Chapter 2

An Exploratory Application of the International Risk Governance Council's Risk Governance Framework to Shipping Risks in the Canadian Arctic

Floris Goerlandt and Ronald Pelot

Abstract The diminishing extent of sea ice in Arctic areas brings opportunities for increased shipping activities in the Canadian Arctic. However, it also causes concerns, e.g., related to environmental pollution to vulnerable areas and impacts on ecosystems at local, regional, and global scales, which can further impact human health. Increased shipping activity also causes concerns about safety risks associated with the navigation of vessels, for instance, related to the response to vessels or people in distress. Appropriate risk management strategies, tools, and equipment are essential to successfully mitigate these risks, with due consideration of concerns of rights-holders, stakeholders, and society at large. In this chapter, an exploratory application of key elements of the International Risk Governance Council (IRGC) risk governance framework is presented, focusing on selected risks associated with shipping in the Canadian Arctic. After introducing the IRGC framework, selected shipping risks in the Canadian Arctic are classified in terms of the type of risk problem these represent. Subsequently, a discussion is given on the implications of this pre-screening for selecting appropriate risk governance strategies. The chapter concludes with a discussion on suggestions for future work on risk governance in a Canadian Arctic maritime shipping risk context.

Keywords Canadian Arctic · International Risk Governance Council · Marine pollution · Maritime safety · Oil spill · Pollution preparedness and response · Risk characterization · Risk governance · Search and rescue · Shipping risk

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2.1 Introduction

The effects of global warming are projected to lead to a significant decrease of the extent of sea ice coverage in Arctic and sub-Arctic marine environments (Barnhart et al. 2016; Höglund et al. 2017). This has already led to increased maritime activities in Arctic areas, whereas future conceptualizations and images of a changing Arctic include increased human activities such as hydrocarbon development, mining, shipping, fisheries, and tourism (Arbo et al. 2013).

Developments in offshore oil and gas extraction have attracted significant attention, with Norway and the Russian Federation leading exploration and exploitation efforts in offshore Arctic areas including, for instance, the Barents Sea and the Pechora Sea (Morgunova 2015). Despite the large offshore hydrocarbon reserves, there is considerable uncertainty about the prospects of sustained oil and gas developments in the Arctic (Arbo et al. 2013) due to the multitude of related climatological, economic, and geopolitical uncertainties (Harsem et al. 2011). In the Canadian Arctic, a moratorium on new oil and gas exploration licences was announced in 2018, with most existing licences clustered in the Beaufort Sea off Yukon and the Northwest Territories, and in the Arctic Islands Region in Nunavut. Currently, no production licences have been issued (CIRNAC 2018).

Another major prospect for increased maritime activity in the Arctic is shipping. Arctic shipping routes are increasingly seen as viable transport connections between global markets, with possible benefits such as decreased voyage time and associated costs (Lasserre et al. 2016; Beveridge et al. 2016). Nevertheless, economic uncertainties and concerns about navigational safety remain important reasons why, on a global scale, Arctic shipping currently still accounts for a relatively insignificant share of the total commodity flows (Lee and Kim 2015; Meng et al. 2017). In a Canadian context, there is a long history of maritime activities in the Arctic, consisting mainly of destination traffic to support northern communities and mining industries (Arctic Council 2009; Brooks and Frost 2012). Due to a combination of factors, including changing sea ice conditions and trends in resource exploration and community re-supply needs, there has been a steady and significant increase in the vessel traffic in Canadian Arctic waters (Engler and Pelot 2013; Pizzolato et al. 2014), a trend which continues to manifest itself and which is projected to continue in the future (Council of Canadian Academies 2017). Questions related to possible tolls based on sovereignty considerations, as well as other economic uncertainties and safety concerns, nevertheless currently preclude Canadian Arctic transportation routes from becoming significant trade routes for commercial transit traffic (Lu et al. 2014). A market segment where the lengthening of the ice-free season has led to a remarkable increase in activity is the tourism industry, where more cruise vessels and recreational vessels have been navigating in Canadian Arctic waters in recent years (Lasserre and Têtu 2015; Halliday et al. 2018; Palma et al. 2019).

These developments towards increased maritime activities in Arctic marine areas raise various concerns. Focusing on shipping risks in the Canadian Arctic, various

safety and environmental risks have been identified and studied, with possible effects on local, regional, or global scales (Council of Canadian Academies 2016). The increased recreational boating and cruise vessel activity presents challenges for ensuring the safety of human life at sea, in particular for implementing effective search and rescue in remote and harsh environments (Ford and Clark 2019; Drewniak and Dalaklis 2018). Environmental and ecosystem risks related to increased shipping activity in Arctic waters with comparatively local effects are associated with disturbances to marine mammals by shipping noise (Halliday et al. 2017), vessel-whale strikes (Elvin and Taggart 2008; Hauser et al. 2018), and exposure to chemical pollutants (McWhinnie et al. 2018). Risks that possibly affect larger areas include, for instance, oil spills from shipping accidents (Nevalainen et al. 2018). Especially collision and grounding accidents present scenarios with a possibly significant oil outflow and widespread related ecosystem damage (Afenyo et al. 2017; Tabri et al. 2018). Finally, shipping emissions of black carbon, sulphur dioxide, and nitrogen oxides can impact the regional Arctic climate and ecosystem (Winther et al. 2014), where black carbon emissions in the Arctic can even have global implications as such emissions can reduce snow albedo, leading to increased heat absorption by the earth (Zhang et al. 2019a).

Focusing on maritime transportation, there is a growing body of academic literature presenting models, approaches, and frameworks for assessing safety and environmental risks (e.g., Lim et al. 2018; Kulkarni et al. 2020). Several risk models and analyses have also been presented for shipping risks in Arctic and sub-Arctic environments, mostly related to navigational accident and oil spill occurrence, and the associated ecosystem and socio-economic impacts (e.g., Valdez Banda et al. 2016; Nevalainen et al. 2018; Zhang et al. 2019b; Afenyo et al. 2019). Guidelines for preventive and response-related shipping risk assessment have also been developed by several international organizations (e.g., IMO 2010, 2018; IALA 2013; HELCOM 2018a).

