Waterway risk analysis for area-based management of shipping risks

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How can risk analysis be used for area-based management of shipping risks?

Area-based shipping risk management approaches

Waterway risk analysis approaches

Opportunities and challenges: Need for risk governance

# Area-based shipping risk management approaches

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Traffic Separation Schemes

- Lanes on the water in congested and/or converging areas

- Aim to reduce collision risk by separating traffic, and direct traffic away from environmentally sensitive areas

- Usually accompanied by reporting schemes and/or monitoring services

TSS Strait of Juan de Fuca, Puget Sound, Haro Strait, Boundary Pass, Strait of Georgia
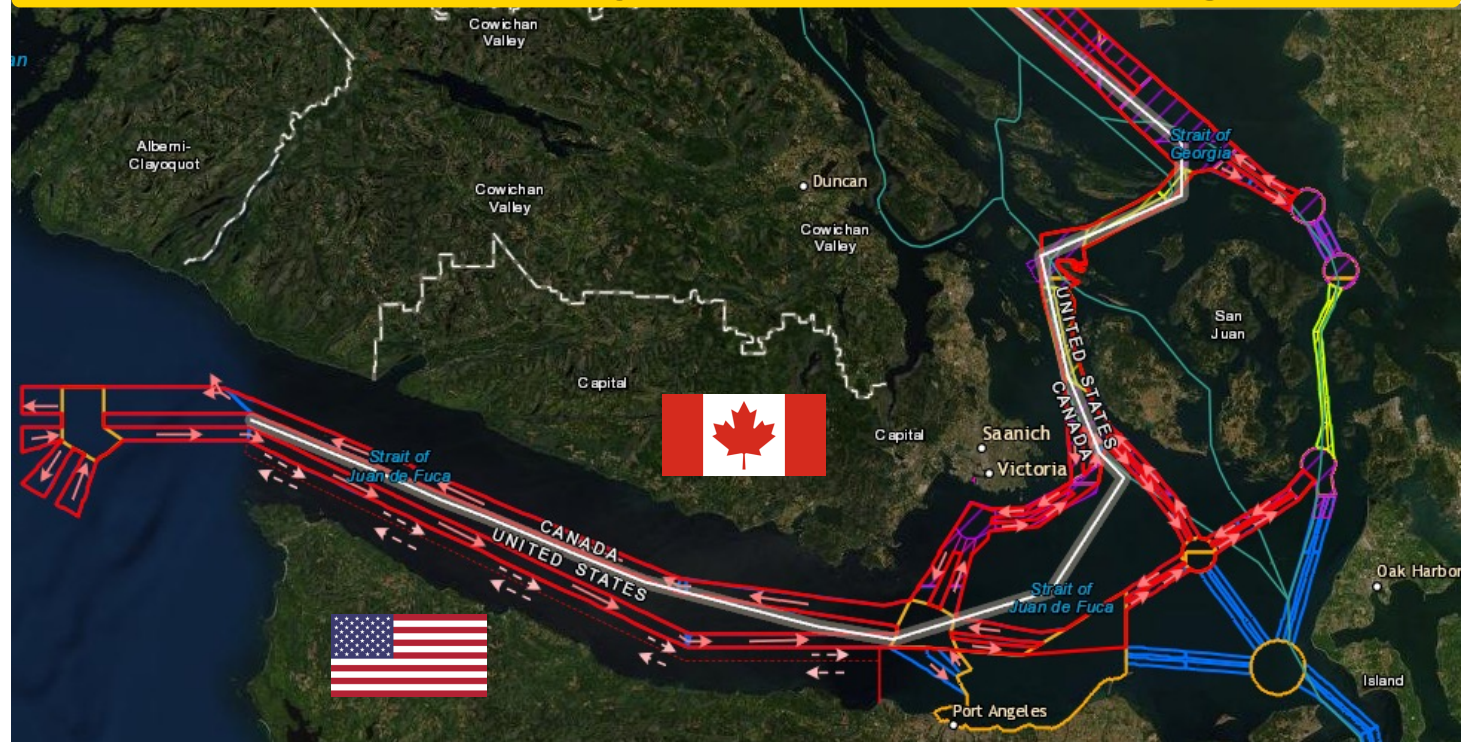
Source: www.dillon.ca | www.wikipedia.org
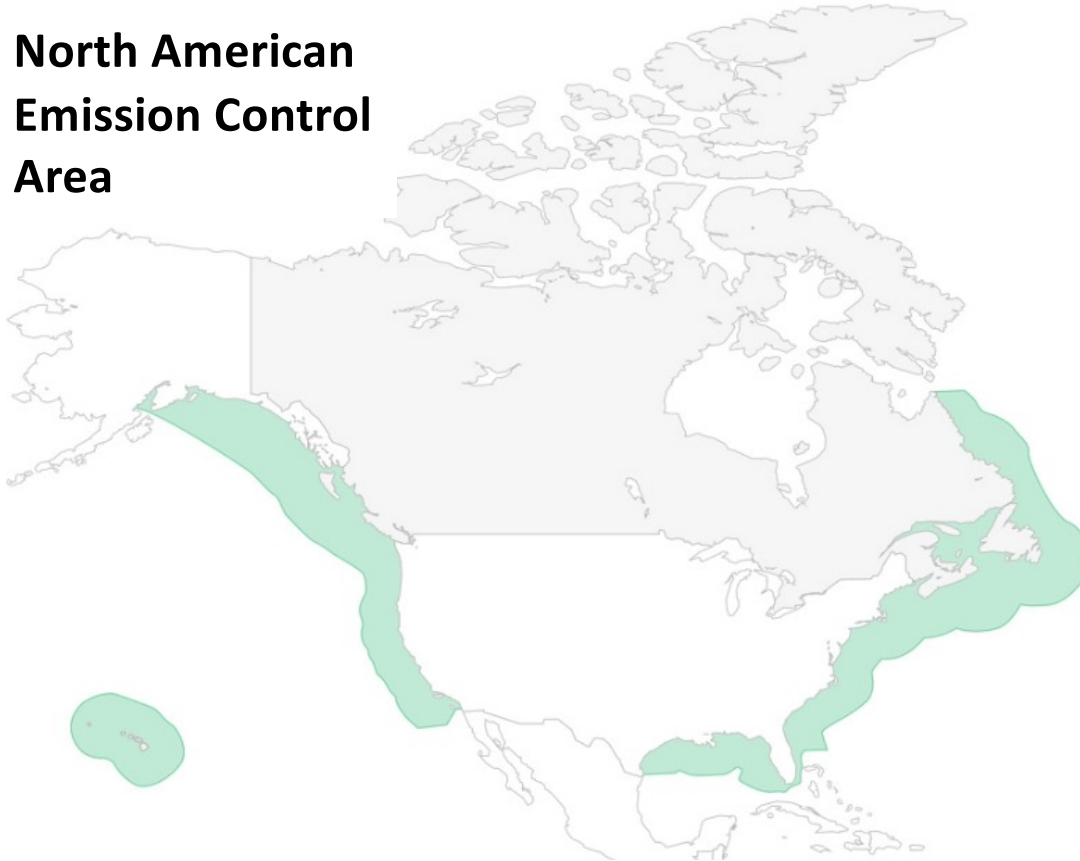
# Emission Control Areas

