KRISO-EKMOA Joint Session

Sustainable Shipping Technologies in the Arctic



July 21, 2022 Marine & Ocean Engineering Session

15:45-16:10

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Background

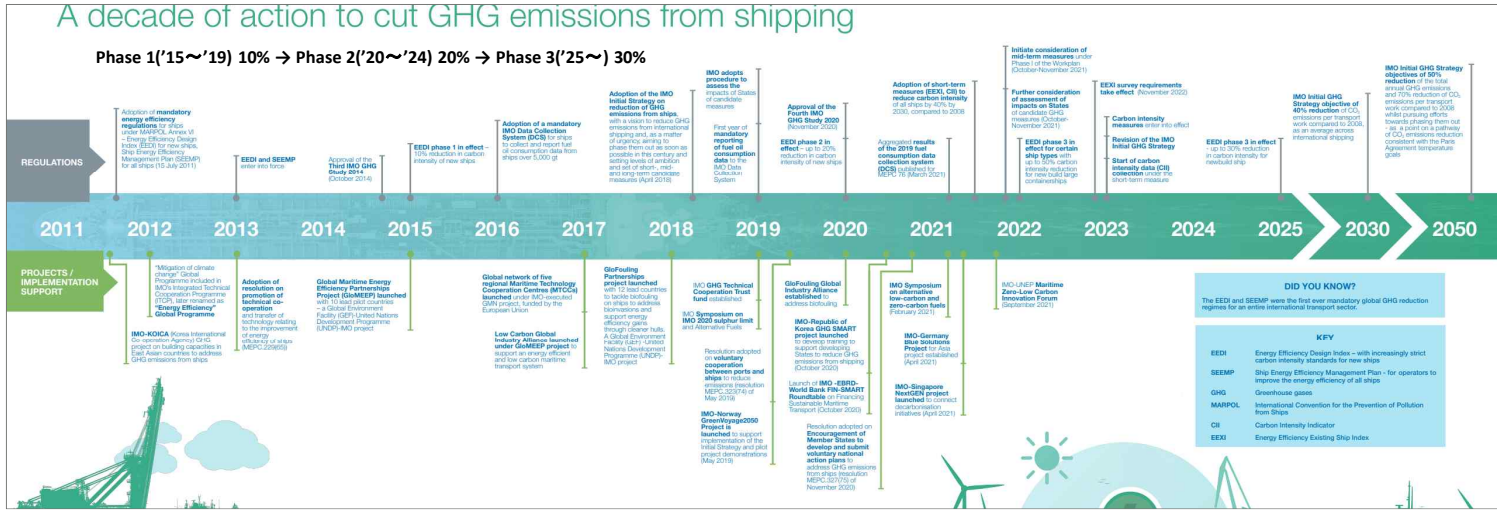
Climate Change, Prospects for the NSR…



Background

Initial IMO GHG Strategy (2018)

IMO Action is to reduce the total annual GHG emissions by at least 50% by 2050.





European Commission

Press release | 2 February 2022 | Brussels

EU Taxonomy: Commission presents Complementary Climate Delegated Act to accelerate decarbonisation

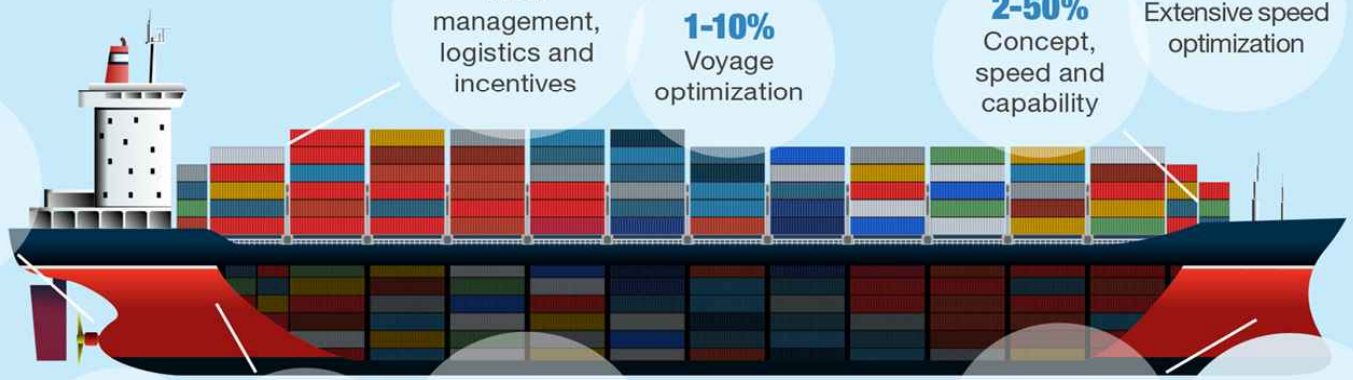
The European Commission has today presented a Taxonomy Complementary Climate Delegated Act on climate change mitigation and adaptation covering certain gas and nuclear activities. The College of Commissioners reached a political agreement on the text, which will be formally adopted once translations are available in all EU languages.

IMO’s work to cut GHG emissions from ships

IMO’s mandatory measures

A wide variety of design, operational and economic solutions

Achieving the goals of the Initial IMO GHG Strategy will require a mix of technical, operational and innovative solutions applicable to ships. Some of them, along with indication on their approximate GHG reduction potential, are highlighted below.