Despite these advances, academic work on maritime transportation risks has mostly addressed empirical investigations and technical risk analyses and model development. However, there is a growing awareness that in addition to developing technical models and tools, and deriving risk assessment results based on these, there is a need for developing risk management approaches to incorporate these results into organizational risk management processes. For instance, Sepp Neves et al. (2015) proposed a framework for oil spill risk management, based on the ISO 31000 risk management standard (ISO 2018), focusing on how different tools can be integrated to support oil pollution preparedness, planning, and risk communication, with a case study in the Mediterranean Sea area. HELCOM (2018a) further adapted the ISO 31000 standard, defining four interrelated risk management processes for facilitating oil spill preparedness and response risk management at a regional, transnational level. These processes each address particular risk management questions associated with different decision contexts, for which an associated risk assessment toolbox has been developed. A case study is presented in HELCOM (2018b). Haapasaari et al. (2015) propose a regional risk governance framework for

maritime safety policy-making in the Gulf of Finland, where scientific assessments are applied alongside stakeholder deliberation to assess maritime risks and to ensure maritime safety, reminiscent of earlier proposals for scientific proceduralism by Shrader-Frechette (1991) and Stern and Fineberg (1996).

While these proposals and developments are valuable, they lack clear mechanisms for framing shipping risk problems. It is known that different stakeholder groups can conceptualize risk problems based on distinct types of knowledge and consequently favour different possible risk mitigation measures (Parviainen et al. 2019). In addition, in the absence of an explicit phase focusing on characterizing important dimensions of the addressed risks, suboptimal risk management strategies may be applied. This can lead to a situation where stakeholder concerns are insufficiently addressed, possibly leading to distrust and societal conflict. Conversely, for certain risks, investing time and resources in broad stakeholder consultations and extensive risk communication campaigns may lead to undue delays and excessive costs (Klinke and Renn 2002). For addressing such issues, organizational risk management falls short due to a focus on the particular values, objectives, and context of a given organization. Instead, a systematic risk governance approach needs to be defined, spanning multiple institutions and stakeholders, while aligning processes and mechanisms by which risk problems are framed and characterized, assessed, communicated, and related decisions taken (Renn et al. 2011).

In the Canadian Arctic context, the Northern Marine Transportation Corridors (NMTC) initiative aims to adaptively govern ship traffic in the region to reduce the likelihood of marine incidents and to enable more effective emergency response. The aim of the NMTC is to focus services on the most frequented routes, inducing shipping companies to further intensify the use of these routes, although there are no intentions to mandate this. Recommendations have been made to create a forum and governance structure for Arctic shipping corridor development and management (The Pew Charitable Trusts 2016). Considering also the recent decline of offshore hydrocarbon developments in the area, there is an opportunity to improve the governance of offshore energy exploration and production and related shipping activities (Gulas et al. 2017).

In light of the above, this chapter aims to outline the International Risk Governance Council (IRGC) risk governance framework, suggesting it as a feasible basis for further developing shipping risk governance in the Canadian Arctic. Particular attention is given to how risks are characterized during the pre-screening in the pre-assessment phase and the implications that this has for implementing an appropriate risk governance process. This is presented in Sect. 2.2. Subsequently, in Sect. 2.3, these generic risk-theoretic concepts are linked with selected shipping risks in the Canadian Arctic. An exploratory risk pre-screening is presented for these examples, and tentative risk governance implications are drawn. Section 2.4 presents a discussion, whereas Sect. 2.5 concludes the chapter.

2.2 IRGC Risk Governance Framework: A Brief Overview

2.2.1 IRGC Framework: Introduction

The IRGC risk governance framework (IRGC-RGF) was developed as a comprehensive approach for understanding, analysing, and managing risks. As opposed to organizational risk management standards such as ISO 31000:2018, which focus on managerial decision-making within an organization, its focus is on societal governance of risk, that is, on how to perform decision-making when various actors are involved. This requires interaction, coordination, and possibly reconciliation between various roles, perspectives, goals, and activities (IRGC 2017). The IRGC-RGF pays particular attention to the qualitatively different nature of different risk problems and the implications that this has for how the related interaction, coordination, and reconciliation mechanisms are implemented.

As illustrated in Fig. 2.1, the IRGC-RGF consists of several interlinked phases, where cross-cutting aspects involve processes and considerations that affect these phases throughout its application. In the remainder of this chapter, the focus is on the pre-assessment phase, in particular on risk pre-screening, which is elaborated on in Sects. 2.2.2 and 2.2.3. The phases are briefly outlined below; for further details the reader is referred to IRGC (2005, 2017) and Aven and Renn (2010).

The *pre-assessment phase* aims first to frame the problem in relation to issues which different societal actors may associate with the risk, setting the boundaries to

Fig. 2.1 IRGC risk governance framework. (Based on IRGC 2017)

achieve a common understanding of the risk issue, or to establish awareness of different risk perceptions. Second, through identification of early warning and monitoring mechanisms, evidence is detected to establish whether the risk realization is plausible. Third, a pre-screening is performed to assign a risk to predefined assessment and management routes.

The *risk appraisal phase* aims at enhancing understanding about the risk through knowledge-focused activities. A technical/scientific assessment of the risk provides knowledge about the causes and consequences of the risk; about vulnerability, the occurrence likelihood and consequence severity, and possible mitigation measures; and about the associated uncertainties. A concern assessment provides insights into risk perceptions and addresses questions from societal actors about its social and economic implications.

In the *characterization and evaluation phase*, a judgement is made about the acceptability of risk, providing a bridge between the knowledge and value-based dimensions of risk governance. The characterization compiles the evidence from the risk appraisal phase, whereas the evaluation involves broader value-based issues, which can also influence the judgement. Risks are considered acceptable when their occurrence likelihood and the consequence severity are limited, so that no further risk reduction measures are required. If the risk is not considered acceptable based on the decision-making mechanisms of the particular context, while the activity is nevertheless considered worthwhile to pursue, additional measures are required to reduce the occurrence likelihood or the consequence severity. Issues such as the societal needs for the risk to be present, the choice of technology and substitution potential, and the equity-related compensation mechanisms are relevant here as well, that is, issues related to policy-making and societal risk balancing.

The *risk management phase* addresses the design and implementation of actions and measures to reduce, transfer, avoid, or retain the risks. This involves issues such as the realization of options, monitoring their implementation, and obtaining and acting upon feedback from the risk management practice.