North American Emission Control Area

- Emissions of SOx, NOx, and PM should be below specified thresholds for applicable vessels

- Aim to reduce harmful impacts on humans and marine environment

- In Canadian waters north of 60 deg N, (and Arctic waters): currently no ECA

Area-based operational requirements and restrictions

- Speed limits

- Pilotage

- Tugboat assistance

- Under keel clearance

- Air draft (bridges)

- Anchorage locations

- Vessel monitoring

- …

Halifax harbour approach and port area

Anchorages
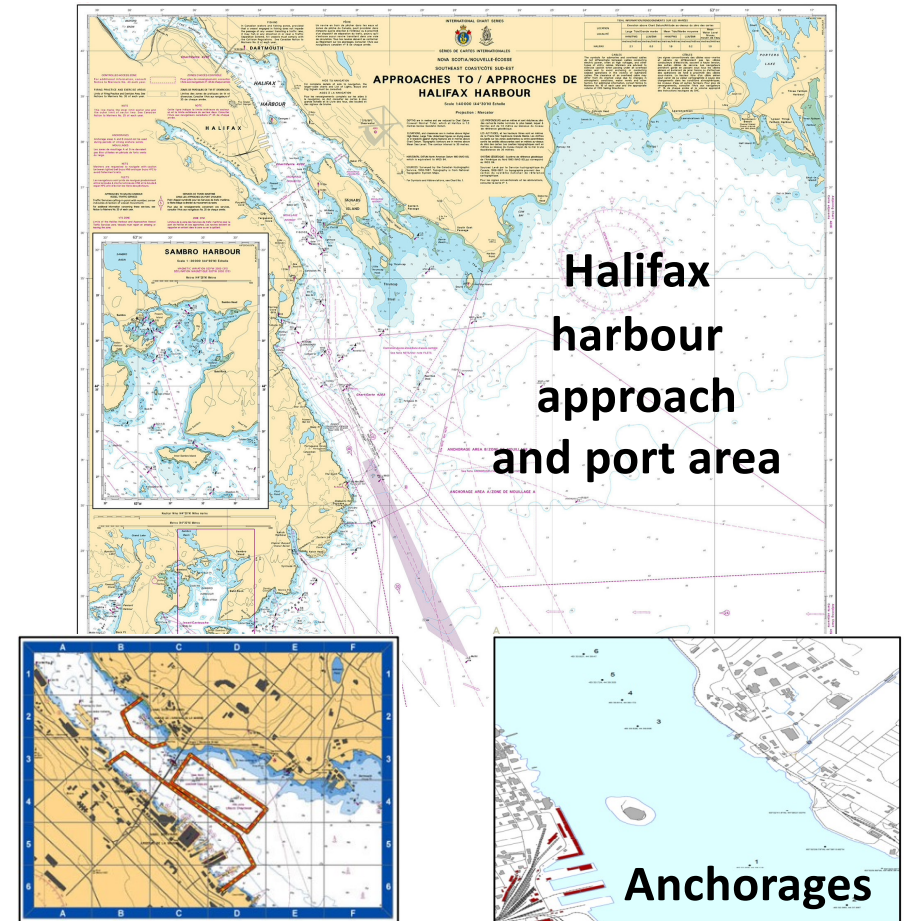
Controlled Access Zones

Source: Halifax Port Authority. 2016. Port Practices and Procedures, 93 p.

Emergency response areas

Arctic Council SAR Agreement Area of Responsibility
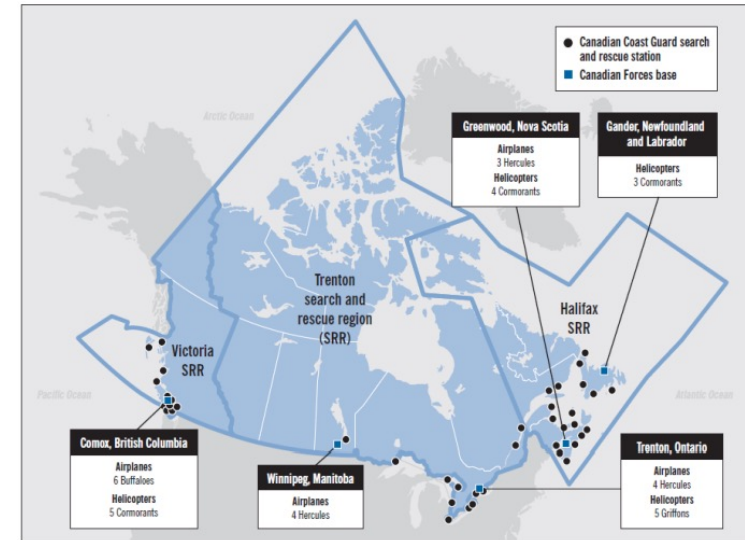
Search and Rescue Regions

- Information sharing between states

- Experience exchange

- Joint exercises and training

- Joint operations reviews

Canadian SAR regions

Source: Leroux J.G.R. 2017. Canadian Forces College, 34p. | Arctic SAR Agreement. 2011, 18p.

Waterway risk analysis approaches

How to set requirements for risk mitigation?

Risk management

- Establishing the context

- Risk identification

- Risk analysis

- Risk evaluation

How to set requirements for risk mitigation?