5-15% Power and propulsion systems

5-50% Fleet management, logistics and incentives

1-10% Voyage optimization

2-50% Concept, speed and capability

up to **75%** Extensive speed optimization

50-90% Full electric

35% Bio-LNG/LPG

90% Biofuel 3rd generation

80-100% Hydrogen and other synthetic fuels

1-10% Energy management

2-20% Hull and superstructure

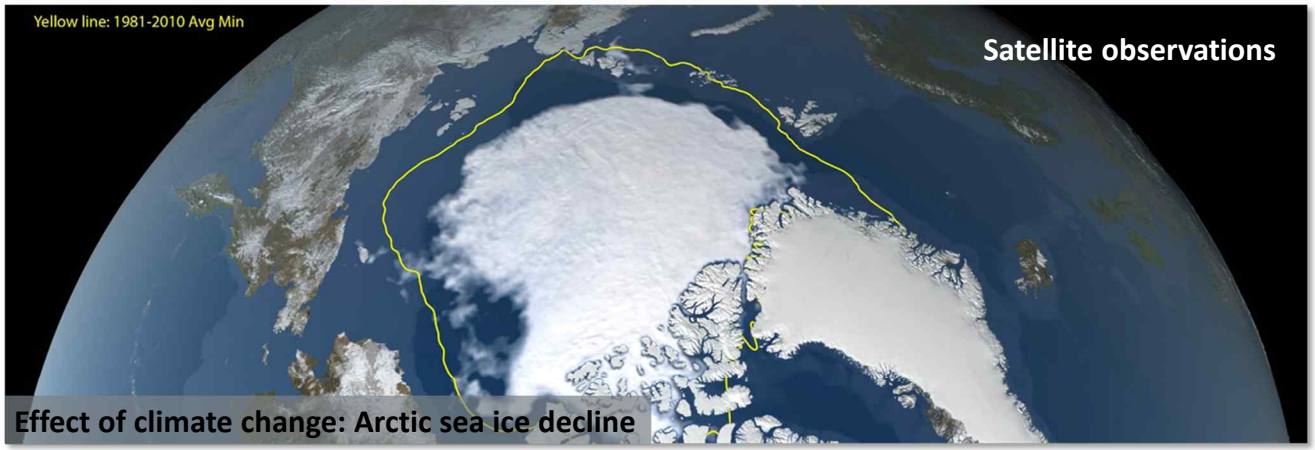
5-25% Hull biofouling management

The new opportunity of the NSR

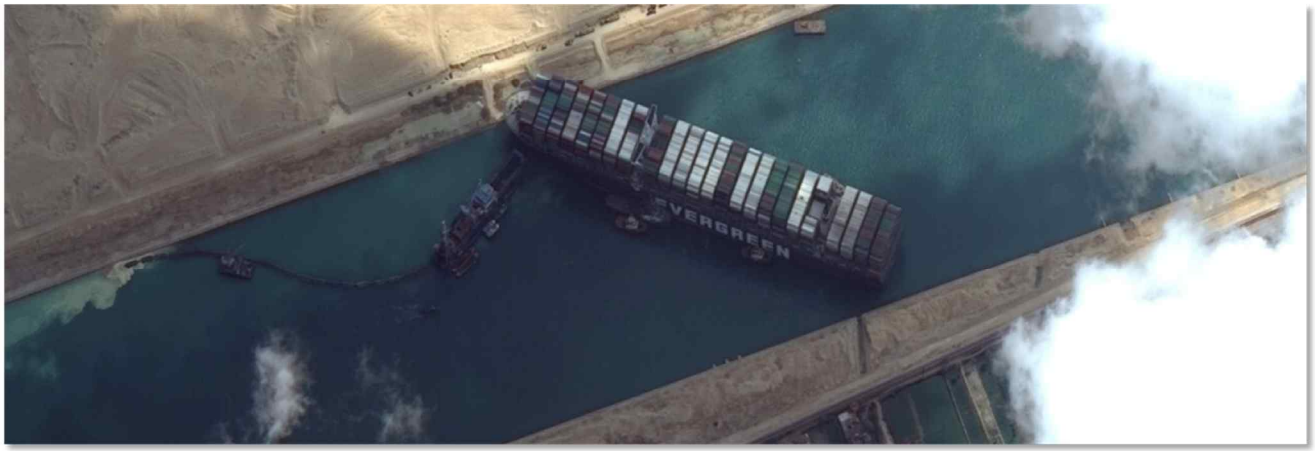
- **Fully opening the NSR may play a significant role in reshaping the world trade map**

Arctic sea ice hits 2021 minimum

This summer's minimum ice cover was twelfth-lowest ever — and scientists warn that the long-term trend towards shrinking continues.



Effect of climate change: Arctic sea ice decline



Suez Canal blockage March 23, 2021

The accident, which blocked traffic through the shortest maritime route between Europe and the lands lying around the Indian and western Pacific oceans, has highlighted a huge potential risk for a business that supports immense daily flows of goods around the world.

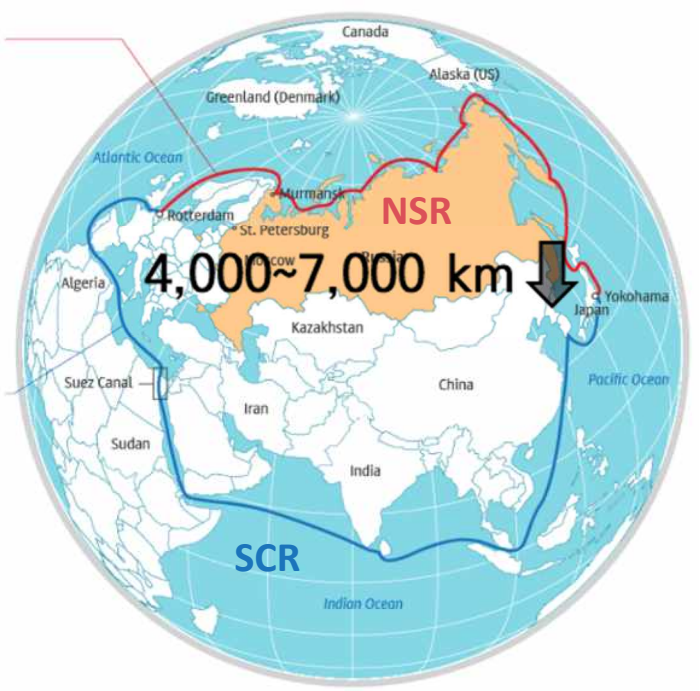
Navigating the future of Arctic Shipping