The *cross-cutting aspects* include consideration of context, risk communication, and stakeholder involvement. Given the different sociocultural, institutional, political, and economic contexts in which risks require consideration, it is important to recognize issues such as organizational capacity, actor networks, political and regulatory culture, and social climate when contextualizing and implementing the risk governance processes. Legal dimensions, including possible impacts on Indigenous rights, require consideration as well. Risk communication aims at exchanging risk-related information between different groups. It is central to achieve trust in risk management and allows risk assessors and scientists to disseminate findings, societal actors to have their voices heard and provide inputs, and risk managers to explain the rationale of policy decisions. The involvement of various societal actors ensures appropriate consideration of the plurality of values and interests and seeks to design effective risk management strategies with increased relevance and social license of the decisions.

2.2.2 *Risk Pre-screening According to the IRGC Framework*

A fundamental idea underlying the IRGC risk governance framework is that risks can be qualitatively different. Further, these differences can have important implications for which risk management strategies are effective in managing risks, in particular with respect to the types of discourse applied in the risk appraisal phase, which actors are to be included in the risk governance processes, what types of conflicts one may expect to find related to the risk, and what role risk perception may have. Three aspects are considered fundamental to pre-screen risks in the pre-assessment phase, which are useful to devise an appropriate “route” for implementing a risk governance process: complexity, uncertainty, and ambiguity.

Complexity refers to the difficulty in identifying and analysing the causes of events and the consequences these may lead to (IRGC 2017). While it is broadly accepted to be a central notion in risk research, different views on its exact meaning co-exist (Perrow 1999; Dulac 2007; Johansen and Rausand 2014a). In the IRGC-RGF, complexity relates to the characteristics of the system (activity, phenomenon) under investigation. It relates to the number of causal factors with (possible) relevance to the event occurrence and its consequences; interindividual variations; interactive effects among the causal factors, such as non-linear feedback loops which modify the relative importance of causes as the system under study evolves over time; or long delay periods between cause and effect.

Uncertainty refers to a state of knowledge in which the likelihood of adverse consequences, or the severity of these consequences, cannot be accurately described. While there are also several interpretations of uncertainty in the risk literature (Rowe 1994; Winkler 1996), the dominant feature of the concept focuses on the knowledge limitations of an assessor in describing risk (Flage et al. 2014). A common distinction is made between outcome uncertainty and evidence uncertainty. The former focuses attention on the assessor’s uncertainty about the possible occurrence of the event and its consequences, while the latter focuses attention on the strength of the evidence for making statements about these occurrences (Goerlandt and Reniers 2016). Evidence uncertainty can manifest itself due to the limitations of available data, wide variations of expert estimates, significant simplifications and inaccurate results of models, or the important role of assumptions in the evidence base.

Ambiguity has attracted less focus in risk research compared to uncertainty and complexity, but is commonly understood as relating to different interpretations of the meaning of evidence or the results of a risk analysis (Johansen and Rausand 2014b). Normative ambiguity is the condition where there are significantly different concepts about what can be regarded as tolerable, acceptable, or equitable. A condition of ambiguity emerges where there are ethics-based difficulties in agreeing on the appropriate values, priorities, or boundaries in defining possible consequences and analysing risk (IRGC 2017).

In the IRGC-RGF, a careful consideration of whether the risks in focus in the problem at hand are complex, uncertain, and/or ambiguous is made in the

pre-assessment phase. Depending on this meta-characterization, different actions and processes are recommended to be implemented in the risk governance process, which is outlined next.

2.2.3 Implications of Risk Pre-screening for Implementing Risk Management

Figure 2.2 shows the so-called risk governance escalator, which systematically depicts the implications of the dominant risk characteristic (simplicity, complexity, uncertainty, ambiguity) on how risk governance can be effectively implemented for a given risk in the different phases shown in Fig. 2.1.

Depending on which risk characteristic is found to be predominant in the pre-screening of the pre-assessment phase, a different “route” can be chosen to implement the risk governance processes. These “routes” contain distinct focal points for what knowledge should be obtained in the risk appraisal phase and how this can be achieved, which relates to what types of conflicts can be expected among different stakeholders. They also suggest which actors are to be included in the risk governance processes and what mechanisms can be expected to be appropriate for doing this. Finally, the routes suggest what role risk perceptions may have in the risk governance. In the following sections, these aspects of the risk governance escalator are briefly explained for the different routes associated with the four risk types shown in Fig. 2.2: simple risk problems and complexity-, uncertainty-, and ambiguity-induced risk problems.

ROLE FOR RISK PERCEPTION			Communication-focused	As basis for societal discourse
TYPE OF CONFLICT		Cognitive	Cognitive Evaluative	Cognitive Evaluative Normative
ACTORS	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
TYPE OF DISCOURSE	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	Complexity	Uncertainty	Ambiguity

Fig. 2.2 Risk governance escalator: implications of risk characterization. (Based on IRGC 2005, 2017; Aven and Renn 2010)

2.2.3.1 Simple Risk Problems

In simple risk problems, the cause–effect relationships associated with the risk are well understood, there are relatively few relevant causal factors, and there are few interactive effects between these factors. There are, furthermore, only little interindividual variations in the mechanisms underlying the occurrence of the risk event or its consequences. There is strong evidence for making statements about the risk, that is, experts have ample experience with handling these, there are sufficiently accurate models available, and/or there are data to make reliable risk estimations. Stakeholders agree on boundaries in defining possible consequences and on what constitutes acceptable risk.

An example of such a risk in the maritime domain may be the design of a conventional cargo vessel according to traditional prescriptive statutory and class design rules. Such a design involves risks such as loss of watertight integrity, capsizing, or structural collapse, but the regulator and maritime industry have ample experience and good models to design such vessels and verify compliance with the prescriptive rules. The risk associated with such vessel designs is broadly accepted across stakeholders through experience-based codification in the ship design rules.

As indicated in Fig. 2.2, the relevant actors in such risks are the regulatory bodies and industry experts. An instrumental discourse is maintained in the risk appraisal and in their communication, that is, the focus is on existing routines (e.g., the prescriptive rules and associated documentation requirements throughout the ship design).

2.2.3.2 Complexity-Induced Risk Problems

As outlined in Sect. 2.2.2, complexity-induced risk problems are characterized by the large number of causal factors, interindividual variations, interactive effects among causal factors, and/or long delay periods between cause and effect. Nevertheless, the evidence for analysing the risk is strong, in the sense that good models are available for analysing event occurrences and associated consequences, there is relevant expertise available, and/or there are good data to perform the analysis. Moreover, there is a broad agreement among the key societal actors in framing the risk and in what constitutes acceptable risk. An example of such a risk in the marine domain, further elaborated in Sect. 2.3.1 below, may be the risk-based ship structural design of vessels operating in Arctic environments.