Risk management

- Establishing the context } **Values**
- Risk identification
- Risk analysis } **Evidence**
- Risk evaluation } **Values**

The diagram shows:
- 1. Establishing the context
- RISK ASSESSMENT
- 2. Risk identification
- 3. Risk analysis
- 4. Risk evaluation
- 5. Risk treatment
- A. Communication and consultation
- B. Monitoring and review

Source: ISO. 2018. Standard 31000:2018

Data, measurements, and models

Marine Incidents and Accidents Dashboard
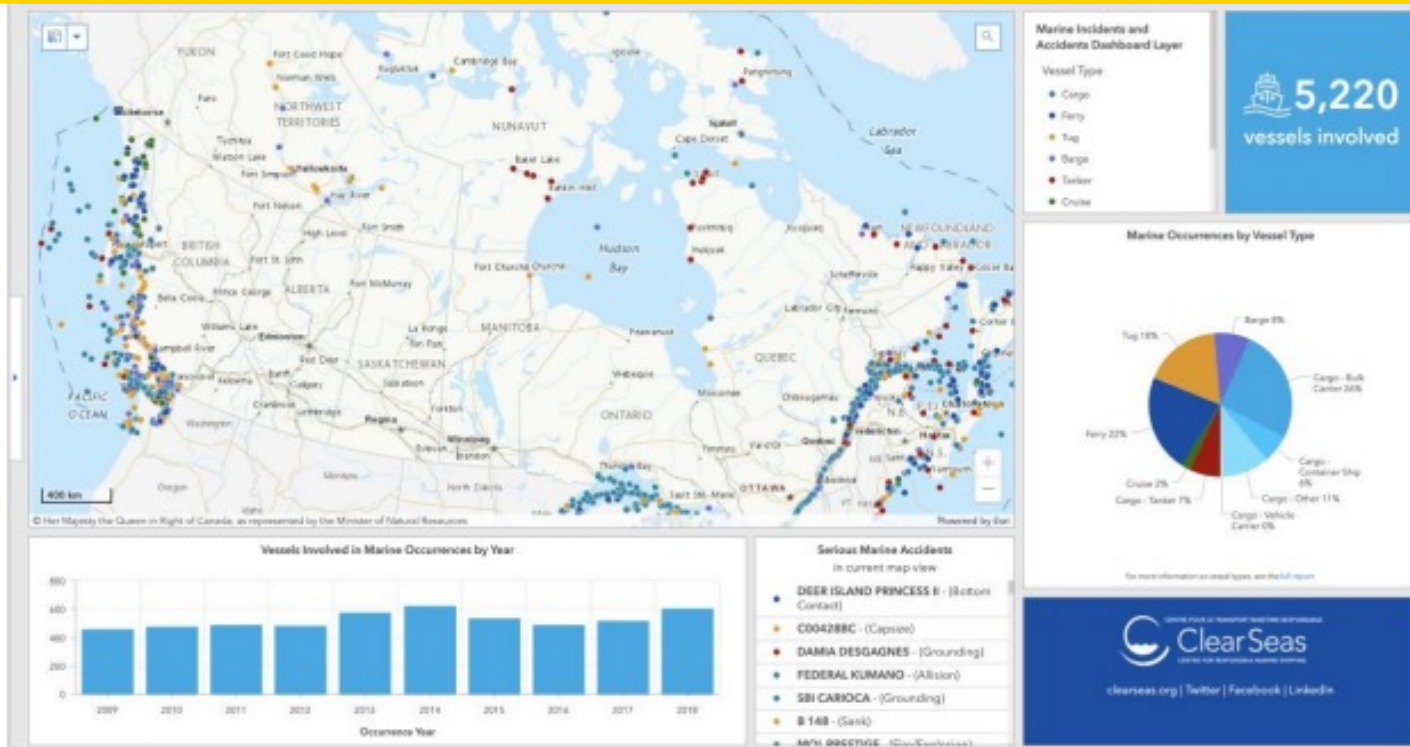
Source: www.clearseas.org
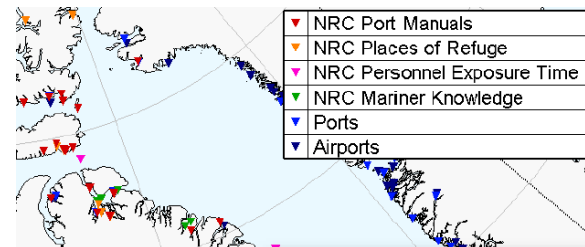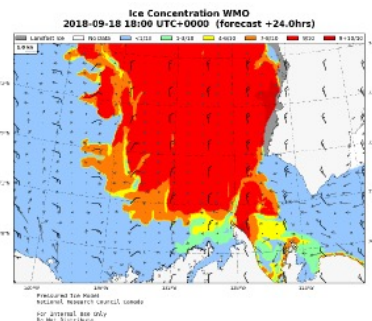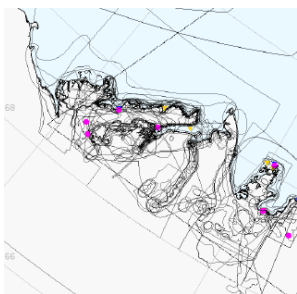
Data, measurements, and models