- **Opening up the northern sea route will change the face of trade.**

Challenges and Opportunities of the NSR

20
Time in transit (days)

33
Time in transit (days)



Arctic Shipping Trends (*incl. merchant vessel*)
25% ▲

2013
1298
Ships

2019
1628
Ships



Navigational risk factors of the Arctic shipping



Environmental Protection and Polar Code

Arctic environment, intergovernmental forum, and regulation…



The importance of the Arctic and environmental considerations

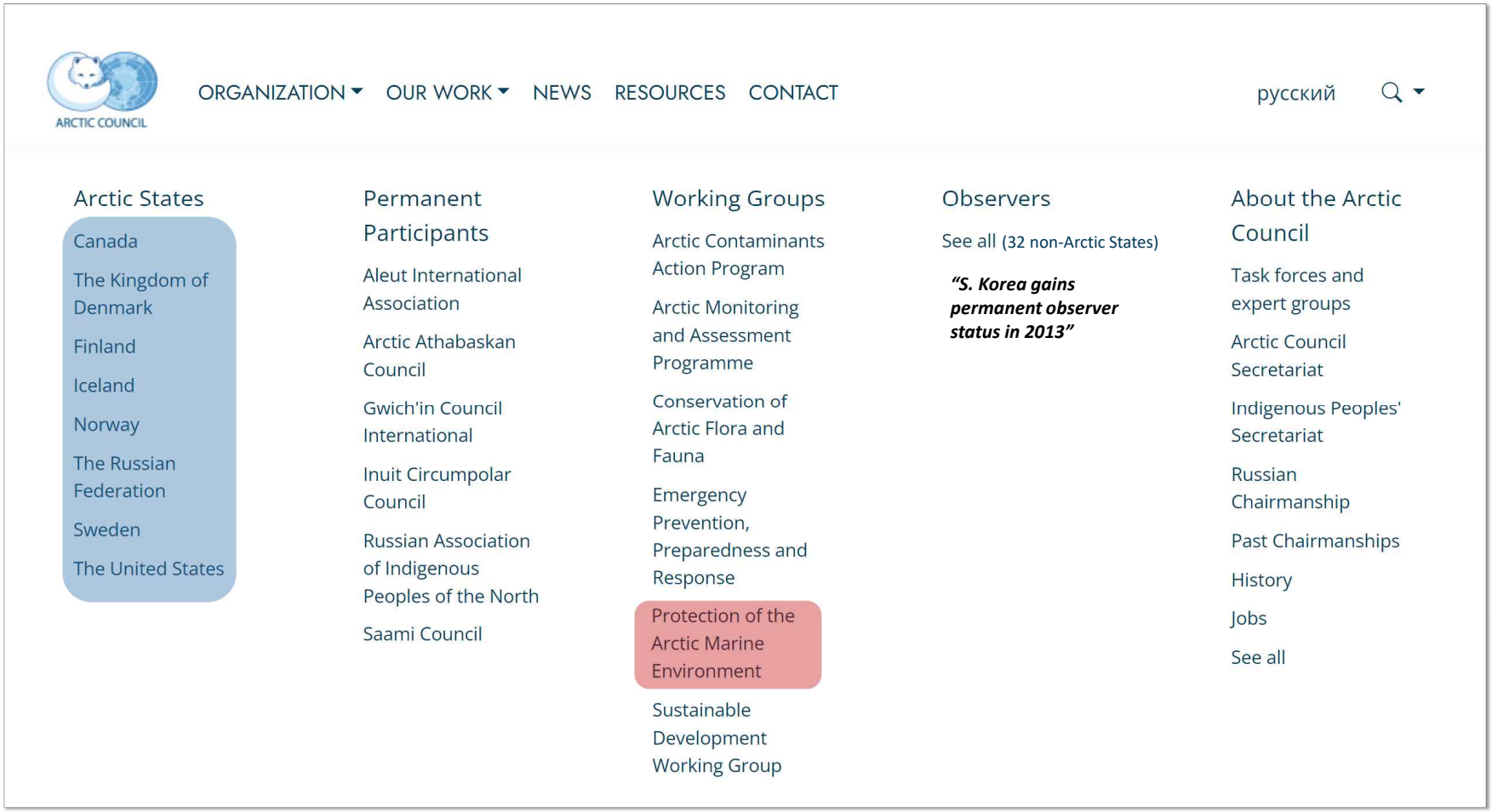
- **International cooperation and regulation are necessary to ensure sustainable development in the Arctic.**