As indicated in Fig. 2.2, the type of conflict is cognitive in nature: causal mechanisms are complex and there are variations in the mechanisms leading to the risks. Existing routines are insufficiently well developed to analyse the risks and the effects of risk mitigation measures. Hence, an epistemological discourse is adopted, that is, the knowledge of the risk is maximized, for example, by gathering and analysing data or by developing new models for estimating the event occurrence or the consequences. Actors involved in this risk problem include regulatory bodies, industry experts, and external scientists.

2.2.3.3 Uncertainty-Induced Risk Problems

As outlined in Sect. 2.2.2, uncertainty-induced risk problems are characterized by the limited knowledge about the possible occurrence of events and their consequences. There is a lack of expertise on which to base reliable risk judgements, there are little data or information available, and models are non-existing or very simplified and crude. Thus, various strong assumptions are made in the risk appraisal, and uncertainties are high. Usually, uncertainty is exacerbated by the presence of complexity, that is, by the presence of multiple causes, non-linear interactions, variabilities, and long incubation periods. Nevertheless, there is broad agreement among societal actors on how to frame the risk and about what constitutes acceptable risk. An example of such risk in the maritime domain, further elaborated in Sect. 2.3.2, may be the safety risks related to an increase in shipping activity in the Canadian Arctic, the implications this has for search and rescue preparedness, and the various impacts this may have on community first responders.

As indicated in Fig. 2.2, the type of conflict is cognitive and evaluative in nature: causal mechanisms are complex, and there are variations in the mechanisms leading to the risks, which are moreover poorly understood, with limited data or experience available, and models are tentative, crude, or non-existing. Hence, a reflective discourse is adopted, whereby efforts are made to increase the scientific knowledge of the risk, the affected stakeholders are systematically consulted, and reflective interaction processes are implemented to collectively decide on an acceptable way forward. Multicultural considerations, such as principles related to free, prior, and informed consent in these interaction processes, are important to account for. Actors involved in this risk problem include regulatory bodies, industry experts, external scientists, and the affected stakeholders.

2.2.3.4 Ambiguity-Induced Risk Problems

As outlined in Sect. 2.2.2, ambiguity-induced risk problems are challenging due to the substantially different conceptualizations between, or even within, different societal actor groups as to what constitutes acceptable or equitable risks. The different value systems and worldviews lead to different conceptualizations of the boundaries of the risk problem, leading to fundamentally different priority settings between stakeholders. Ambiguity-induced risk problems are often exacerbated through the complexity of the risk problem, that is, through the large number of causal factors, their interaction effects, variabilities, and delay periods. Moreover, uncertainties are typically high, that is, there is limited knowledge about the possible occurrence of events and their consequences. An example of such a risk in the maritime domain may be the risk of a severe oil spill in the Canadian Arctic, as further elaborated in Sect. 2.3.3.

As indicated in Fig. 2.2, the type of conflict is cognitive, evaluative, and normative in nature: causal mechanisms are complex and there are variations in the mechanisms leading to the risks. These risks, moreover, are poorly understood, with

limited data or experience available, and the models are tentative, crude, or non-existing. Importantly, the different worldviews and value systems of stakeholders lead to fundamental conflicts between societal actors about the acceptability of risk, the need for additional risk-reducing mechanisms, the equity of the risk distribution across stakeholder groups, the urgency of seeking technical or procedural substitutions, and even the need to allow the risk-bearing activity to take place at all.

Hence, a participative discourse is adopted, whereby efforts are made to increase the scientific knowledge of the risk, the affected stakeholders are systematically consulted, and reflective interaction processes are implemented to collectively decide on an acceptable way forward. Additionally, a wider societal debate is held, where the views of civil society and the public at large are considered. This debate is spearheaded by opinion leaders from not-for-profit organizations and industry, scientists, and political actors and is facilitated by the media through debate programmes, documentaries, investigative reports, and opinion polls. Actors involved in this risk problem thus include regulatory bodies, industry experts, external scientists, affected stakeholders, and civil society at large. In the Canadian Arctic, focusing on shipping risks, Indigenous organizations such as the Inuit Circumpolar Council and the Qikiqtani Inuit Association have an important role to represent rights-holders. In addition, international organizations such as the Arctic Council, through the Protection of the Arctic Marine Environment, Emergency Prevention Preparedness and Response, and Sustainable Development Working Groups play a significant role in building knowledge on the impacts of shipping in the Arctic, as evidenced by the various reports these groups have issued on shipping (Arctic Council 2009).

2.2.3.5 The Role of Risk Perception in Uncertainty- and Ambiguity-Induced Risk Problems

Risk perception is a collection of notions which people form about risks based on common sense reasoning, personal experience, social communications, and cultural traditions (Aven and Renn 2010). They are associated with the experiential system of human thinking and judgement, which is holistic, affective, associative, experiential, and based primarily on images, metaphors, and narratives. In contrast, risk analysis is conceived to be based on factual evidence, such as data, models, and judgements rooted in the analytic system of human thinking, which is logical and conscious, and based primarily on symbols, words, and numbers (Slovic 1987).

Societal risk governance and management involves allocating scarce public resources to the protection of human health and safety and environmental protection. Hazards and adverse consequences manifest themselves in the real world, whereas risk perceptions are not necessarily aligned with the factual evidence about the possible event occurrence and consequences. This disparity has led to scholarly debate about the appropriateness of relying on public risk perceptions for risk management decision-making (Cross 1998; Pidgeon 1998). Arguments against include the prejudiced or even discriminatory nature of public attitudes, the potential for a

misguided focus on perception management rather than addressing actual issues, and the heterogeneity of public risk perception. Arguments in favour of accounting for risk perception include that these reflect basic public values, that stakeholders should have input into risk decisions that affect them, and that perceptions have real consequences, because they lead to actions which can entail costs and new risks, which can make the situation worse.

In the maritime domain, risk perceptions are comparatively less well studied than the technical aspects of risk analysis, and they are considered peripheral to the decision-making processes (Skjong and Wentworth 2001). Commentators have voiced expectations that risk analyses should be objective and fact-based and that risks should be balanced with monetary costs (Skjong 2005; Psaraftis 2012).