Canadian Arctic Shipping Risk Assessment System (CASRAS)
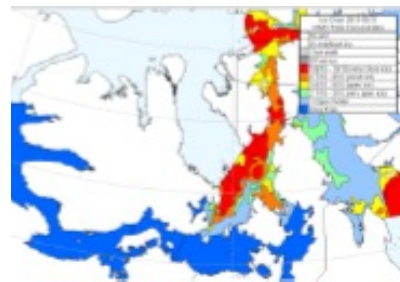
- Ice charts and model forecasts
- Land use, conservation and protection datasets
- Regional and mariner knowledge, emergency mgmt. datasets
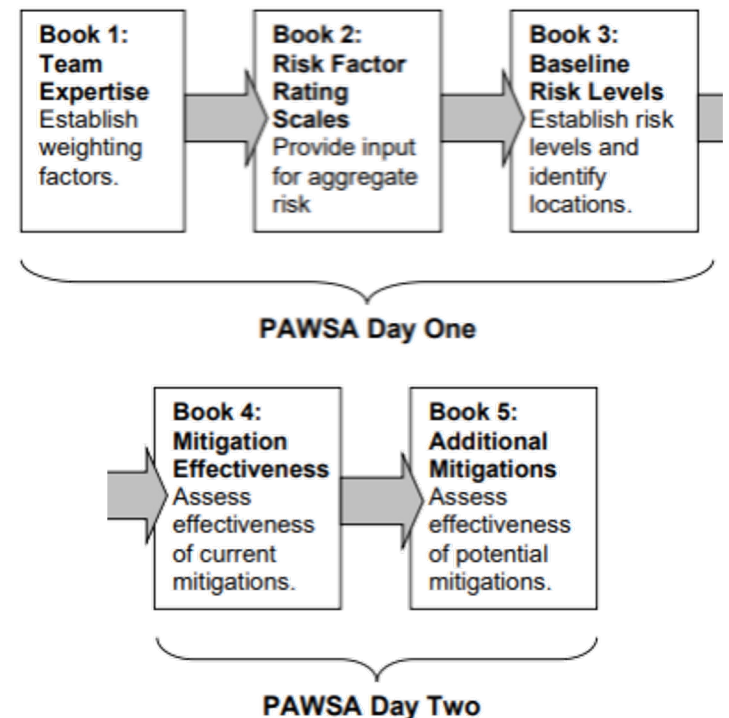- POLARIS risk index calculation

Source: Sudom D. 2021. CASRAS. National Research Council Canada, 25p.

Expert judgment and consensus processes

Ports and Waterways Safety Assessment (IALA PAWSA)

Waterway Risk Model

Vessel Conditions	Traffic Conditions	Navigational Conditions	Waterway Conditions	Immediate Consequences	Subsequent Consequences
Deep Draft Vessel Quality	Volume of Commercial Traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
Commercial Fishing Vessel Quality	Traffic Mix	Visibility Restrictions	Bottom Type	Hazardous Materials Release	Aquatic Resources
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic

Book 1: Team Expertise Establish weighting factors. → **Book 2: Risk Factor Rating Scales** Provide input for aggregate risk → **Book 3: Baseline Risk Levels** Establish risk levels and identify locations.