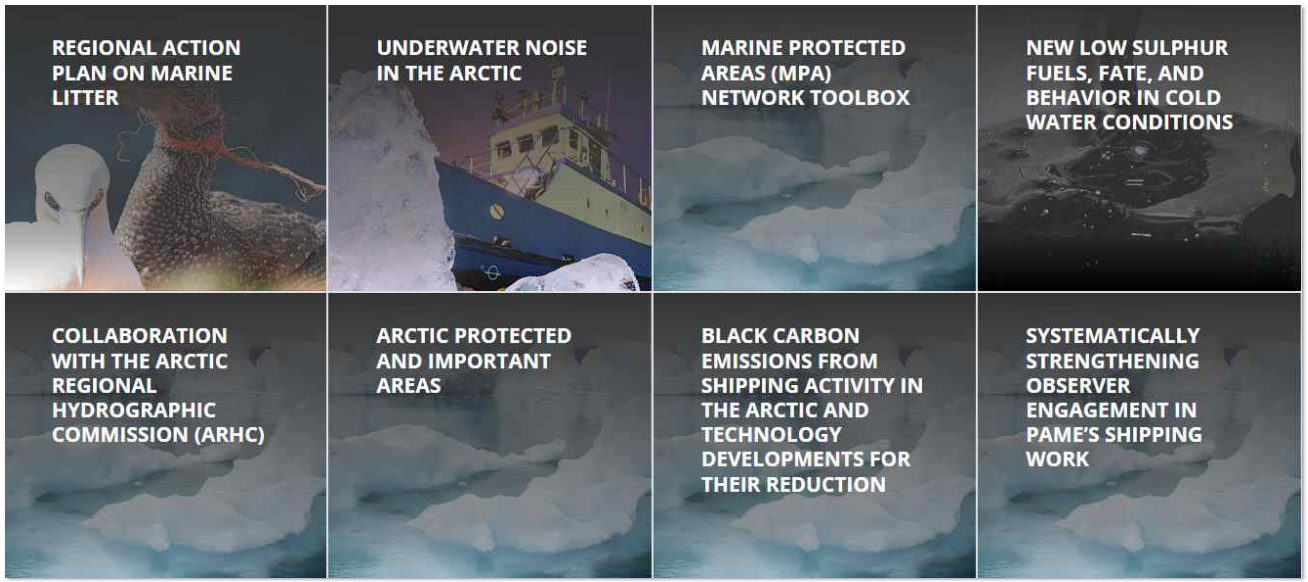


Arctic Council : Intergovernmental Forum



The protection and sustainable use of the Arctic marine environment

- **PAME(establishment 1991 Arctic Environmental Protection Strategy)**
  - **PAME's projects largely operate within the following themes:**
    - **Arctic Shipping**
    - **Marine Protected Areas**
    - **Resource Exploration and Development**
    - **Ecosystem Approach to Management**
    - **Arctic Marine Pollution**

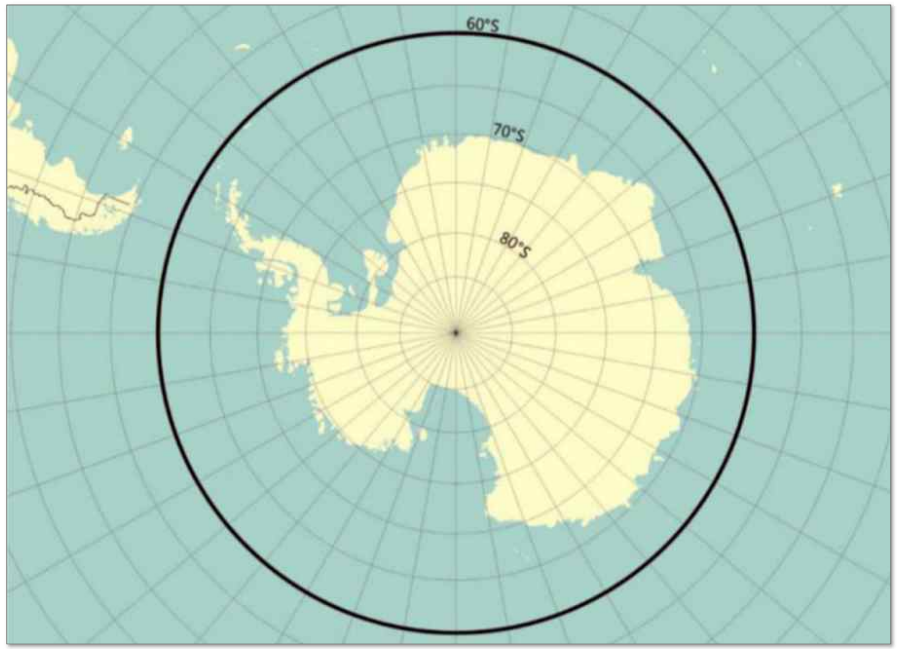


International Code for Ships Operating in Polar Waters

- **Polar Code (Regulatory requirements)**
  - **The mandatory Polar Code, for ships operating in Arctic and Antarctic waters, entered into force on 1 January 2017.**



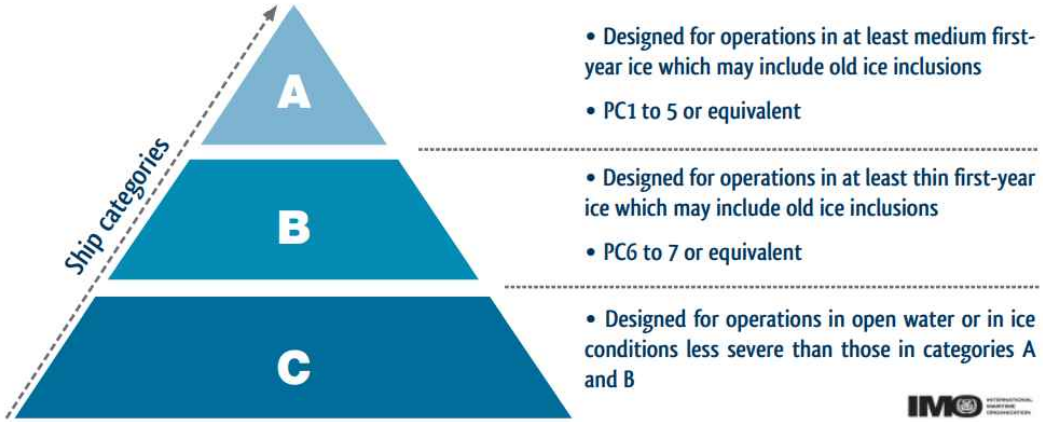
Arctic



Antarctic

International Code for Ships Operating in Polar Waters

- **Polar Ship Category A, B, and C**
  - **A ship's category determines the applicability of some requirements and regulations in the Code.**



Content	Intended for	Remark
Part I	·Part I-A: Mandatory provisions on safety measures in accordance with the relevant SOLAS chapter ·Part I-B: Recommendations on safety	Included through a new chapter XIV in SOLAS
Part II	·Part II-A: Mandatory provisions on pollution prevention in accordance with relevant MARPOL Annexes ·Part II-B: Recommendations on pollution prevention	Included in MARPOL Annexes I, II, IV and V

Polar Operational Limitations Assessment Risk Indexing System

- **IMO Methodology, POLARIS**
  - **It is the choice for operators on their Polar Ship Certificate for stating limitations for operating in ice.**

Winter Risk Values(RVs)

