Aldo Chircop
Floris Goerlandt
Ronald Pelot
Claudio Aporta *Editors*

Area-Based Management of Shipping

Canadian and Comparative Perspectives

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Abbreviations

ABM	area-based management
ABNJ	areas beyond national jurisdiction
ACNV	Arctic Corridors and Northern Voices project
ADMICO	Assistant Deputy Minister's Interdepartmental Committee on Oceans (DFO)
AIRSS	Arctic Ice Regime Shipping System
AIS	automatic identification systems
APEI	Areas of Particular Environmental Interest
ASSPPR	*Arctic Shipping Safety and Pollution Prevention Regulations*
ATBA	area to be avoided
AtoN	aids to navigation
AWPPA	*Arctic Waters Pollution Prevention Act*
BBNJ Agreement	*Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction*
BC	British Columbia (Canada)
BN	Bayesian Network
BWM Convention	*International Convention for the Control and Management of Ships' Ballast Water and Sediments*
CASRAS	Canadian Arctic Shipping Risk Assessment System
CBD	*Convention on Biological Diversity*
CCAMLR	*Convention on the Conservation of Antarctic Marine Living Resources*
CCG	Canadian Coast Guard
CCME	Canadian Council of Ministers of the Environment
CE	cumulative effects
CEMS	cumulative effects of marine shipping initiative
CEPA	*Canadian Environmental Protection Act*
CHA	*Canada Health Act*
CHS	Canadian Hydrographic Service
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada

CIS	Canadian Ice Service
CISE	Common Information and Sharing Environment (EU)
CMA	*Canada Marine Act*
CMAC	Canadian Marine Advisory Council
CNMCAA	*Canada National Marine Conservation Areas Act*
CNPA	*Canada National Parks Act*
CNWA	*Canadian Navigable Waters Act*
CNZEAA	*Canadian Net-Zero Emissions Accountability Act*
COLREGs	*International Regulations for Preventing Collisions at Sea*
CSA 2001	*Canada Shipping Act, 2001*
CTA	*Canada Transportation Act*
CWA	*Canada Wildlife Act*
CWS	Canadian Wildlife Service (ECCC)
DCPA	Distance to Closest Point of Approach
DFO	Department of Fisheries and Oceans (Fisheries and Oceans Canada)
DGICO	Director General-level Interdepartmental Committee on Oceans (DFO)
DND	Department of National Defence (Canada)
DSS	decision support system
DST	decision support tool
EBSA	Ecologically or Biologically Significant Marine Area
EC	European Commission
ECA	emission control area
ECCC	Environment and Climate Change Canada
ECHO	Enhancing Cetacean Habitat and Observation Program
EEZ	exclusive economic zone
EGCS	exhaust gas cleaning system
EHTO	Ekaluktutiak Hunters and Trappers Organization
EMSA	European Maritime Safety Agency
EMSA initiative	Enhanced Maritime Situational Awareness initiative
ESSIM	Eastern Scotian Shelf Integrated Management
EMSWe	European Maritime Single Window environment
EU	European Union
FPFAA	*Federal-Provincial Fiscal Arrangements Act*
FPIC	Free, Prior and Informed Consent
FRHA	*Fishing and Recreational Harbours Act*
FRPFIA	*Federal Real Property and Federal Immovables Act*
FSA	formal safety assessment
GCM	general circulation model
GHG	greenhouse gas
GIS	geographic information systems
GLWQA	*Agreement between Canada and the United States of America on Great Lakes Water Quality*
GoC	Government of Canada

IAA	*Impact Assessment Act*
IAAC	Impact Assessment Agency of Canada
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICC	Inuit Circumpolar Council
ICLL	*International Convention on Load Lines*
ICO	Interdepartmental Committees on Oceans (DFO)
ICRW	*International Convention for the Regulation of Whaling*
ICS	Incident Command System
IHR	*International Health Regulations*
ILO	International Labour Organization
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission (UNESCO)
IOM	integrated ocean management
IQ	Inuit Quaijimajatuqangit (Inuit traditional knowledge)
IRGC	International Risk Governance Council
IRGC-RGF	IRGC risk governance framework
IRI	Incident Response Isochrones
IRMAS	IALA Risk Management Summary
IRPA	*Immigration and Refugee Protection Act*
IRSA	Incident Response Service Areas
ISC	*International Convention on Salvage*
ISPS Code	International Ship and Port Facility Security Code
IWRAP	IALA Waterway Risk Assessment Programme
JCP	Joint Marine Pollution Contingency Plan
JRT	Joint Response Team
LOMA	large ocean management area
LRIT	long-range identification and tracking
M	nautical mile
MaPP	Marine Plan Partnership for the North Pacific Coast
MARPOL	*International Convention for the Prevention of Pollution from Ships*
MARSEC	marine security
MASS	maritime autonomous surface ships
MBCA	*Migratory Birds Convention Act*
MEPC	Marine Environment Protection Committee (IMO)
mNSW	maritime National Single Window (EU)
MPA	marine protected area
MRS	mandatory reporting systems
MRTC	maximum response time cut-off
MSC	Maritime Safety Committee (IMO)
MSP	marine spatial planning
MTSA	*Marine Transportation Security Act*
MTSR	*Marine Transportation Security Regulations*
NAECA	North American Emission Control Area