Nevertheless, in the IRGC-RGF, risk perceptions are considered important especially in uncertainty- and ambiguity-induced risk problems. For uncertainty-induced risks, risk perceptions are seen to have a role in the reflective discourse among regulators, industry experts, external scientists, and affected societal actors. The stakeholders are able to express their concerns and views, which can then be addressed in stakeholder engagement processes. Thus, risk perceptions are primarily considered in the context of risk communication. In ambiguity-induced risk problems, understanding and accounting for risk perceptions is also important in risk communication and is embedded in the wider societal discourse. In these risk problems, the different underlying worldviews and value structures of societal actors can give rise to conflict; thus, it is important to acknowledge and to act upon risk perceptions to build trust in the risk governance process and to ensure a wide societal acceptance of the outcomes of the decision processes (IRGC 2017; Aven and Renn 2010).

2.3 Exploratory Risk Pre-screening of Selected Shipping Risks in the Canadian Arctic

As mentioned in the introduction, increased shipping in the Canadian Arctic brings various risks to the area. There are risks to the vessel from the environment: for instance, hull damage can lead to loss of watertight integrity and loss of stability, and the harsh cold environments can lead to freezing of water spray and icing on deck, which can lead to occupational accidents such as slips and falls. Conversely, the ship can be considered as a hazard, which can cause adverse consequences to the environment. For instance, vessel movements lead to underwater noise, which can have harmful effects to marine biota. Vessels can strike large marine mammals such as whales, leading to increased mortality in vulnerable populations. Accidental oil spills from damaged vessels can have disastrous consequences to entire ecosystems. Even the mere navigational presence of vessels in ice-covered waters may disrupt ice-bound transport or hunting routes used by Indigenous populations when navigation lanes are broken in sea ice fields and hence present a sociocultural risk.

Unregulated tourism can also overwhelm small local Inuit communities, presenting another example of sociocultural risks with a specific relevance in the Arctic.

Various risk mitigation measures are already in place to reduce the occurrence likelihood and the consequence severity. For instance, the adoption of the Polar Code has set new ship design and operational requirements for vessels operating in the Arctic (Polar Code 2014/15). Under the auspices of the Arctic Council, agreements have been made between Arctic states addressing cooperation on marine oil pollution preparedness and response (Arctic Council 2013) and aeronautical and maritime search and rescue in the Arctic (Arctic Council 2011). Within Canada, recent activities to mitigate Arctic shipping risks include the Low Impact Shipping Corridors Initiative, where voluntary shipping corridors are proposed to enhance maritime safety and to minimize environmental impacts on ecologically sensitive areas (The Pew Charitable Trusts 2016; Chénier et al. 2017). The implementation of these corridors is made in partnership with Indigenous communities and Arctic stakeholders under the Oceans Protection Plan (Transport Canada 2017).

In this section, an exploratory pre-screening of selected Arctic shipping-related risks is presented. As outlined in Sect. 2.2.1, this is part of the pre-assessment phase of the IRGC-RGF and serves as a basis for assigning the risk to an assessment and management route, as presented in Sect. 2.2.3. Section 2.3.1 focuses on risk-based structural ship design, Sect. 2.3.2 addresses maritime search and rescue, while Sect. 2.3.3 explores preparedness and response to accidental oil spills.

2.3.1 Arctic Risk-Based Ship Structural Design in Sea Ice Conditions

Ship design is an important way to mitigate risks to and from vessels. Ship concept design involves many interconnected issues that jointly affect the ship safety level. These include the design of lines and body plan, hydrostatics and buoyancy, free-board, hull structure, propulsion and manoeuvring arrangements, and damage stability (Evans 1959). Further essential design aspects affecting vessel safety include the arrangements for fire protection, detection, and extinction and life-saving appliances.

Traditionally, the complex interdependencies of hull and equipment design are encoded in prescriptive requirements derived from statutory and classification rules, which together aim to ensure an appropriate safety level. These stipulate exact technical specifications to which a design must conform. Since 2003, through concepts such as goal-based standards and risk-based ship design, there have been developments towards increased design flexibility (Hoppe 2005). In goal-based standards, the technical implementation is not strictly prescribed. Rather, goals are defined at a high level, aimed at building and operating safe and environmentally friendly ships. A set of functional requirements should be made to comply with these high-level goals, but the rules do not specify how these requirements are to be achieved.

In risk-based design, the compliance of the design with the functional requirements is demonstrated through a risk assessment of the design, that is, by identifying what can go wrong, estimating the associated probabilities and consequences, and comparing the results with risk acceptance criteria (Papanikolaou 2009). The Polar Code also allows for such a goal- and risk-based design approach (Polar Code 2014/2015), but many requirements of, for example, the International Convention for the Prevention of Pollution from Ships (MARPOL) are mostly prescriptive.

In Arctic and sub-Arctic waters, hull damage occurs relatively frequently due to the high local ice pressures on the ship hull. In the Canadian Arctic, despite the implementation of operational procedures such as the Arctic Ice Regime Shipping System (AIRSS) (Transport Canada 2018) or, more recently, the Polar Operational Limit Assessment Risk Indexing System (POLARIS) (Stoddard et al. 2015; IMO 2016), such damages range from slight deformations to the hull plating to large holes, which have led to the sinking of vessels and can lead to pollution incidents (Kubat and Timco 2003). Rather than relying on prescriptive design standards, risk-based design approaches for ice-class vessels, focusing on the hull design, have been proposed (Kujala et al. 2019).

As indicated in Sect. 2.3.2, this is an example of a complexity-induced risk. Risk-based hull design for ice-class vessels involves many interrelated issues, including the characteristics of the expected sea ice cover during the vessel's life-time, ice loads resulting from the ice-hull structure interaction, the hull structural response, and limit states. These issues involve many interrelated factors: there are different ice environments with many ice types, including level ice, ridges, and compressive regions. These lead to a range of failure mechanisms and ice-hull interaction modes such as ice crushing, bending, and spalling and hence different ice loads. The hull structural response is implicated by the characteristics of the ice pressure distributions, the material characteristics, and the structural particulars. These factors stand in a complex relationship to one another, with interactive effects between, for example, hull form, structural design, and ice loads, and variations, for example, in ice characteristics and materials.