Polar Ship Category	Ice Class	Ice Free -	New Ice 0-10cm	Grey Ice 10-15cm	Grey White Ice 15-30cm	Thin First-year Ice 1st Stage 30-50cm	Thin First-year Ice 2nd Stage 50-70cm	Medium First-year Ice 1st Stage 70-95cm	Medium First-year Ice 2nd Stage 95-120cm	Thick First-year Ice 120-200cm	Second-year Ice 200-250cm	Light Multi-year Ice 250-300cm	Heavy Multi-year Ice 300+cm
A	PC 1	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
B	PC 6	3	2	2	2	2	1	1	0	-1	-2	-3	-3
	PC 7	3	2	2	2	1	1	1	-1	-2	-3	-3	-3
C	1A Super	3	2	2	2	2	1	0	-1	-2	-3	-4	-4
	1A	3	2	2	2	1	0	-1	-2	-3	-4	-4	-4
	1B	3	2	2	1	0	-1	-2	-3	-3	-4	-5	-5
	1C	3	2	1	0	-1	-2	-2	-3	-4	-4	-5	-6
	No Ice Class	3	1	0	-1	-2	-3	-3	-3	-4	-5	-6	-6

Summer Risk Values(RVs)

Polar Ship Category	Ice Class	Ice Free -	New Ice 0-10cm	Grey Ice 10-15cm	Grey White Ice 15-30cm	Thin First-year Ice 1st Stage 30-50cm	Thin First-year Ice 2nd Stage 50-70cm	Medium First-year Ice 1st Stage 70-95cm	Medium First-year Ice 2nd Stage 95-120cm	Thick First-year Ice 120-200cm	Second-year Ice 200-250cm	Light Multi-year Ice 250-300cm	Heavy Multi-year Ice 300+cm
A	PC 1	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	2	2	1	-1	-2	-2
B	PC 6	3	2	2	2	2	1	2	1	0	-2	-3	-3
	PC 7	3	2	2	2	1	1	1	0	-1	-3	-3	-3
C	1A Super	3	2	2	2	2	1	1	0	-1	-3	-4	-4
	1A	3	2	2	2	1	0	0	-1	-2	-4	-4	-4
	1B	3	2	2	1	0	-1	-1	-1	-2	-4	-5	-5
	1C	3	2	1	0	-1	-2	-1	-2	-3	-4	-5	-6
	No Ice Class	3	1	0	-1	-2	-3	-2	-2	-3	-5	-6	-6

RIO_{SHIP}	Category A & B (PC1 – PC7)	Category C (below PC7)
$RIO \geq 0$	Operation Permitted	Operation Permitted
$-10 \leq RIO < 0$	Limited Speed Operation Permitted	Operation Not Permitted
$RIO < -10$	Operation Not Permitted	Operation Not Permitted

w/o Icebreaker Escort

RIO_{SHIP}	Category A & B (PC1 – PC7)	Category C (IA Super – IA)	Category C (below IA)
$RIO + 10 \geq 0$	Operation Permitted	Operation Permitted	Operation Permitted
$-10 \leq RIO + 10 < 0$	Limited Speed Operation Permitted	Limited Speed Operation Permitted	Operation Not Permitted
$RIO + 10 < -10$	Operation Not Permitted	Operation Not Permitted	Operation Not Permitted

w/ Icebreaker Escort

Calculating the Risk Index Outcome (RIO)

$$RIO = (C_1 * RV_1) + (C_2 * RV_2) + (C_3 * RV_3) + \cdots (C_n * RV_n)$$

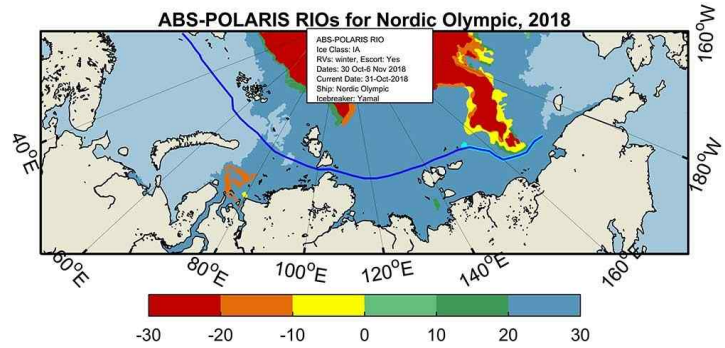
- $C_1 \ldots C_n$: **Concentrations of ice types within an "ice regime"**
- $RV_1 \ldots RV_n$: **Corresponding Risk Index Values for each Ice Class**

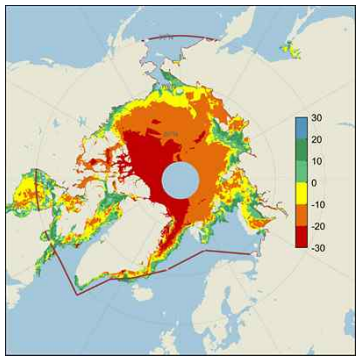
Polar Operational Limitations Assessment Risk Indexing System