NARW	North Atlantic right whale (*Eubalaena glacialis*)
NDC	Nationally Determined Contribution (Paris Agreement)
NEAFC	North-East Atlantic Fisheries Commission
NG-VTMS	Next Generation vessel traffic management system
NMA	national maritime administration
NMC	Nunavut Marine Council
NMCA	national marine conservation area
NORDREG	*Northern Canada Vessel Traffic Services Zone Regulations*
NOTMAR	*Notice to Mariners*
NOx	nitrogen oxide
NPP	Environmental Prevention and Response National Preparedness Plan
NRC	National Research Council of Canada
OA	*Oceans Act*
OECMs	other effective area-based conservation measures
OPP	Oceans Protection Plan
OPRA	One Page Risk Assessment
OPRC	*International Convention on Oil Pollution Preparedness, Response and Co-operation*
OSPAR	*Convention for the Protection of the Marine Environment of the North-East Atlantic*
OTMA	*Oil Tanker Moratorium Act*
PAOR	*Port Authorities Operations Regulations*
PAR	*Physical Activities Regulations*
PAWSA	Ports and Waterways Safety Assessment
PHAC	Public Health Agency of Canada
PIER	Planning for Integrated Environmental Response programme
PLTA	*Payments in Lieu of Taxes Act*
PM	particulate matter
PNCIMA	Pacific North Coast Integrated Management Area
POLARIS	Polar Operational Limit Assessment Risk Indexing System
POR	places of refuge
PPPPFR	*Public Ports and Public Port Facilities Regulations*
PPR	pollution preparedness and response
PQ	Province of Quebec
PSSA	particularly sensitive sea area
PVM	Proactive Vessel Management initiative
reg	regulation
RIO	Risk Index Outcome
RFMO	regional fisheries management organization
RO	response organization
s	section
SAAS	service area analysis scenario
SAR	search and rescue
SARA	*Species at Risk Act*

sch	schedule
SCS	safety control structure
SEG	SafeSeaNet Ecosystem Graphical User Interface
SIRA	Simplified IALA Risk Assessment Method
SISAR	Search and Rescue Program Information Management System
SOLAS	*International Convention for the Safety of Life at Sea*
SOx	sulphur oxide
SRKW	Southern Resident killer whale
SRS	ship reporting system
SSCZ	shipping safety control zones
STAMP	Systems-Theoretic Accident Model and Processes
STPA	Systems-Theoretic Process Analysis
TC	Transport Canada
TCPA	Time to Closest Point of Approach
TOR	terms of reference
TRC	Truth and Reconciliation Commission of Canada
UCA	unsafe control action
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	*United Nations Convention on the Law of the Sea*
UNDP	United Nations Development Programme
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNESCO	United Nations Educational, Scientific and Cultural Organization
URN	underwater radiated noise
USNIC	United States National Ice Center
VFPA	Vancouver Fraser Port Authority
VHF	very high frequency
VIWSC	Victoria Island Waterways Safety Committee
VME	vulnerable marine ecosystem
VOO	vessels of opportunity
VORR	*Vessel Operation Restriction Regulations*
VPDCR	*Vessel Pollution and Dangerous Chemicals Regulations*
VPZ	Voluntary Protection Zone
VTMIS	Community Vessel Traffic Monitoring and Information (EU)
VTMS	vessel traffic monitoring systems
VTS	vessel traffic services (zone)
VTSZR	*Vessel Traffic Services Zones Regulations*
WAHVA	*Wrecked, Abandoned or Hazardous Vessels Act*
WHO	World Health Organization
WMO	World Meteorological Organization

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Chapter 1
Introduction

Aldo Chircop, Floris Goerlandt, Claudio Aporta, and Ronald Pelot

Abstract This chapter introduces area-based management (ABM) in shipping against the historical and policy backdrop of control of international navigation in defined areas of ocean space, culminating with the development of the international law of the sea in the twentieth century. The *problematique* of ABM in shipping is set out as a deliberate and scientifically supported exercise guided by multiple factors, including how risks posed by ships and risks posed to ships are scientifically assessed and perceived by regulators, rightsholders, stakeholders, and the public at large. Finally, the chapter describes the book's purposes, approach, research context, structure, and chapters.

Keywords ABM tools · Area-based management · Decision support · Governance · Indigenous peoples · International navigation · Law of the sea · Marine spatial planning · Maritime regulation · Occupational health and safety · Ports · Risk governance · Search and rescue · Vessel traffic management

1.1 Introduction

The idea of control over shipping in a defined area of ocean space is an ancient one and predates the emergence of the law of the sea in the seventeenth century. The Greek historian Polybius recounted how in the Second Punic War the Roman and

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Carthaginian empires agreed on a dividing line in the middle of the Mediterranean Sea which their ships were not permitted to cross (Chircop, 2006). The idea was classically captured by the great debate between *mare liberum* and *mare clausum* sowing the seeds of the future international law of the sea. In 1609, Hugo Grotius argued that "[b]y the Law of Nations navigation is free to all persons whatsoever," and subsequently John Locke, in considering fishing, referred to "the Ocean, that great and still remaining Common of Mankind" and argued for its exemption from appropriation (Grotius, 1609, chap 1; Locke, 1690, chap V s 30). In contrast, in 1635, John Selden argued for mare clausum, subjecting the sea to the exercise of sovereignty and exclusive use, followed subsequently by Cornelius van Bynkershoek, who in 1703 argued on the dominion of the sea (Selden, 1635; van Bynkershoek, 1703). The concepts of an "open" sea for the free use by all and the "closed" sea subject to control were central to the development of the fundamental rights and responsibilities of flag States to have their ships navigate freely and the ability of coastal States to control international shipping in marine areas within their jurisdiction. More than three and half centuries later, the outcome was a delicate balance between coastal State and international navigation rights enshrined in the constitution for the world ocean, the *United Nations Convention on the Law of the Sea*, 1982 (UNCLOS, 1982).

In setting out the rules on jurisdiction over ships and ocean space, UNCLOS established a framework for the regulation of international shipping, including through area-based management (ABM). ABM consists of a suite of tools for the spatial organization and control of ocean space in achieving defined policy and planning goals, such as sustainability, conservation, safety, and public order at sea. Most of these tools regulate accessibility and mobility at sea by a wide variety of classes of vessels, which in turn are subject to international rules and standards. Within the UNCLOS framework, the International Maritime Organization (IMO), created by a separate earlier convention in 1948, is designated as the competent intergovernmental organization for international shipping, and by implication, empowering it to regulate navigation and shipping, include through ABM.

International shipping is only one among many ocean uses addressed by UNCLOS, and indeed while UNCLOS singled out particular ocean uses—namely, dumping, fishing, marine scientific research, navigation, seabed mining, submarine cables and pipelines—it also underscored that the problems of ocean space are interrelated and must be considered as a whole (UNCLOS, 1982, preamble). The recognition of the unity of the marine environment and interactions of ocean uses and their impacts led to general recognition of the need for an integrated approach to ocean development and management. Integrated coastal and ocean development and management are heavily reliant on ABM (including marine spatial planning) to facilitate the organization and management of ocean uses. Marine space is conceptualized not only as an arena for ocean uses but also as a resource, potentially a scarce one in enclosed geography for which there might be competing resource and non-resource uses. The ABM approach enables coastal and ocean managers to prioritize, allocate, and license defined spaces and thereby promote sustainable development of the blue economy.

