

# A Comprehensive Content and Risk Analysis of Maritime Shipping Operations in Arctic Canada

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# Arctic Shipping: A Hot Topic in a Cold Environment

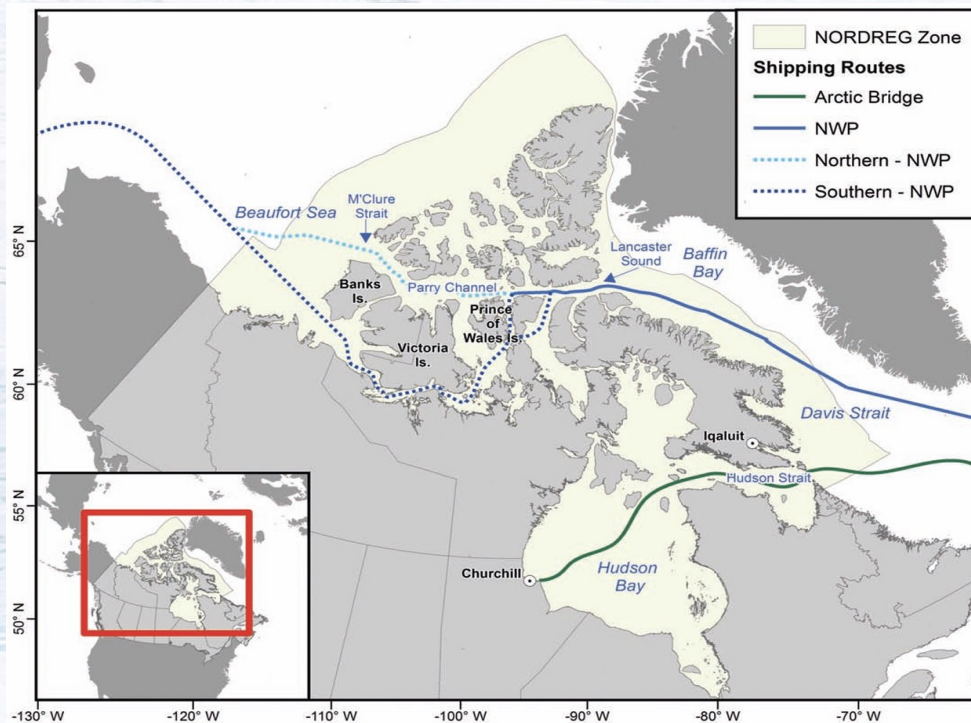


Figure 1. Map of the Northwest Passage with labelled routes and NORDREG zone (Dawson et al., 2018).

- What are all hazards and risks of maritime ship operations within the Northwest Passage?
- Where has previous data been collected from?
- Which hazards and risks can be assessed in future analyses?





# Methodology: A Comprehensive Risk Analysis Framework

**Failure Modes, Effects, & Criticality Analysis (FMECA)**



**94 Peer-reviewed publications** were selected between 2000 - 2023.



Publications were **examined to identify individual comprehensive hazards^ and risks^**, collecting information such as level of consequence, probability of occurrence, present-day causes and consequences (both indirect and direct), and control measures.

**Risk Rating (RR) Scores (Consequence-probability matrix)**

## Risk Rating Indices\*

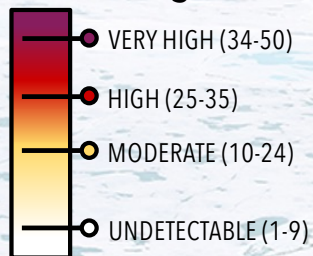


Figure 2. Risk matrix for calculating the level of risk as adopted from the consequence/probability matrix from ISO and IPCC guidelines (Meredith et al., 2019; Peeters & Peng, 2015; ISO, 2009).

PROBABILITY	ALMOST CERTAIN	5	5	20	35	50
	LIKELY	4	4	16	28	40
	BETTER THAN EVEN	3	3	12	21	30
	UNLIKELY	2	2	8	14	20
	REMOTE	1	1	4	7	10
	Score	1	4	7	10	
		LOW	MEDIUM	HIGH	CATASTROPHIC	
		CONSEQUENCE				

**Data Quality Analysis**

## Data Quality Indicators\*

- |                            |                                 |
|----------------------------|---------------------------------|
| <b>EVIDENCE SCORE (ES)</b> | <b>LEVEL OF AGREEMENT (LoA)</b> |
| • EVIDENCE TYPE            | • RISK AGREEMENT                |
| • EVIDENCE AMOUNT (%)      | • AGREEMENT DISTRIBUTION        |
| • EVIDENCE CONSISTENCY     | • AGREEMENT QUANTITY            |
| • EVIDENCE QUALITY         |                                 |



VERY LOW

VERY HIGH

\*Adopted from IPCC guidelines for uncertainties document (Meredith et al., 2019).