- **POLARIS, a decision support system for maritime management**



Automatic sea ice detection in satellite





Source: ABS

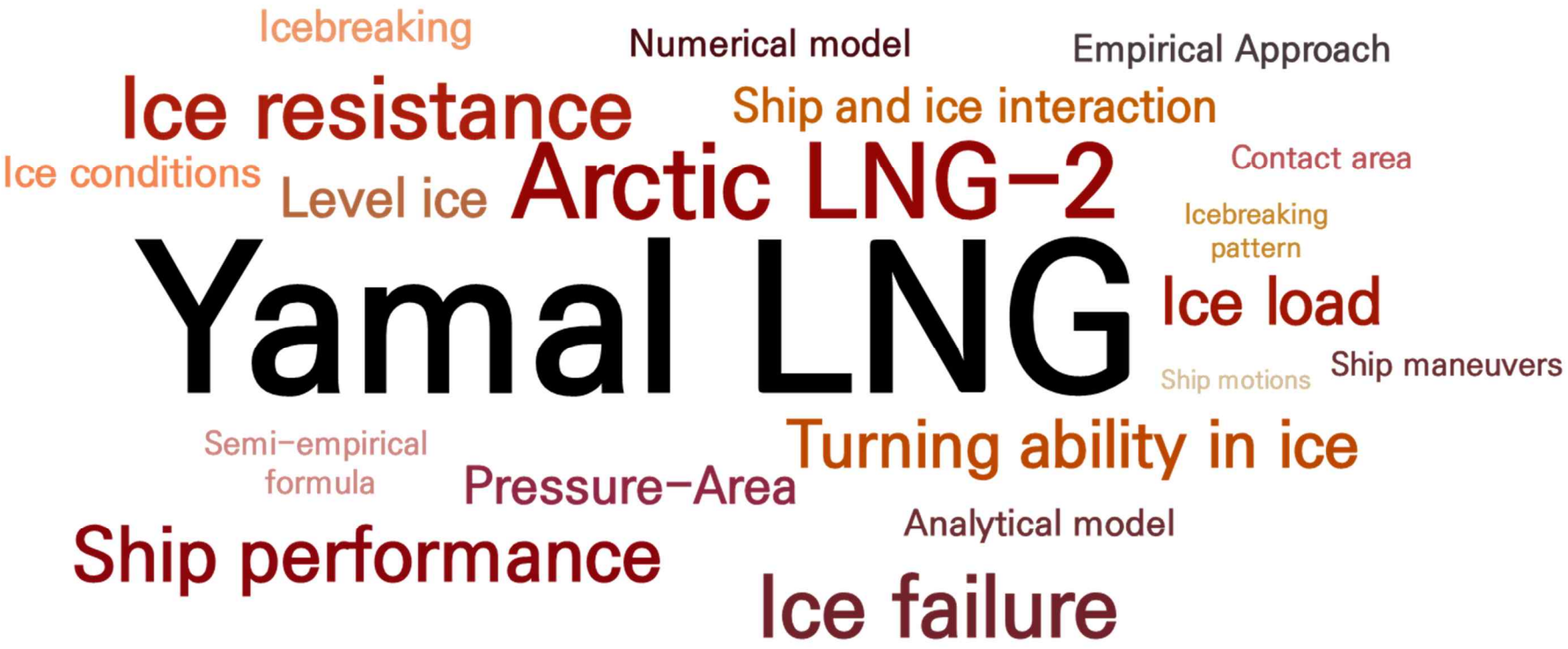
Shipping route optimization in ice

Sustainable Shipping Technologies in the Arctic

Characteristics of technology and Future trend….

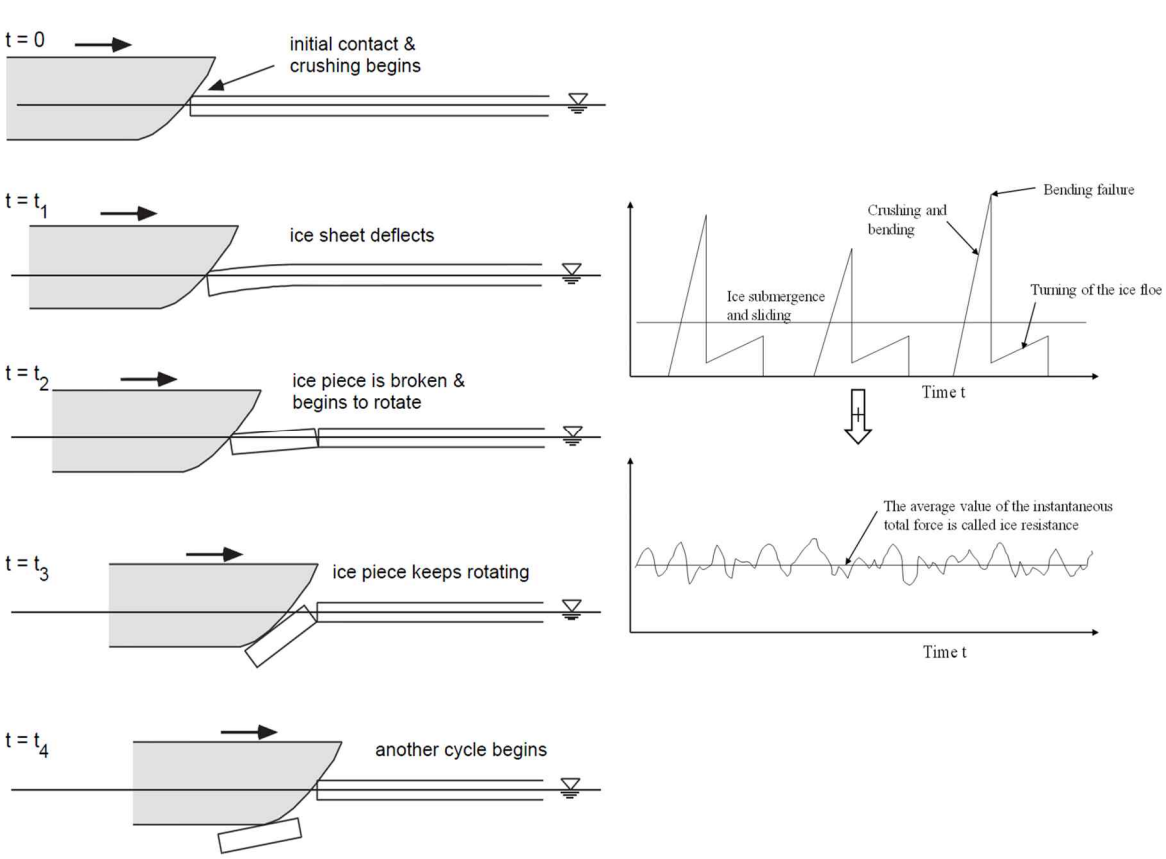


Keyword analysis in shipping sector



How well can predict ship performance in ice?

- **Model test in an ice tank**







How well can predict ship performance in ice?