States and domestic public authorities weigh many factors in defining and allocating ocean space to preferred or multiple users, because not all ocean uses and users are equal or produce comparable impacts. Under international law, some ocean uses are protected, perhaps even "sacrosanct," such as the traditional freedoms of navigation, fishing, laying of submarine cables and pipelines, and marine scientific research, because they have been negotiated or treated as such in history. Within national jurisdiction, some ocean uses are preferred and protected more than others for other reasons and therefore are allocated primary or even exclusive access to defined spaces because of their strategic, economic, and social values and impacts.

ABM is also fundamental to the exercise of coastal State jurisdiction in the international law of the sea. Often, coastal States exercise their rights, such as for resource development, and perform their responsibilities, for example, with respect to marine conservation, through ABM regulatory tools. They assert control in this manner and apply both domestic and international standards to ensure maritime safety, environment protection, and security.

1.2 The *Problematique* of the Book

At first blush, ABM in shipping is most visible with respect to maritime trade routes. The examples that immediately come to mind are routeing measures for maritime safety and special areas for pollution prevention under IMO's major safety and pollution conventions (SOLAS 1974, chap. V; MARPOL 1973/78, Annexes I–VI). However, the application of ABM in shipping is not limited to commercial vessels. As platforms for ocean use, ships provide services to virtually all the industrial uses of the ocean because they are a common technological denominator. For instance, specially designed ships help build and maintain offshore windfarms. Similarly, offshore service vessels support oil and gas exploration and production at sea—ditto for offshore aquaculture operations. Submarine cables and pipelines are laid and maintained by specialized ships. Fishing relies on fishing vessels. Marine tourism would not be possible without cruise ships and recreational craft. Hence, IMO has not limited itself to the establishment of rules only for commercial shipping and rather has helped develop and promote standards for a wide variety of vessels providing platforms or support for the exploration and development of ocean space and its resources. Hence the use of ships is central to the discourse of ABM in the marine environment.

Shipping technology aside, the regulation of the various uses of ocean space, while using ABM approaches, has relied on tools used for ABM in shipping. For example, the use of offshore structures and installations for a wide range of ocean uses is accompanied by the designation of safety zones for the control of navigation and most especially as areas to be avoided by vessels other than those servicing the structures and installations. Submarine cables and pipelines are marked on charts and usually accompanied by restrictions on the anchoring of ships in their vicinity. Marine protected area (MPA) regulation frequently concerns the movements of ships in protected waters, in addition to setting conservation objectives and restricting a range of ocean uses. Moreover, even outside MPAs and other conservation areas, routeing measures for shipping, such as navigation routes to be used, areas to be avoided, and speed measures, may be employed to protect marine species and other interests. Hence, the tools used for ABM in shipping are equally applicable for other ocean uses.

ABM in shipping is not some arbitrary exercise in carving out ocean spaces, but rather a deliberate process guided by multiple factors, most especially by how risks posed by the industrialization of ocean space are perceived in the eyes of regulators, rightsholders, stakeholders, and the public at large, as well as evidenced by science and other knowledge. Sociologists have characterized contemporary societies as "risk societies," which are preoccupied with an omnipresent array of risks and uncertainties (Beck, 1992; Beck et al., 1994). The modern era of the late nineteenth and twentieth centuries is characterized by industrialization, urbanization, and scientific advancements. While these have led to unprecedented prosperity and progress, for instance, in relation to the much-increased use and commercial exploitation of ocean spaces, these advancements also brought about profound social, economic, and cultural changes. Through a sociocultural preoccupation with a makeable future, combined with a reflexive impulse of continuously critically reexamining and questioning established norms, systems, and knowledge, individuals and institutions have become increasingly aware of the many risks and uncertainties associated with modernization.

In Beck's risk society, risks are complex and interconnected, and their causes are often incompletely understood and their impacts difficult to predict. An essential characteristic of the "risk society" is therefore that the possible, malleable, and thus changeable futures are made into objects of present-day decision-making. This requires institutions to develop and implement processes and tools to identify and increase the understanding of various risks, decide on their acceptability, identify and realize options to mitigate the risks, and create mechanisms for monitoring and control. ABM can be readily interpreted as mechanisms to extend the sociocultural norms of the "risk society" to ocean spaces, through risk management principles and actions.

The notion of "risk" in shipping concerns potential hazards posed by ships, or to which ships are exposed, and can be understood broadly and from various disciplinary perspectives. While on the one hand producing massive economic and social benefits through maritime trade, enhancing mobility and other services, ships entail safety, environmental, and security risks. They are noisy machines that generate wastes, pose public health threats as emitters of air contaminants, are vectors of disease, cause marine pollution when they lose cargo or bunker fuel, can be weaponized, and potentially elbow out other marine users in their areas of operations. ABM of marine spaces can help prevent or mitigate those and other risks, for example, by controlling onboard waste management and discharge in designated marine areas or ports.

Ships also face risks which can be managed by ABM information and mitigation measures. Traffic separation schemes enhance the safety of ships by providing separate shipping lanes. Ships cannot sail under all environmental conditions, and hence navigation in certain areas, such as in the polar regions, is subject to dedicated rules. Similarly, ABM rules determine the extent to which ships can be loaded, depending on season and the zones they trade in. Risks can be mitigated when reliable weather and navigational conditions are communicated to ships, and the responsibilities for the delivery of such services are organized according to geographical zones. The designation of places of refuge serves to assist ships in need of assistance to stabilize their condition in areas of relative safety. The designation of areas to be avoided helps prevent ship strikes of marine mammals. Furthermore, ships serve as a living environment for seafarers and passengers. When a ship encounters a calamity at sea, people on board face acute safety risks to their lives. This necessitates maintaining a level of emergency preparedness and the development of infrastructure and assets for search and rescue at sea. ABM measures in shipping are vital for human safety at sea.