PAWSA Day One

→ **Book 4: Mitigation Effectiveness** Assess effectiveness of current mitigations. → **Book 5: Additional Mitigations** Assess effectiveness of potential mitigations.
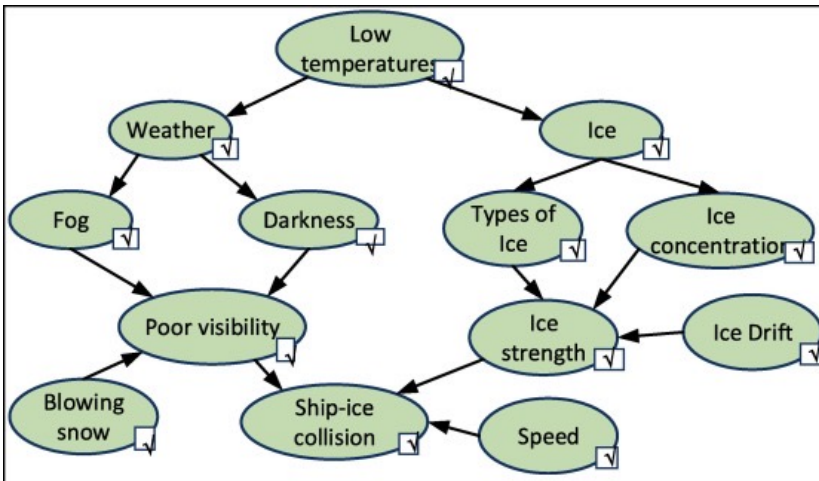
PAWSA Day Two

Source: IALA. 2022. IALA Guideline G1124, 11p.

Risk models and formal analysis techniques

Probabilistic model for ship-ice collision in Arctic waters

Optimization model for enhancing SAR response in Atlantic Canada
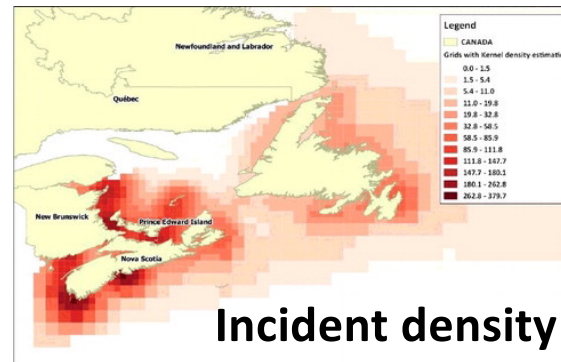
Incident density
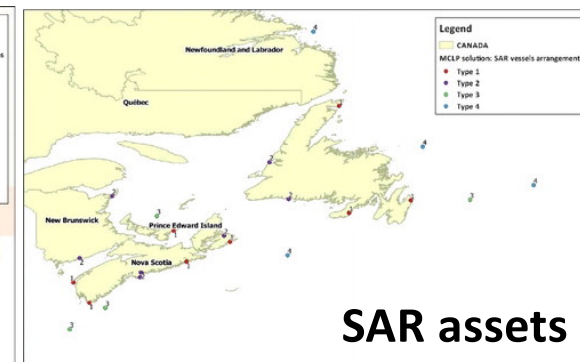
SAR assets

$$\text{Problem 1}: \text{Max}: Z = \frac{\sum_i w_i x_i}{\sum_i w_i} \quad (3)$$

$s.t.$

$$x_i \leq \sum_j \sum_k a_{ij}^k y_j^k, \quad \forall\, i \text{ Primary coverage constraint} \quad (4)$$

$$\sum_j y_j^k \leq p^k, \quad \forall\, k \text{ Fixed number of available vessels in each type} \quad (5)$$

$$y_j^k = 0 \quad \forall\, j \in J_S,\ k \in \{1,2\} \text{ Offshore location constraint} \quad (6)$$

Source: Khan et al. 2020. *Safety Science* 130:104858 | Akbari et al. 2018. *Annals of Operations Research* 267:3-28.

Canadian Shipping Risk Inventory

Canadian Marine Shipping Risk Forum

Opportunities and challenges: Need for risk governance

Waterway risk analysis: Opportunities

- Improved evidence on risks can support making better decisions, and justify decisions on risk mitigation measures

- Can improve efficient use of resources

- Can facilitate consensus building if stakeholders disagree

- Many models have been proposed by practitioners and academics, for various shipping risk problems

- Risk-based approaches are increasingly used for other aspects of shipping (goal-based ship design standards, safety management systems, risk-based inspections,…)

Source: Goerlandt et al. 2017. *Safety Science* 99B:127-139 | Parviainen et al. 2022. *Marine Policy* 135:104863.