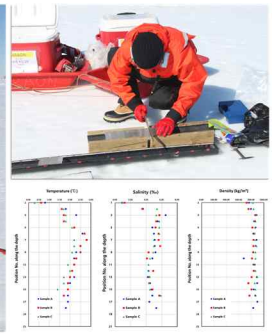
- **Full-scale ice trial test**



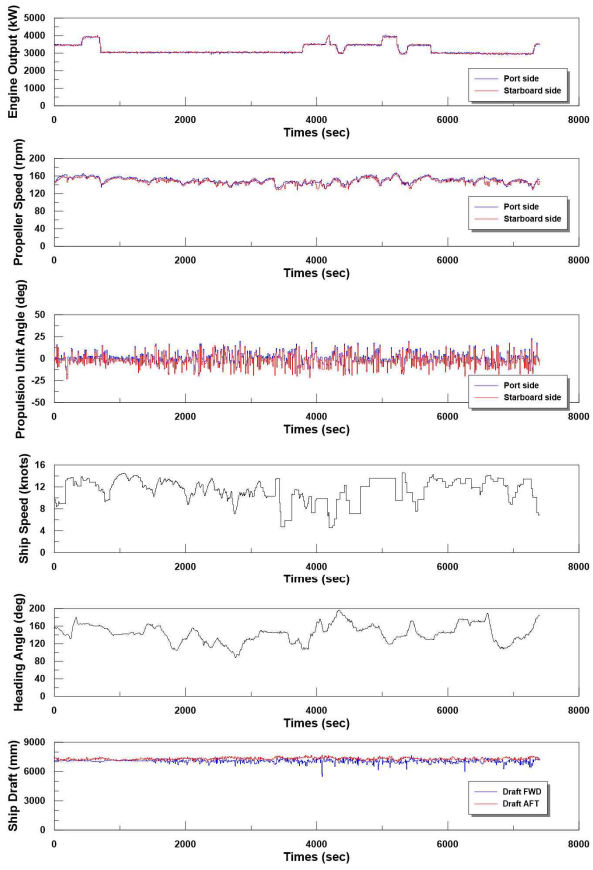


Sample	Compressive strength of sea ice (MPa)	Flexural strength of sea ice (kPa)
A	4.42	291
B	4.18	272
C	3.04	209
Average	3.88	257

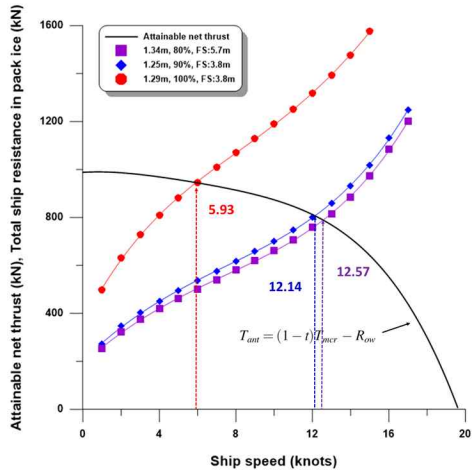
Drill a hole in the ice with an ice auger