1.3 Purpose and Approach of the Book

Against the above backdrop, this book explores the multiple layers of area-based regulatory approaches and management measures and their nuances in shipping. It sets out a taxonomy of ABM and aims to build a comprehensive understanding of the range of spatially defined management tools used with respect to the mobility and activities of ships irrespective of the ocean uses and industries they serve. Attention is paid to analytical techniques and processes that can be used to gain insights into the risks associated with shipping in marine spaces, and broader aspects related to ABM governance of ocean space, including its legal basis, technological developments, and sociocultural considerations. By developing an understanding of key concepts and how ABM is or can be used in regulating and managing ships, we seek to underscore the actual and potential value and role of the regulatory and management tools developed for shipping in the larger context of integrated coastal and ocean management and more specifically in marine spatial planning.

The perspectives employed in this book are international, comparative, and Canadian. Much of ABM in shipping finds its legitimacy and authority in international conventions setting out international rules and standards for shipping and aiming at creating a balance between coastal State rights and responsibilities on the one hand and international navigation rights on the other. Most of the researchers and contributors to this book are based in Canada, and consequently there is an emphasis on the Canadian context and practices. With coastal frontage on three oceans and diverse international and domestic shipping interests, Canada is an ideal laboratory to observe and understand ABM in shipping in action, how international standards are domesticated, and the compromises necessary to ensure efficiency, effectiveness, and equity. In recent years, Canadian ABM practices have been increasingly consultative with ocean users, stakeholders, and, most importantly, Indigenous peoples' governments and organizations whose constitutionally protected rights are affected. Hence, the book considers current and emerging ABM practices to mitigate the risks and impacts of shipping in Canada and in a comparative manner with other appropriate jurisdictions.

The book is necessarily multidisciplinary and interdisciplinary. The contributors represent various disciplines and fields, most especially anthropology and Indigenous studies, industrial engineering and risk, law and maritime governance, and marine management. Most of the authors have been working collaboratively over the years enabling them to fuse perspectives and methods and thereby produce interdisciplinary outputs. The outputs are a mixture of theoretical approaches and practical applications when specific problems are addressed. They are collectively or individually guided by several fundamental questions aimed at exploring theoretical explanations of the relationship between risk, spatial designations, functions to be performed, mobility, temporal dimensions, and perceived benefits, including the following: how do and should we conceive maritime risks and related costs and benefits? What is the relationship between risk, space, function, and mobility of ships? What values and interests guide or should at least inform ABM in shipping? How do or should we strategize the use of area-based approaches to the governance of shipping? Should various ABM initiatives be integrated or coordinated or simply be pursued opportunistically? What roles do or should public authorities play? What roles do other key actors, such as industry associations, Indigenous organizations, and nongovernmental organizations play? What are effective consultation processes and what facilitates effectiveness? What decision support systems are needed for ABM? How should we conceptualize "good" or "best" ABM practices in the governance of shipping, and what are illustrative examples?

1.4 Research Context

This work is an integral part of the Ocean Frontier Institute-funded project Module N: Navigation Safety and Environment Protection, funded by the Canada First Research Excellence Fund and co-led by researchers from the Schulich School of Law, Department of Industrial Engineering and Marine Affairs Program, at Dalhousie University. Its content draws on lessons learned from research conducted since inception of the project and more directly from lessons derived from the project's second major workshop, Shipping Risk Mitigation Research and Practice in Canada: Considering Area-Based Management Approaches, convened jointly with the Clear Seas Centre for Responsible Marine Shipping in 2022.[1]

[1] ClearSeas, *Shipping risk mitigation research and practice in Canada: Considering area-based management approaches*, https://clearseas.org/event/workshop-using-area-based-management-to-reduce-marine-shipping-risks-in-canada/. Accessed 23 Feb 2024.

1.5 Book Structure

The book is organized in four parts with chapters grouped under each and designed in a manner that enables the flow of themes and discussions, as follows: Part I: Principles and Frameworks; Part II: Vessel Traffic Management; Part III: Marine Spatial and Environmental Planning; and Part IV: Managing Human Safety in Remote Areas. The structure of the book is meant to tackle different perspectives, theoretical approaches, and examples of the broad variety of ABM measures that target shipping directly or indirectly. The content flow unfolds from more generic discussions of policy, regulatory, and legal frameworks to studies of vessel traffic management, examples of ABM in marine and environmental planning, and the management of human safety in remote areas, with an emphasis on the Canadian Arctic.

The introduction (Chap. 1), which sets out the purpose, rationale, context, and structure of the book, is followed by five chapters in Part I, Principles and Frameworks. This part sets the stage for an in-depth discussion of ABM by providing the conceptual framework for understanding the use of ABM in the governance of shipping at various levels, including global, Canadian, local, and Indigenous peoples. In Chap. 2, Aldo Chircop, Claudio Aporta, Floris Goerlandt, and Ronald Pelot theorize on the nature of the relationship between risk, spatial definitions, and the functional approach at the heart of ABM in the governance of shipping, most especially in Canada. They craft an approach to understanding the taxonomy of ABM tools that are shipping-specific and others that affect shipping without being purposely geared toward it. The chapter links the use of ABM tools to an emergent "risk society" and explores tools in the interrelated realms of assessment, management, and governance. Finally, the chapter discusses the role of social license in the context of Canada's commitments and obligations toward Indigenous peoples.

In Chap. 3, Paula Doucette and Samuel Mansfield explore cumulative effects assessments (CEA) in marine shipping in the context of ABM. They explore how CEA is used to evaluate changes in the environment which are caused by interactions among human activities and natural processes through a cumulative lens. The authors state that Canada's historic approach of assessing projects individually does not always provide a complete understanding of cumulative effects at the regional level. In alignment with an ABM approach, they propose regional CEAs to account for analysis and decisions based on the effects in a region. The authors analyze the Cumulative Effects of Marine Shipping (CEMS) initiative (led by Transport Canada in the context of the Oceans Protection Plan), as an example of a regional CEA which was codeveloped through collaboration with different stakeholders and rightsholders. They provide a detailed analysis of the CEMS assessment in the Cambridge Bay area of Nunavut, in Arctic Canada.