Waterway risk analysis: Challenges (1)

- Current models are often designed to support analysis of specific risks with pre-determined policies, need for integrative/cumulative risk models capable of exploratory policy analysis

- Complexities and uncertainties of shipping risks raise questions about the validity of risk models, esp. causality in accident models for prevention

- Possibility of re-orientation of paradigm towards models supporting successful outcomes, instead of models focusing on avoiding harm

- Technical analyses: expertise, transparency, communication

Source: Goerlandt et al. 2017. *Safety Science* 99B:127-139 | Parviainen et al. 2022. *Marine Policy* 135:104863.

Waterway risk analysis: Challenges (2)

- Problem framing involves value judgments, need for close collaboration between analysts and stakeholders

- Increased evidence on risk does not necessarily simplify making decisions on risk acceptance, involves value judgments

- Risk models do not account for risk dimensions such as ubiquity, persistency, reversibility, delay effect, violation of equity, potential for mobilization

- Incorporation of traditional knowledge in academic work on risk analysis is underdeveloped

Source: Goerlandt et al. 2017. *Safety Science* 99B:127-139 | Goerlandt F., Pelot R. 2020. Governance of Arctic Shipping, Springer, p.15-41.
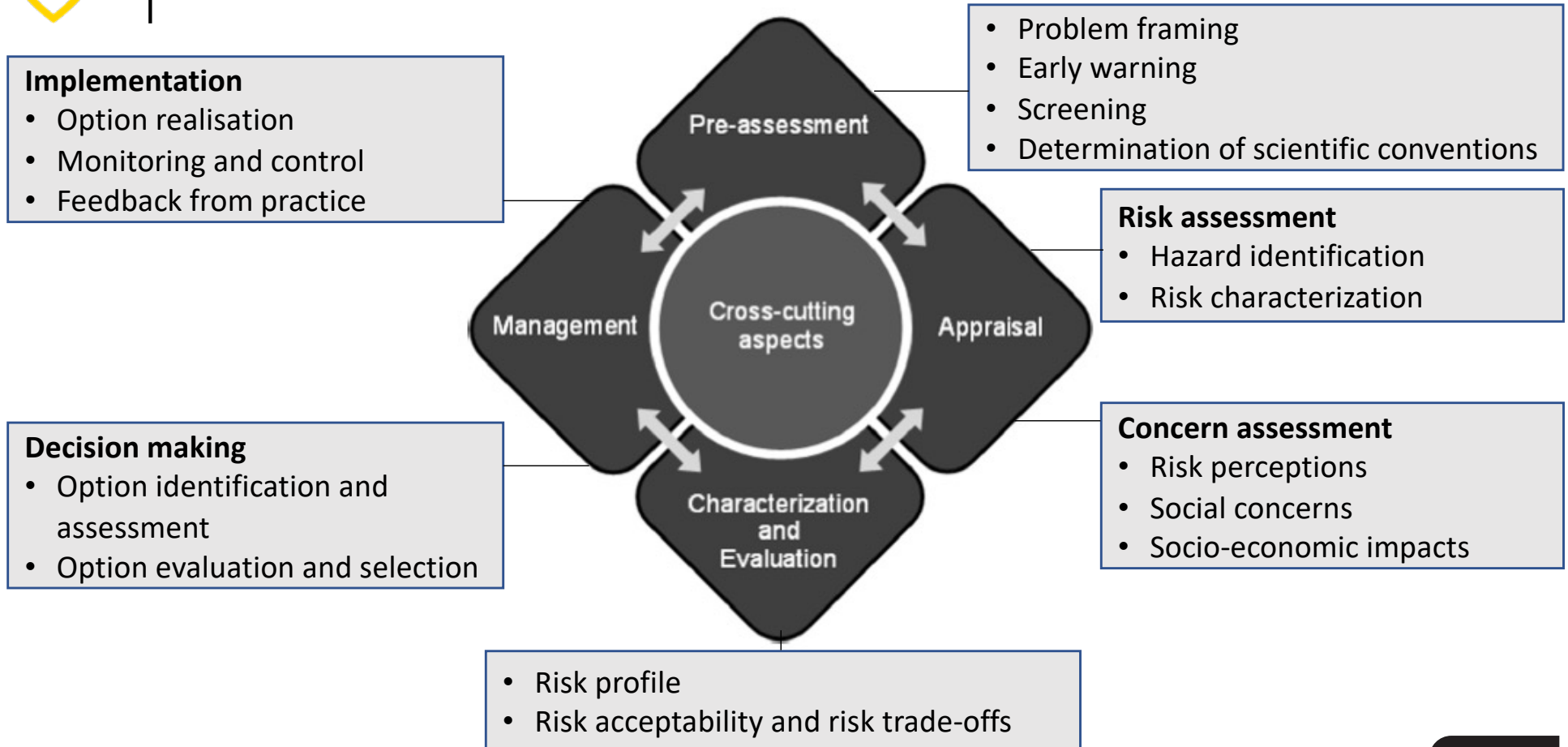
Risk governance: beyond information-push