^All terminology and definitions used within this analysis was taken from IPCC AR6 Report (IPCC, 2022).

# Methodology: A Comprehensive Risk Analysis Framework



## Hazard

The **potential occurrence of a natural or human-induced physical event or trend** that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

## Risk

The **potential for adverse consequences for human or ecological systems**, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.

^All terminology and definitions used within this analysis was taken from IPCC AR6 Report (IPCC, 2022).



## Risk Analysis Results

### RISK

Risk Name	RR INDEX	RR Score	Data Quality Rating	Data Quality - Details
Operational discharges	HIGH	33.40	HIGH	High agreement, Medium evidence
Lack of Inuit agency	HIGH	33.00	HIGH	High agreement, Medium evidence
Degradation of indigenous cultural and natural resources	HIGH	32.80	HIGH	High agreement, Medium evidence
Underwater noise pollution	HIGH	32.55	HIGH	High agreement, Medium evidence
Reduction in resources to locals	HIGH	32.00	HIGH	Medium agreement, Medium evidence
Lack of support for indigenous communities	HIGH	31.50	HIGH	Medium agreement, Medium evidence
Black carbon air emissions	HIGH	31.23	HIGH	High agreement, Medium evidence
Exploitation of natural reserves	HIGH	30.56	HIGH	High agreement, Medium evidence
Oil spill clean-up costs	HIGH	29.88	HIGH	High agreement, Medium evidence
Travelling through marine protected areas	HIGH	29.06	HIGH	High agreement, Medium evidence

### HAZRD

Hazard Name	RR INDEX	RR Score	Data Quality Rating	Data Quality - Details
Transportation of dangerous goods	VERY HIGH	41.36	HIGH	High agreement, Medium evidence
Multi-year sea ice presence	VERY HIGH	36.31	VERY HIGH	High agreement, Robust evidence
Air emissions (combustion)	HIGH	35.54	VERY HIGH	High agreement, Medium evidence
HFO carriage and transport	HIGH	35.00	HIGH	High agreement, Medium evidence
Navigational obstacles	HIGH	30.40	HIGH	High agreement, Medium evidence
Sea ice melt	HIGH	30.05	HIGH	High agreement, Robust evidence
Operating in shallow waters	HIGH	28.88	VERY HIGH	High agreement, Robust evidence
Climate fluctuation	HIGH	28.16	HIGH	High agreement, Medium evidence
Fire onboard	HIGH	27.75	HIGH	Medium agreement, Medium evidence
Sea ice concentration	HIGH	27.26	HIGH	High agreement, Robust evidence

## Risk Analysis Results - continued

### THEMES

Thematic Group	RR INDEX	RR Score	Data Quality Rating	Data Quality - Details
Community	HIGH	32.061	MODERATE	Medium agreement, Medium evidence
Pollutants	HIGH	29.383	MODERATE	Medium agreement, Medium evidence
Sea Ice	HIGH	29.376	HIGH	High agreement, Medium evidence
Environmental	HIGH	26.374	HIGH	High agreement, Medium evidence
Social	HIGH	26.116	MODERATE	Medium agreement, Medium evidence
Economic	MODERATE	24.623	MODERATE	High agreement, Medium evidence
Operational	MODERATE	23.394	MODERATE	Medium agreement, Medium evidence
Assessment	MODERATE	22.948	MODERATE	Medium agreement, Medium evidence
Navigational	MODERATE	22.143	HIGH	High agreement, Medium evidence
Human	MODERATE	21.755	MODERATE	Medium agreement, Medium evidence

- **55 hazard variables were inventoried** (24 recommended for further examination) where 'Transportation of dangerous goods' and 'Multi-year sea ice' received the highest RR scores.
- **99 risk variables were inventoried** (47 recommended for further examination) where 'Community member displacement' and 'Socioeconomic impacts to indigenous peoples' variables received the highest RR scores.
- **12 thematic groups were inventoried** (5 considered 'HIGH' risk and recommended for further examination) where 'Community' and 'Pollutant' themes received the highest RR scores.



## Risk Analysis Results - continued

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## Next Steps & Timelines



- **Completion of a spatial analysis to identify important nodes, vessel routes, and points of interest along the NWP.**
- **Facilitation of a comprehensive risk assessment** of all priority maritime shipping risks.



# Thank you

If you have any questions or comments on this research project, please email [crett041@uottawa.ca](mailto:crett041@uottawa.ca) or contact using the QR code below:



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