The next three chapters discuss area-based solutions at different scales. In Chap. 4, Nele Matz-Lück and Shams Al-Hajjaji provide background and analysis to understand the international legal framework of ABM tools. The chapter provides a comprehensive bird's-eye view of tools, focusing on global conventions, most especially the *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction* 2023, and regionally limited instruments such as regional fisheries agreements. The authors reflect upon whether these ABM tools are set up in a coherent manner or whether they place burdens upon the shipping sector that are not necessary in pursuing sustainability in ocean governance.

In turn, in Chap. 5, Aldo Chircop and Scott Coffen-Smout consider ABM tools for shipping in Canada. The authors provide a comprehensive survey of both the regulatory tools available for the direct spatial management of shipping, as well as the indirect ways of spatial management of shipping through tools (e.g., the designation of marine protected areas), whose principal purpose is marine conservation, but which may have incidental effects on shipping. Key legislation within Canada is described and some of its strengths and weaknesses are analyzed. The authors reflect on various aspects of ABM tools, including their purposes and functions, their role in implementing international regulatory commitments, and their function in the allocation of ocean space. They question whether ABM tools should always be integrated in a broader ocean management approach or if their application should also be context-dependent and used for specific problem-solving in space and time. Possible future directions are also explored.

In Chap. 6, Claudio Aporta, Leah Beveridge, and Weishan Wang reflect on the use of decision support systems in the context of ABM in shipping and how these can be effectively conceptualized and aligned with the traditional knowledge of Indigenous peoples. A key question is how Indigenous knowledge can be included in the design and implementation of area-based planning initiatives that relate to shipping, both through decision support tools and decision support systems. The authors theorize on the meaning of engagement in the Canadian context of reconciliation and reflect upon the characteristics of decision support tools and systems for ABM, which can contribute to (or limit) decolonizing processes of governance. The focus of the chapter is on the Canadian Arctic, in which some concrete initiatives for and applications of decision support tools and systems are interpreted and discussed. The authors propose that political, ontological, and methodological dimensions of the governance problem must be addressed for true engagement to happen, charting a path for future research and development in this area.

Part II on Vessel Traffic Management comprises two chapters offering different perspectives, historical backgrounds, theoretical insights, and current trends on issues surrounding vessel traffic management and risk analysis. In Chap. 7, Floris Goerlandt provides an overview of risk analysis techniques currently proposed at an international level and discusses theoretical approaches for conceptualizing, assessing, and dealing with risk in the context of marine shipping. The author focuses on risk analysis techniques for ship accident prevention in marine areas, which are used to support decisions on the need for area-based measures, and on options to control navigations risks such as routing measures or vessel traffic management. The chapter gives an overview of the current internationally recommended process for waterway risk management and on the risk assessment tools included in the international guidelines. He then provides a brief overview of some influential accidental causation theories, which (often implicitly) underlie the design of these risk assessment tools. Through a selection of risk assessment tools from the internationally recommended toolbox and from the academic literature, an analysis is presented of how accident theories underlie different tools. Focus is also directed toward how, and to what extent, physical, environmental, infrastructural, and organizational aspects of marine space are considered in these selected tools and in the accident theories on which these build. A discussion is provided, focusing on questions about the reliability and validity of the tools and how these tools are recommended to be used in decision-making processes. The chapter outlines several directions for future research and development in the field.

In Chap. 8, Anish Hebbar, Jens-Uwe Schröder-Hinrichs, and Serdar Yildiz discuss trends in autonomy and digitalization in the European context. The authors provide a historical background to understand the trends, tracing links between shipping management techniques in 300 BC in Alexandria, the introduction of radar technology combined with radio communication after World War II, and the establishment of the vessel traffic services (VTS) commonly used today. The authors provide a succinct overview of the regulatory basis for vessel traffic management at the international level and insights in the applicable standards for VTS to support safety of navigation. The authors subsequently examine regional approaches to and experiences with vessel traffic management in European waters. Insights are provided in the legislative basis and technical functionality of the Community Vessel Traffic Monitoring and Information (VTMIS) system, the European Union Maritime Information and Exchange system (SafeSeaNet), and the European Maritime Single Window environment (EMSWe). Emphasis is placed on reporting requirements and data sources and to autonomy and digitalization. Contemporary developments of vessel traffic management focus on the interoperability of mandatory reporting systems, data exchange capabilities, and sea traffic management services. The chapter identifies future trends and challenges of vessel traffic management, especially in relation to developments toward autonomous vessels.

Part III, Marine Spatial and Environmental Planning, comprises two chapters addressing ABM issues from the perspectives of collaborative governance frameworks, risk governance, and the role of ports and places of refuge. In Chap. 9, Weishan Wang and Claudio Aporta provide a comparative study of the use of ABM collaborative approaches in shipping governance. In particular, the authors propose that an existing and successful management program, the Voluntary Protection Zone (VPZ) for shipping along the west coast of Haida Gwaii, could serve as a model for the development of a governance framework for the Northern Low-Impact Shipping Corridors initiative in Arctic Canada. The authors analyze the VPZ project as an example of an ABM tool that enhances safe maritime navigation while also respecting Indigenous rights and being informed and influenced by Indigenous perspectives and knowledge. The chapter identifies several issues and challenges that will be encountered during the implementation and governance of Transport Canada's Corridors initiative and describes how similar issues and challenges were addressed with the VPZ through a unique collaboration between the Council of the Haida Nation, the Government of Canada, and the maritime shipping industry.