For many of these phenomena, there are data and models available, so that, in principle, a ship can be designed with an explicit calculation of the expected hull damages in operations in ice environments over its life cycle (Bergström 2017). Conceptual approaches for risk metrics and acceptance criteria in risk-based design have been proposed (Papanikolaou 2009). Further developments in modelling the ice environment and the ship-ice interaction are however desirable. Risk metrics, evaluation criteria, and cost-effectiveness criteria for environmental effects associated with ship hull failures in Arctic environments especially require further work (Kujala et al. 2019).

Referring to Fig. 2.2 and Sect. 2.3.2, this means that to effectively mitigate Arctic shipping risk through risk-based design approaches, there is a need for collaboration between regulators, marine industry experts (including ship designers and construction yards), operational experts (such as experienced master mariners and ice navigators), and scientific experts. The focus should be on an epistemological discourse aimed at maximizing the scientific knowledge about the phenomena outlined

above. Subsequently, a more instrumental discourse should be targeted to translate the scientific knowledge into suitable engineering tools that are aligned with regulatory requirements and the industrial contexts in which these tools would be applied.

2.3.2 Human Safety at Sea: Maritime Search and Rescue Response Preparedness

When maritime accidents endanger the life of people on board vessels, search and rescue is an important operational response mechanism. In the Canadian Arctic, there have been a number of navigational accidents where search and rescue services have been essential to avoid human casualties. For instance, the *Clipper Adventurer* grounded in 2010 with 128 passengers on board in Coronation Gulf, Nunavut, while on a cruise (TSBC 2012). More recently in 2018, the *Akademik Ioffe* grounded near Kugaaruk, Nunavut, with 163 people on board (TSBC 2019). Considering the harsh environment and the remoteness of the area, such ship accidents can lead to human casualties. Recent increases in recreational boating activity also cause concern for human safety at sea (Dawson et al. 2013), which further underlines the need for effective search and rescue in the Canadian Arctic. This is acknowledged in regulatory efforts, for example, through the agreement on cooperation on aeronautical and maritime search and rescue in the Arctic (Arctic Council 2011).

As indicated in Sect. 2.2.3.3, maritime shipping accidents and the associated search and rescue response preparedness are an example of an uncertainty-induced risk, with cognitive and evaluative conflicts. For effective search and rescue preparedness and response planning, there are several key questions which need consideration. This includes issues such as where accidents can be expected to occur, under which conditions, and what consequences accidents would have. Other questions relate to how effective the response system is in ensuring human safety, what assets are needed, and where to mount a cost-effective response. Also, organizational issues such as training and knowledge management need to be considered to ensure an appropriate response. Compared to other sea areas, uncertainties about the maritime transportation system and the search and rescue system in the Canadian Arctic are higher. These systems moreover are complex, involving many interacting factors, exacerbating the risk management challenge.

In the Canadian Arctic, data about past incidents for response preparedness planning are relatively scarce (Ford and Clark 2019). There are also large uncertainties as to where possible accidents, for which different levels of response would be required, might occur. Here, two accidents types can be distinguished for illustrative purposes: recreational boating accidents and accidents in commercial vessel operations, such as cruise vessels. Experience from other sea areas show that recreational boating incidents, which are relatively frequent, occur largely proportionate to the number of such vessels navigating the area (Venäläinen and Sonninen 2013). Hence,

if it is possible to predict where such activities would take place, relatively good estimates can likely be obtained of where and under which conditions recreational boating incidents can be expected to occur. However, large-scale accidents involving commercial vessels are rare events, so that accident data are not very useful for obtaining insights in these for response planning purposes. Moreover, due to the complexities involved in the accident causation mechanisms, there are much higher uncertainties about where, and under which conditions, such accidents may be expected to occur (Hänninen 2014). There is a variety of risk models aiming to provide insights in this, but research indicates that these may provide unreliable results even in areas with higher traffic densities (Goerlandt and Kujala 2014). This limits their usefulness in Arctic environments with far less vessel traffic, of which the future traffic intensities are moreover also highly uncertain due to various factors such as economic and geopolitical drivers (Lu et al. 2014).

The search and rescue response effectiveness also involves high uncertainty. There is operational experience in the Canadian Arctic, including with large-scale evacuation operations for shipping accidents, as indicated above. However, there have to date not been major time-critical disasters involving ship fires, capsizing, or sinking of cruise vessels, for which mass rescue operations would be necessary. Uncertainty about the response effectiveness to such events is high, and arguments have been made that the current Canadian Arctic search and rescue preparedness is insufficiently developed to cope with such disasters (Ford and Clark 2019). Moreover, insights from other sea areas suggest that effective response involves a wide array of factors, including environmental conditions, the physical characteristics of the distressed vessel, the accident circumstances and its organizational preparedness, and the availability of suitable aeronautical and maritime response resources, including the presence of vessels of opportunity (Norrington et al. 2008). There is a lack of systematic knowledge about many of these aspects in Arctic environments.

Given the complexities and uncertainties associated with the organization of the search and rescue system, operations research models can be useful for obtaining insights into the cost-effectiveness of different assets for responding to maritime incidents and accidents. Such models can also help in optimizing the fleet composition and in deciding the location of the assets. There have been developments to create such models, for example, Akbari et al. (2018). To the authors' knowledge, however, no comparable models have been developed that can account for the uncertain conditions of the Canadian Arctic environment.

Given the large uncertainties about many aspects of the Arctic maritime transportation system and the search and rescue response system in the Canadian Arctic, uncertainty can be considered the predominant characteristic of this shipping risk problem. Referring to Fig. 2.2 and Sect. 2.2.3.3, the characterization of the risk as uncertainty-induced signifies a need for a reflective discourse among regulators, affected societal actors, industries, and external scientists. In these interaction processes, there should be room for the various actors to express concerns and voice their risk perceptions and suggest approaches for mitigating the risks. The focus of discussions should be on obtaining a shared understanding of acceptable ways

forward. This may involve questions about the role of local communities in search and rescue response (Senate Canada 2018), the development and implementation of transport corridors to cluster available resources in more manageable geographical areas (The Pew Charitable Trusts 2016), the support for acquisition or development of specialized response assets such as icebreaking vessels or autonomous response systems (see Chap. 5 in this volume), or questions related to the locus of responsibility for the financial burden of the response system operation (see Chap. 4 in this volume).

Simultaneously, however, there is a need for collaboration between regulators, marine industries, scientific experts, and local communities. Recognizing the findings from the reflective stakeholder-oriented discourse, this collaboration should focus on an epistemological discourse, aimed at maximizing the scientific knowledge about the phenomena outlined above and towards developing suitable models and decision support systems to plan effective search and rescue risk management strategies in the area.