Profiles of temperature, salinity, and density



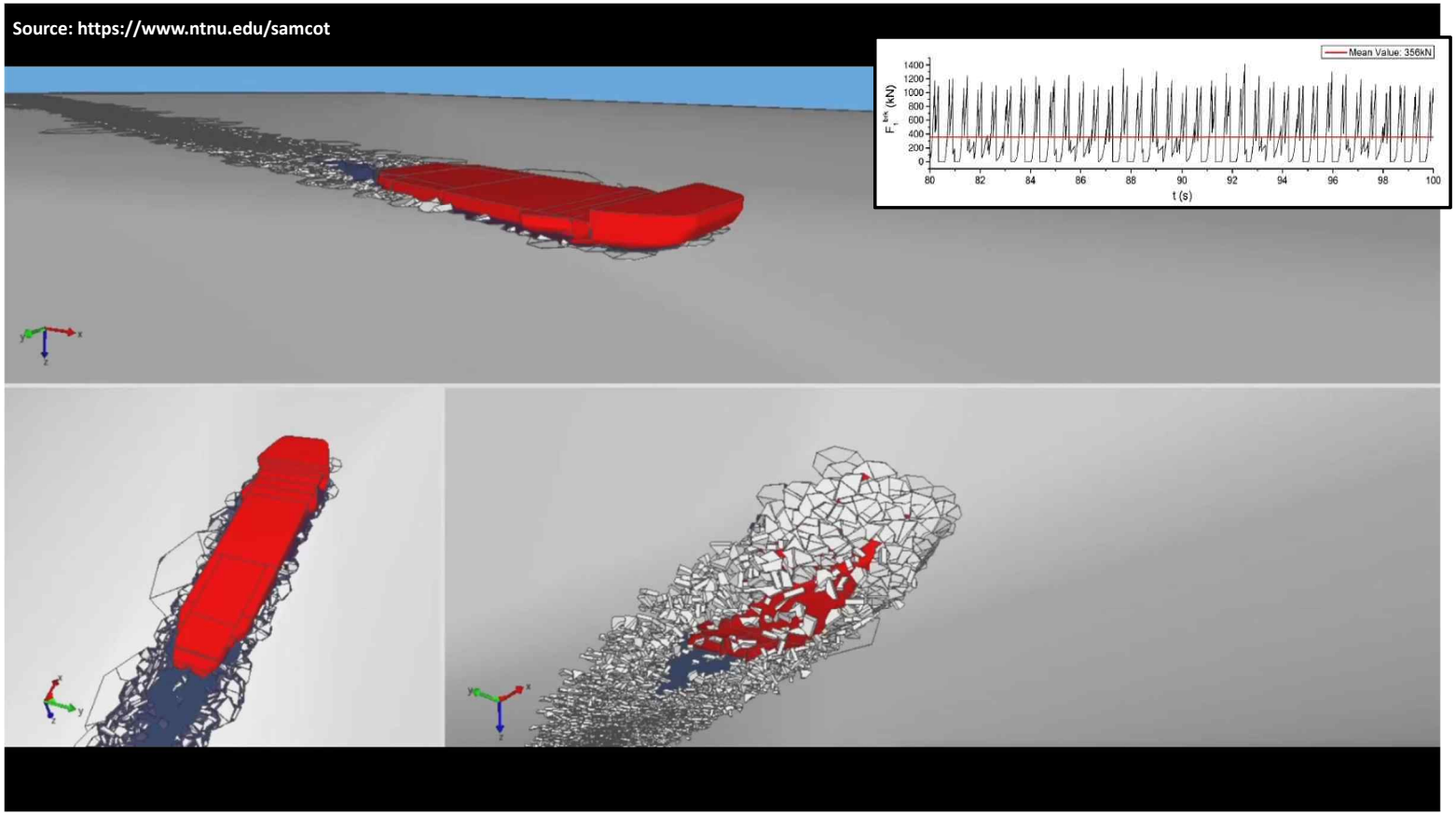


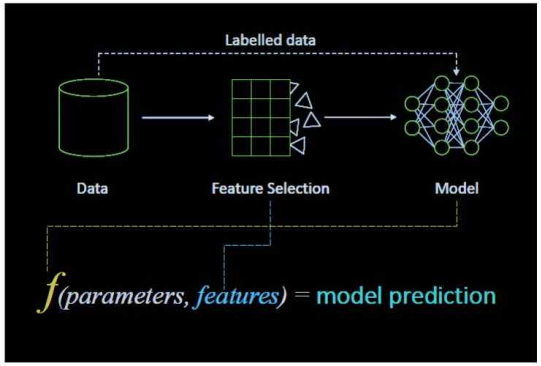


How well can predict ship performance in ice?

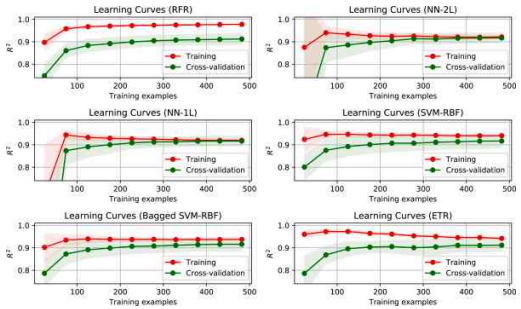
- **Numerical simulation & Deep learning algorithm**

Source: https://www.ntnu.edu/samcot





Data Analyzing by AI



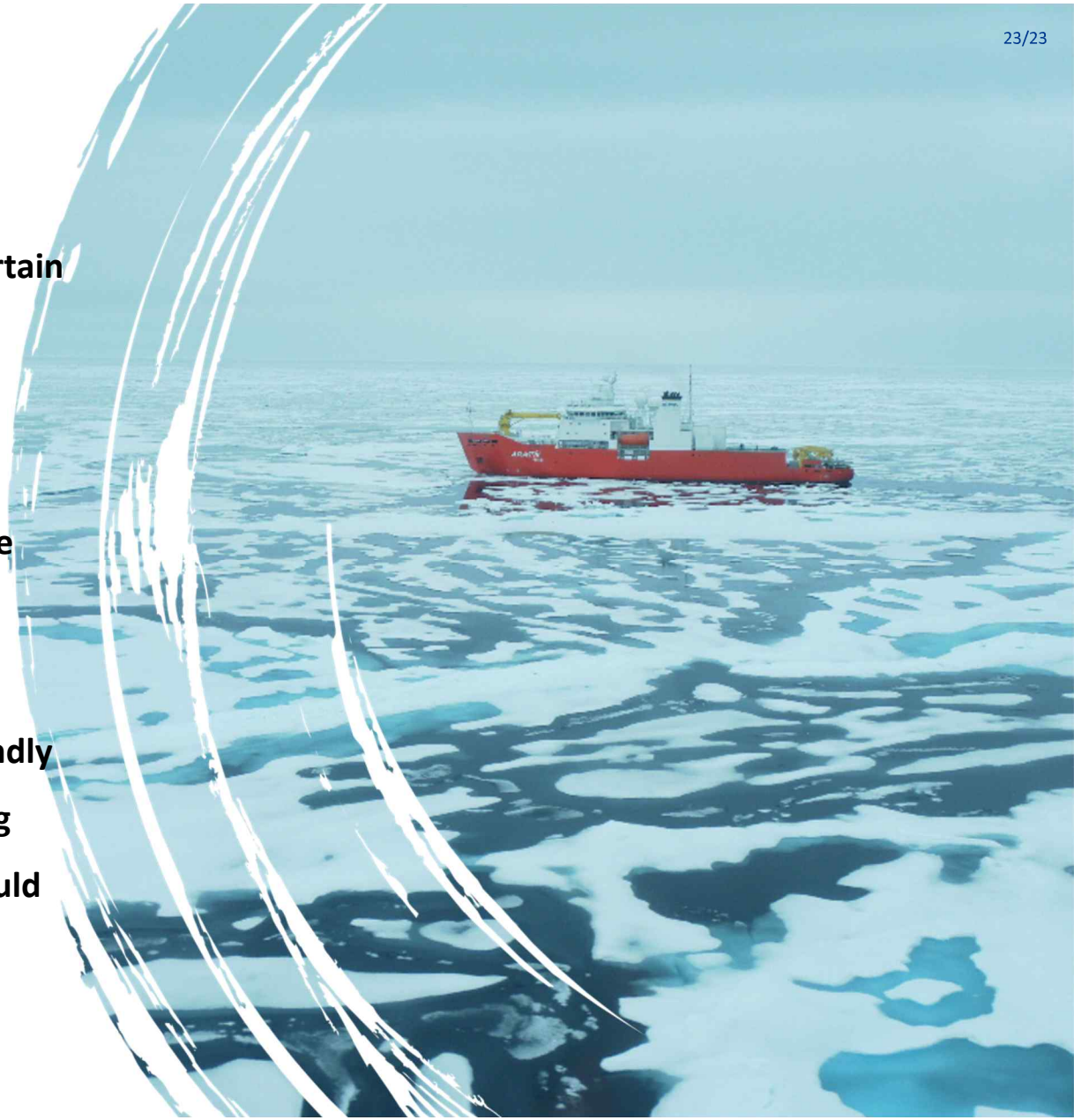
Concluding Remarks

Key findings….



Conclusions

- As climate change leads to resource and infrastructure development, demand seems certain to grow for high-tech innovative technologies attuned to the Arctic's unique features.
- International cooperation and regulatory frameworks are necessary to ensure sustainable development in the Arctic regions in terms of safety and environmental protection.
- In addition, Arctic industries driven by eco-friendly shipping will play an important role in achieving sustainable development in the Arctic. This would reduce the shipping industry's carbon footprint through the Arctic.



Thank You.



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