In Chap. 10, Jessica Cuccinelli, Floris Goerlandt, and Ronald Pelot explore risk governance deficits of marine oil spill preparedness and response in Canada. The authors highlight the need for the development of effective societal risk governance and risk management, particularly in the context of projected increasing shipping traffic in the Canadian Arctic. The chapter describes the current regulatory context and practices for oil spill preparedness and response in Canada, addressing the responsible authorities, approaches for stakeholder and rightsholder engagement, and decision-making processes prior to pollution incidents and during an ongoing response. Through interviews with federal civil servants with expertise in oil spill preparedness and response, the authors systematically identify and explore risk governance deficits, building on the structure of the International Risk Governance Council's Risk Governance Framework. The study's results indicate that the main deficits pertain to factual knowledge about risks, evaluating risk acceptability, implementing and enforcing risk management decisions, organizational capacity for risk management, and dealing with dispersed responsibilities. Relating the findings to ongoing initiatives to strengthen the governance of spill preparedness and response, several policy and management implications are discussed. Finally, several future research and development directions are highlighted, for example, how to better account for Indigenous knowledge in decision-making processes, opportunities for technical developments for enhanced situational awareness, and further research to better understand risk governance deficits from different perspectives.

In Chap. 11, Aldo Chircop explains Canada's system for ports as special management areas with responsibilities over marine and terrestrial spaces to enhance commercial competitiveness, safety, security, and environmental sustainability. Federal law distinguishes between different types of ports, namely, ports managed by Canada Port Authorities, public ports, and small craft harbors, giving attention to relevant responsibilities, actors, and ABM-related activities. The chapter discusses the continuity of terrestrial and marine areas within the jurisdiction of ports, the scope of governance powers, and ports' environmental mission, including the pursuit of sustainability, decarbonization, prevention of marine and air pollution, and protection of marine biological diversity.

Part IV, Managing Human Safety in Remote Areas, consists of two substantive chapters and the conclusion. In Chap. 12, Mark Stoddard, Ronald Pelot, Floris Goerlandt, and Laurent Etienne focus on ABM in the context of Canadian Arctic search and rescue (SAR). A novel approach to delineate surface ship Incident Response Service Areas (IRSA) and Incident Response Isochrones (IRI) is proposed to support strategic SAR planning. This approach is based on an analysis of sea ice, which is related to attainable vessel speeds in different Polar Operational Limits Assessment Risk Indexing System (POLARIS) risk levels, further making use of a network path optimization approach in a geospatial graph network. The authors discuss the use of IRSA and IRI to measure the year-round accessibility and remoteness of maritime locations in the Canadian Arctic, improving the accuracy of estimated maritime SAR surface ship response times to a given incident location. A series of geospatial data products are shown, illustrating the concepts and providing insights in the geospatial and temporal access of the Canadian Arctic for different Polar Class vessels. Several avenues for future work are also highlighted.

In Chap. 13, Desai Shan and Om Prakash Yadav discuss a regional perspective for public and occupational health. The authors discuss the challenges to safe marine operations in the Canadian Arctic (e.g., distances between harbors, a sparse population, extreme weather conditions), which were heightened through the COVID-19 pandemic. They analyze public health measures applicable to vessels and crew operating in the Canadian Arctic adopted by Transport Canada and the Public Health Agency of Canada between 2020 and 2021. Through qualitative semi-structured interviews of key actors in the Arctic shipping sector, the authors evaluate the impact of these public health measures on Arctic shipping and seafarers. The authors' findings suggest that the public health measures implemented to limit the spread of the infection raised health and safety concerns among seafarers.

Chapter 14 concludes the book. The editors revisit the *problematique* and questions set out in the introductory chapter to pull together the various theoretical explanations and findings in each chapter and reflect on the notions of "good" and "best" practices in ABM in the governance of shipping generally and in Canada specifically.

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Part I
Principles and Frameworks

Chapter 2
Understanding Area-Based Management in Shipping

Aldo Chircop, Floris Goerlandt, Ronald Pelot, and Claudio Aporta

Abstract This chapter discusses area-based management (ABM) in shipping in view of developing an understanding of the broad range of tools used and how they are informed by risk and justified by social license. Their purposes are varied and include safety, environmental, security, and public health functions. The chapter first explores shipping-specific and non-shipping-specific ABM tools that have an impact on shipping and proposes an approach to taxonomy and classification. Subsequently, a risk perspective on ABM tools and processes is provided, addressing aspects of risk assessment, management, and governance. Connected especially to the latter, the importance of social license in the context of ABM tools and measures is examined closely. While at first blush the various ABM tools leave an impression of complexity and fragmentation, a closer look demonstrates flexible, nimble, multilevel, and multi-sectoral, problem-solving and management practices operating at the international and domestic levels that inform or guide each other.

Keywords Area-based management · ABM taxonomy · ABM tools · Environmental management · International maritime law · Marine protected areas · Marine spatial management · Maritime safety · Ocean management · Risk governance · Routeing · Social license

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2.1 Introduction

In the contemporary context, the adoption of routeing measures as area-based management (ABM) tools to enhance the safety of international navigation and shipping and mitigate the impacts of shipping is a responsibility exclusively assigned to the International Maritime Organization (IMO), a specialized agency of the United Nations (SOLAS, 1974, reg 10(2)). However, as the quintessential ABM tool in shipping, routeing precedes IMO, and indeed in his 1855 "Letter Concerning Lanes for Steamers," Maury recommended "two steam lanes; across the Atlantic, viz: one for the steamers to go in, and the other for them to come in" and that "the adoption of these lanes; would do away with collisions" (Maury, 1855, 4–5). The idea influenced the North Atlantic Track Agreement of 1898, and in 1911 one-way routes were introduced in the Great Lakes region (Paton, 1983). However, the modern use of ABM, including routeing, to enhance maritime safety, prevent pollution, etc. followed the operationalization of IMO in 1958 and the designation of the first traffic separation scheme in the Strait of Dover (IMO, n.d.; Paton, 1983). Marine protected areas (MPAs) for marine conservation, as another form of ABM, have younger vintage, and their additional purpose to mitigate the effects of shipping on the marine environment is a more recent development (Humphreys & Clark, 2020).

The ABM measures used in shipping are created by diverse public authorities at the international and domestic level in Canada. In addition to IMO routeing measures, other ABM measures may involve the competence of different international organizations, and therefore IMO may collaborate with such organizations in the adoption of measures in areas of shared competence, as with the World Meteorological Organization (WMO) with respect to meteorological forecasting areas known as METAREAS.