- Risk governance is the identification, assessment, management, evaluation, and communication of risks in the context of plural values and distributed authority.

- It is implemented through actions, processes, traditions, and institutions by which authority is exercised and collective decisions are taken and implemented.

Risk governance: beyond information-push

Implementation
- Option realisation
- Monitoring and control
- Feedback from practice

Decision making
- Option identification and assessment
- Option evaluation and selection

Pre-assessment

Management

Cross-cutting aspects

Appraisal

Characterization and Evaluation

- Problem framing
- Early warning
- Screening
- Determination of scientific conventions

Risk assessment
- Hazard identification
- Risk characterization

Concern assessment
- Risk perceptions
- Social concerns
- Socio-economic impacts

- Risk profile
- Risk acceptability and risk trade-offs

Source: IRGC. 2017. International Risk Governance Center, 52p. | Goerlandt F. 2020. *Safety Science* 128:104758.

Key risk characteristics for designing risk governance strategy

Complexity: Relates to number of causal factors, the nature   of their interactions, and their variability (characteristic of the system)

Uncertainty: Relates to how well the risk is understood, e.g. availability of data, variation of expert judgments, robustness of models (characteristic of assessors)

Ambiguity: Relates to different views on values to be   protected, varying concepts of what is   tolerable and equitable (characteristic of rights- and stakeholder worldviews)

Risk governance escalator (1)

	Simple	Complex	Uncertain	Ambiguous
Role for risk perception			Communication-focused	As basis for societal discourse
Nature of conflict		Cognitive	Cognitive Evaluative	Cognitive Evaluative Normative
Actors to be involved	Regulatory bodies Industry experts	Regulatory bodies Industry experts External scientists	Regulatory bodies Industry experts External scientists Affected stakeholders	Regulatory bodies Industry experts External scientists Affected stakeholders Civil society
Focus of the approach	**Instrumental** Use existing routines to assess risks and possible reduction measures	**Epistemological** Maximize the scientific knowledge of the risk and mitigation options	**Reflective** Involve all affected stakeholders to collectively decide best way forward	**Participative** Societal debate about the risk and its underlying implications
DOMINANT RISK CHARACTERISTIC	**Simple**	**Complex**	**Uncertain**	**Ambiguous**

Risk governance escalator (2)

With higher uncertainty and ambiguity, importance of **moving beyond an information-push model** increases

Importance of **understanding and assessing risk governance practices**

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Source: Goerlandt F., Pelot R. 2020. Governance of Arctic Shipping, Springer, p.15-41.

Common risk governance deficits as basis for assessing and improving governance

Assessing and understanding risks		Managing risks	
A1	Early warning systems	B1	Responding to early warnings
A2	Factual knowledge about risks	B2	Designing effective risk management strategies
A3	Perceptions of risk	B3	Considering a reasonable range of risk management options
A4	Stakeholder/rightsholder involvement	B4	Designing efficient and equitable risk management policies
A5	Evaluating the acceptability of risk	B5	Implementing and enforcing risk management decisions
A6	Misrepresenting information about risk	B6	Anticipating side effects of risk management
A7	Understanding complex systems	B7	Reconciling time horizons
A8	Recognizing fundamental / rapid changes in systems	B8	Balancing transparency and confidentiality
A9	Use of formal models	B9	Organizational capacity (assets, skills, capabilities)
A10	Assessing potential surprises	B10	Dealing with dispersed responsibilities
		B11	Dealing with common problems and externalities
		B12	Managing conflicts of interests, beliefs, values, and ideologies
		B13	Acting in the face of the unexpected

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Source: IRGC. 2009. International Risk Governance Center, 92p.

Thank you!
Questions?

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