2.3.3 Accidental Oil Spills from Shipping: Pollution Preparedness and Response

Oil spills are known to have the potential for disastrous impacts on marine ecosystems, can have detrimental impacts on economic sustainability of industries and coastal communities, and can have health implications for affected people (Chang et al. 2014). In coastal areas inhabited by culturally vulnerable groups, oil spills can furthermore lead to dramatic shifts in sociocultural patterns (Miraglia 2002). In the Canadian Arctic, navigational accidents such as the groundings of the *Clipper Adventurer* (TSBC 2012) and the *Akademik Ioffe* (TSBC 2019) fortunately only led to minor pollution incidents. However, as suggested by historic accident cases, such as the spill of the *Exxon Valdez* in sub-Arctic waters (Miraglia 2002) and accident risk models of ship navigation in ice-covered and Arctic waters (Afenyo et al. 2017; Valdez Banda et al. 2016), there is a possibility of a major spill in the region. Examples of oil spills in ice-covered waters include the accident with the *Antonio Gramsci* on 6 February 1987 (IOPC Fund 1989) and the *Runner 4* on 5 March 2006 (Wang et al. 2008), both in the Gulf of Finland. These are testament to the challenges for oil spill response in ice conditions, even in areas with much better infrastructure and more response assets. Apart from regulatory efforts to prevent accident occurrence in the Arctic, for example, through the provisions of the Polar Code (2014/2015), such as mandatory carriage of a Polar Water Operational Manual, it is essential to implement a performant oil spill preparedness and response system. This is acknowledged, for instance, through the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic (Arctic Council 2013). Another possible mitigation measure to reduce the risk of oil spills in the Arctic is the ban of the use and carriage for use of heavy fuel oil (HFO), which is

currently under consideration in the International Maritime Organization (see Chap. 14 in this volume).

As indicated in Sect. 2.2.3.4, maritime shipping accidents and the associated preparedness and response to oil spills are an example of an ambiguity-induced risk, with cognitive, evaluative, and normative conflicts. For effective oil spill preparedness and response planning, there are several key questions which need consideration. These include where accidents can be expected to occur, under which conditions, how much oil would be released from the vessel, where it would drift to, and what ecosystem, economic, health-related, and sociocultural impacts a spill would have, for example, on Inuit communities acting as first responders. Other questions relate to how effective the response system is to collecting the oil or otherwise mitigating its negative impacts and what assets are needed for maximizing the response effectiveness (HELCOM 2018a). Compared to other sea areas, uncertainties about the maritime transportation system and the oil response system are higher. Moreover, these systems are complex, which further complicates appropriate risk management. Importantly, there is also a normative dimension to the risk problem, caused by different worldviews and value structures of the involved parties, leading to normative ambiguities, which further complicate the risk management and governance.

In the Canadian Arctic, there are little data about past oil spill incidents given the comparatively low traffic volumes and low accident rate. Large-scale accidents involving commercial vessels are rare events, for which accident data generally are insufficient. Ship accident risk models are considered as an alternative, and several such models have been proposed (Lim et al. 2018), including in Arctic and sub-Arctic environments (Afenyo et al. 2017; Valdez Banda et al. 2016). The complexity of accident causation mechanisms in socio-technical systems such as maritime transportation, together with the limited knowledge about the risk-influencing factors and the fact that these factors interact and change over time, however, results in large uncertainties about where maritime accidents may occur and under which conditions (Hänninen 2014). Even in areas with more intense traffic, more experience, and better data availability, research indicates that maritime accident risk models may be unreliable, limiting their practical usefulness (Goerlandt and Kujala 2014). Moreover, there are large uncertainties about the development of the transportation flows across and into the Canadian Arctic for various social, economic, and geopolitical reasons (Lu et al. 2014; Gulas et al. 2017).

The effectiveness of the oil spill response system also involves high uncertainty. While there is operational spill response experience in Arctic environments, past accidents and risk analyses show that the effectiveness of spill response is not easy to ensure even in more populated areas with better infrastructure (Wang et al. 2008; Lu et al. 2019) and that there are important gaps in the response capacity in the Canadian Arctic (Council of Canadian Academies 2016). It is worth mentioning in this context that unlike in other Canadian marine regions, there currently is no standing response organization in the Arctic (WWF 2017). Insights from spill response in ice environments furthermore suggest that effective spill response involves many interrelated factors, including environmental conditions, the

operability of response assets, and organizational preparedness (Lu et al. 2019). There is a lack of systematic knowledge about many of these aspects in Arctic environments.

Given the complexities and uncertainties about the spill response system, several models and tools are available for pollution preparedness and response planning (e.g., HELCOM (2018a)). However, there are important gaps in existing modelling approaches for spill preparedness and response risk management in Arctic environments (Li et al. 2016).

Despite the above outlined complexities and uncertainties involved in Arctic maritime transportation and oil spill response, oil spill risks from shipping in the Canadian Arctic can be considered as an ambiguity-induced risk problem. The wide range of possible impacts of oil spills, including environmental, economical, health-related, and sociocultural consequences, can lead to disagreement between stakeholders about what to protect and where priorities for spill preparedness should lay. More fundamentally, stakeholders representing maritime industries, coastal communities, and non-governmental organizations may have different views about the desirability of increased shipping traffic in the Canadian Arctic: where some see economic opportunity, others may see unnecessary disruption of marine environments or threats to traditional ways of life. The issue of offshore oil spill risks is also an issue that regularly appears in the national media, attracting interest from the public at large.

These different stakeholders' views about the need for the risk-imposing activity give a normative dimension to this risk problem. The different views of involved stakeholders and the diverse opinions held by the public at large lead to challenges in framing the risk problem and to agreeing on appropriate priorities and on what constitutes acceptable and equitable risk. These different views are related to fundamentally different worldviews and value systems, characteristics of ambiguity-induced risk problems.