Today, ABM tools are widely considered as vital to address complexity and conflict in the pursuit of sustainable ocean use, conservation, and management. They are used separately from or within the context of ocean management and marine spatial planning (MSP) to produce a range of safety, security, and environmental protection outcomes. Most recently and of great significance, ABM has been introduced to play a prominent role in the *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction* (BBNJ Agreement, 2023) (see Chap. 4, this volume).

There is extensive literature on ABM in the marine environment, most especially on MSP and MPAs, respectively, for managing user conflicts and promoting marine conservation (Ehler & Douvere, 2009; Ehler, 2021), but to a lesser extent with respect to maritime safety (Boisson, 1980; IMO, 2023). Surprisingly perhaps, there is little literature that treats the full scope and scale of ABM tools in shipping in a consolidated work, in comparison with works limited to routeing, special areas for vessel-source pollution prevention, and particularly sensitive sea areas (PSSAs) (IMO, 2023; Roberts, 2007; Roberts et al., 2010; Chircop, 2018).

This chapter attempts to contribute to the general literature on the use of ABM in shipping by proposing classification and taxonomy to clarify the purpose and scope of tools and the nature of the relationship between risk, spatial definition, functions, and social license in supporting multiple ocean uses and interests. The governance of shipping in Canada is used as context because of this jurisdiction's extensive experience in various ocean environments and the authors' familiarity with it.

The chapter starts by setting out the conceptual approach, with a focus on definitions, classification, and terminology at the international level and in Canada. Next, a risk perspective on ABM tools and processes is proposed as a lens to understand ABM tools and processes, focusing on the risk object of ABM tools and related risk management and governance aspects. This is followed by discussion of the social license expectations of ABM tools in the governance context. The chapter concludes with reflections on ABM design.

2.2 Conceptual Approach

2.2.1 Definitions

Defined in basic terms and not limitedly to shipping, an ABM tool "is an approach that enables the application of management measures to a specific area to achieve a desired policy outcome" (UN Environment, 2018). We would add that the chosen management measures are designed to perform designated functions to achieve higher order policy goals. In the context of shipping, ABM tools consist of a wide range of measures adopted by different public authorities at various geographical and temporal scales for the setting and management of the standards, operations, and impacts of shipping and the provision of services to navigation and shipping.

ABM measures may also be defined for specific applications, for example, to address the needs of a particular instrument. For example, the BBNJ Agreement, defines "area-based management tool" to include "a marine protected area, for a geographically defined area through which one or several sectors or activities are managed with the aim of achieving particular conservation and sustainable use objectives in accordance with this Agreement" (BBNJ Agreement, 2023, art 1(3)). In this chapter, we use the broader definition in the previous paragraph to include a wider range of ABM tools than simply for conservation and sustainable ocean use but at the same time include the BBNJ definition within our scope.

2.2.2 Classification and Terminology

Given the wide range of ABM tools used in shipping, we propose a high-level classification that divides these measures in two major groups. The definitions of terms are set out in the glossary appended to this chapter. At the highest level of classification, a distinction may be maintained between (a) shipping-specific measures and

(b) non-shipping-specific measures that have an impact on shipping. The first group consists of tools adopted under the authority of international maritime law instruments and Canadian maritime legislation to regulate navigation and shipping represented in Tables 2.1 and 2.2, respectively. The second group in Table 2.3 consists of tools mandated mostly by Canadian environmental law to enable marine spatial planning and marine conservation.

2.2.2.1 International Maritime Law ABM Tools

International maritime law ABM tools are adopted primarily by IMO, some jointly with other international organizations. In addition to its own constitutive instrument, the IMO derives its authority from the *United Nations Convention on the Law of the Sea*, 1982 (UNCLOS), various provisions of which imply an ABM regulatory role for IMO, and various international maritime conventions for which it is responsible, including its own constitutive instrument (UNCLOS, 1982; Chircop, 2015).

Table 2.1 sets out such tools by type of tool, issuing authority and source of mandate, purposes, functions, and spatial scales. The list is not exhaustive and serves to illustrate the diversity of ABM tools and approaches in shipping. The principal issuing authority at the international level is IMO. However, in the case of some tools, IMO shares or exercises joint authority with other international organizations, such as the World Health Organization (WHO) and WMO. The purposes of the listed ABM tools vary, and while most are regulatory in character, some perform other purposes such as to organize and facilitate the delivery of specific services (e.g., weather forecasts, search and rescue) and facilitate international cooperation. The functions performed are primarily the enhancement of maritime safety, pollution prevention and response, marine conservation, maritime security, and protection of public health. The various tools operate at designated geographical scales, mainly at the regional, subregional, and local levels. The bulk of the tools serve safety at sea and environmental protection and will be next discussed from these perspectives.

The principal international ABM safety tools concern load lines, METAREAS, NAVAREAS, routeing and reporting measures, polar safety standards, as well as places of refuge and search and rescue areas. Load lines and polar safety standards share the common purpose of regulating construction, design, or operations standards. A major maritime safety instrument for which IMO is responsible, the *International Convention on Load Lines*, 1966 (ICLL), and its 1988 Protocol use an ABM approach for the load of ships according to navigation zone and season to address identified safety risks (see Sect. 2.3.2) (ICLL, 1966/88). The regulation of polar shipping is also informed by an ABM approach at the regional level. Operating under the authority of the *International Convention for the Safety of Life at Sea*, 1974 (SOLAS), and the *International Convention for the Prevention of Pollution from Ships* (MARPOL), Part I of the International Code for Ships Operating in Polar Waters (Polar Code) provides safety standards for regional shipping in Arctic waters and the Antarctic Area (SOLAS, 1974; MARPOL, 1973/78; Polar Code, 2014/15, Part I-A).

