: Canadian Coast Guard