Referring to Fig. 2.2 and Sect. 2.2.3.4, the characterization of the risk as ambiguity-induced signifies a need for a normative discourse among regulators, affected stakeholders, industries, and external scientists, where the perceptions, concerns, and opinions of the public at large also are considered. The focus of this discourse should be on understanding the underlying reasons for the concerns and views of the different parties; risk perceptions will also have a fundamental role as a basis for this societal discourse. Rather than focusing on the immediate concerns about the oil spill risk from shipping activities in the Arctic, it may be appropriate to have more fundamental discussions and engagement, with more far-reaching governance and policy implications. Such debates may, for example, focus on the desirability of shipping activities in the Arctic in light of the economic opportunities and ecological and sociocultural risks this entails. Possible alternatives for shipping, or technological alternatives for the use of oil, also can be considered in these discussions. This focus relates to the importance of reaching a consensus about appropriate risk framing in the pre-assessment phase of the IRGC-RGF, as introduced in Sect. 2.2.1. Simultaneously, there is a need for an instrumental discourse and collaboration between regulators, industries, and scientific experts to better understand the risks and stakeholder concerns and to develop improved ways to assess the risks and ensure that these are appropriately mitigated.

2.4 Discussion

In the previous section, selected Arctic shipping-related risks have been considered in light of their predominant risk characteristics and implications of this pre-screening categorization for the implementation of risk governance processes. It is, however, stressed that this analysis is exploratory: according to the pre-assessment phase of the IRGC-RGF, the characterization of a risk as one of the risk problem types should be made in stakeholder consultation processes with societal actors. This is essential, as framing the risk problem and setting the boundaries of issues to consider in risk management is a value-laden decision, not the direct result of a science-based analysis (Shrader-Frechette 1991). Hence, the presented analysis should be considered as an input to such discussions.

As shown, risk pre-screening can assist in deciding the scope of the processes in risk governance, including which actors to involve, what type of discourse to engage in, and the extent to which risk perception is considered. Further details about how to engage in risk communication and what are suitable stakeholder engagement processes for the different risk problem types are described in Aven and Renn (2010).

Furthermore, the risk governance framework can also be used to identify and resolve risk governance deficits, both in the assessment and understanding of risks and in managing the risks (IRGC 2009). Liaropoulos et al. (2016), for example, offer a case study involving search and rescue at offshore platforms in Greece. It may be a worthwhile endeavour to map out how risk governance is implemented for various shipping risks in the Canadian Arctic, to identify gaps in the risk governance processes, and to propose improvements. Here, it is important to be mindful of the need to consider the context in which the risk governance takes place, as indicated in Sect. 2.2.1 and further elaborated in IRGC (2017).

An issue of particular importance in the Canadian Arctic context is the role of Indigenous peoples in shipping risk governance. In the IRGC-RGF, the affected stakeholders have a role in the uncertainty- and ambiguity-induced risk problems, as explained in Sects. 2.3.3 and 2.3.4. However, Indigenous peoples in Canada have constitutionally protected rights in matters relating to resource development projects located on their lands or which could infringe on their rights (Boyd and Lorefice 2018). Hence, Indigenous peoples in the Canadian Arctic are not merely stakeholders in the sense intended in the IRGC-RGF (IRGC 2017). Instead, they have the right to be consulted and their free, prior and informed consent is required, and they can resort to legal procedures when this right is violated. Hence, the Indigenous peoples in Canada are better understood as rights-holders rather than stakeholders, making their involvement in matters related to their rights essential. Moreover, compared to Indigenous peoples in other Arctic states (e.g., the Nordic countries), the rights of Indigenous peoples in Canada do not derive from international instruments per se, such as the United Nations Declaration on the Rights of Indigenous Peoples, as they pre-exist that instrument and are constitutionally recognized rights reflected in various provisions of the Canadian legal system (Allard 2018). It is stressed that the exact role of Indigenous peoples in the IRGC-RGF consistent with their rights

and in relation to the various risk types should be further clarified in future work. Further consideration should be given to what their role is in the characterization and evaluation phase, particularly in relation to judgements about risk acceptability and the need for risk mitigation measures.

Another related issue, which is not explicitly considered in IRGC (2017), is the role of traditional knowledge in building evidence for the risk appraisal and risk characterization. Questions requiring more in-depth consideration include how to handle the principles of ownership, control, access, and possession in collecting and using such knowledge for risk appraisal purposes and how to facilitate complementarity of, and how to handle possible contradictions between, traditional knowledge and results from Western science. This also relates to the issue of interpretive ambiguity in the IRGC-RGF, as outlined in Sect. 2.2.2 (see also Chap. 8 in this volume).

Finally, it is noteworthy that existing guidelines for maritime risk analysis and management, such as IMO (2010, 2018), IALA (2013), and HELCOM (2018a), do not distinguish different risk types. These focus exclusively on the risk management process and associated tools for risk identification, analysis, and evaluation. No distinctions are made between different risk problems, that is, characterizations of risks in terms of complexity, uncertainty, or ambiguity are not performed. The presented case studies of shipping risks in the Canadian Arctic nevertheless illustrate that risks can be qualitatively different, which may warrant different risk governance processes. Implementing an appropriate risk pre-screening combined with risk framing and boundary setting in a pre-assessment phase, along with a conscientious appreciation of which actors to include and how to handle risk perceptions, may facilitate finding consensus among different societal actors and improve maritime risk governance processes.

2.5 Conclusion

In this chapter, an exploratory application of the risk governance framework by the International Risk Governance Council is presented. A high-level overview has first been given of the different phases in the framework, covering pre-assessment, risk appraisal, characterization and evaluation, and management, and the cross-cutting aspects of consideration of context, risk communication, and stakeholder involvement.

Subsequently, the focus has been on the concepts of complexity, uncertainty, and ambiguity, which form the basis of risk pre-screening in the pre-assessment phase. The implications of considering a risk as being representative of one of these problem types are outlined through presentation of the risk governance escalator. This framework guides decision-makers in understanding the types of conflicts involved, the appropriate actors to involve in the risk governance, the predominant type of discourse to adopt, and the role of risk perception.

The complexity-, uncertainty-, and ambiguity-induced risk problems are illustrated for selected shipping-related risks in the Canadian Arctic, including

risk-based ship structural design in ice conditions, maritime search and rescue preparedness and response planning, and oil spill pollution preparedness and response planning. An exploratory justification is given for categorizing these risk problems, and a discussion is given about the governance implications in light of the aspects of the risk governance escalator.

While it is acknowledged that the analysis and discussion is exploratory, it is hoped that the consideration of Arctic shipping risks in a risk governance context can be useful to heighten appreciation of the complexities involved and especially about the importance of carefully considering the risk problem type and the associated governance implications.

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