Table 2.1 Shipping-specific ABM measures adopted at an international level (in alphabetical order)

ABM tool	Issuing authority	Purpose	Function	Spatial scale
Load line zones, areas, and seasonal periods	IMO (ICLL)	Regulation	Maritime safety	Regional
MARPOL emission control areas	IMO (MARPOL)	Regulation	Pollution prevention; public health protection	Regional, subregional
MARPOL special areas	IMO (MARPOL)	International cooperation, regulation	Pollution prevention, pollution response, public health protection	Regional, subregional
METAREAS	WMO, IMO (SOLAS)	International cooperation, provision of service	Maritime safety (weather and ice forecasts)	Regional, subregional
NAVAREAS	IMO, WMO (SOLAS)	International cooperation, provision of service	Maritime safety (navigational information)	Regional, subregional
Particularly sensitive sea areas (PSSAs)	IMO (IMO Convention, PSSA guidelines)	Regulation	Pollution prevention, marine conservation	Regional, subregional, local
Places of refuge/ safety	IMO (ISC, IMO POR guidelines)	Provision of service	Maritime safety, pollution prevention, pollution response	Local
Polar code areas (Arctic waters, Antarctic Area)	IMO (MARPOL, SOLAS)	Regulation	Maritime safety, pollution prevention	Regional
Pollution emergency planning and response	IMO (OPRC)	International cooperation, provision of service	Pollution prevention, pollution response	Regional, subregional, local
Quarantine	WHO (IHR)	Regulation	Public health protection	Local
Reporting measures (area specific)	IMO (SOLAS)	Regulation	Maritime safety, pollution prevention, maritime security, public health protection	Regional, subregional, local
Routeing measures	IMO (UNCLOS, SOLAS, COLREGs)	Regulation	Maritime safety, pollution prevention, marine conservation	Regional, subregional, local

(continued)

Table 2.1 (continued)

ABM tool	Issuing authority	Purpose	Function	Spatial scale
Search and rescue areas	IMO (SAR Convention)	International cooperation; provision of service	Humanitarian search and rescue	Regional, subregional

COLREGs Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs, 1972); *ICLL* International Convention on Load Lines; *IHR* International Health Regulations; *ISC* International Convention on Salvage, 1989; *MARPOL* International Convention for the Prevention of Pollution from Ships, 1973/78; *METAREAS* Meteorological Forecasting Areas; *NAVAREAS* Navigation and Meteorological Warnings Areas; *OPRC* International Convention on Oil Pollution Preparedness, Response, and Co-operation, 1990; *POR* places of refuge; *SAR* search and rescue; *SOLAS* International Convention for the Safety of Life at Sea, 1974

Routeing measures are regulatory in nature and adopted by IMO under the authority of UNCLOS and SOLAS, usually for application at the regional, subregional, and local levels. In enabling coastal States to designate sea lanes and prescribe traffic separation schemes in the territorial sea—including for tankers, nuclear-powered ships, and ships carrying dangerous or noxious cargoes—UNCLOS requires them to consider IMO recommendations (UNCLOS, 1982, art 22(3)). In the case of straits used for international navigation, the coastal State has a legal duty to refer proposals for sea lanes and traffic separation schemes to IMO with a view to their adoption, and IMO "may adopt only such sea lanes and traffic separation schemes as may be agreed with the States bordering the straits, after which the States may designate, prescribe or substitute them" (ibid, art 41(4)). There is a similar duty with respect to archipelagic sea lanes passage (ibid, art 53 (9)). IMO has powers to recommend the breadth of safety zones around artificial islands, installations, and structures in the exclusive economic zone (EEZ) and on the continental shelf when the breadth exceeds 500 meters (ibid, art 60(5); art 80 by extension). In the case of clearly defined areas within the EEZ requiring additional protection, IMO is empowered to facilitate the designation of special mandatory measures for the prevention of pollution which may be legislated by coastal States (ibid, art 211(6)).

The purpose of ships' routeing systems is to contribute to maritime safety, navigation efficiency, and environment protection, and routeing measures may be mandatory or recommended (SOLAS, 1974, Ch V, reg 10). Although States are expected to submit proposals to IMO, it is possible they may adopt routeing systems without doing so, in which case they are encouraged to follow IMO guidelines and criteria. A routeing system is defined as "[A]ny system of one or more routes or routeing measures aimed at reducing the risk of casualties; it includes traffic separation schemes, two-way routes, recommended tracks, areas to be avoided, inshore traffic zones, roundabouts, precautionary areas and deep water routes" (IMO, 1985, 2019a). The various measures in the routeing system are defined in the Appendix to this chapter. States are duty-bound to ensure their ships adhere to IMO routeing measures, and in turn ships using mandatory systems are required to log their use.

Table 2.2 Shipping-specific ABM measures in Canadian waters (in alphabetical order)

ABM tool	Responsible authority	Purpose	Function	Spatial scale
Arctic waters	TC (AWPPA, CSA 2001)	Regulation	Maritime safety, pollution prevention	Regional
Green corridors	Port authorities (CMA)	Provision of service, international cooperation	Decarbonization, trade facilitation	Regional
Icebreaking areas	CCG (OA)	Provision of service	Maritime safety	Regional, subregional, local
Marine conservation routeing and speed measures	TC (CSA 2001)	Regulation	Marine conservation	Subregional, local
North American Emission Control Area (NAECA)	TC (CSA 2001)	Regulation	Pollution prevention, public health	Regional, local
Northern low-impact shipping corridors (Arctic waters)	TC/CCG/CHS (CSA 2001, OPP)	Provision of service	Infrastructure focus, maritime safety, pollution prevention	Subregional, local
Oil tanker traffic moratorium (west coast)	TC (OTMA)	Regulation	Pollution prevention	Subregional, local
Pilotage areas	Pilotage authorities (PA)	Provision of service	Maritime safety, pollution prevention	Regional
Places of refuge/ safety	TC (CSA 2001, WAHVA, PORCP)	Provision of service, regulation	Maritime safety, pollution prevention	Local
Pollution emergency response	TC/ECCC (CSA 2001, GLWQA)	Provision of service, regulation, international cooperation	Pollution response	Regional, subregional, local
Port areas	TC/port authorities (CMA, MTSA)	Regulation	Maritime security	Local
Proactive Vessel Management (PVM) (low-impact corridors in Arctic and BC waters)	TC (CSA 2001, OPP)	Provision of service	Maritime safety, pollution prevention	Subregional, local
Quarantine	PHAC/TC (CHA)	Regulation	Public health	Regional, subregional, local

(continued)

Table 2.2 (continued)

ABM tool	Responsible authority	Purpose	Function	Spatial scale
Reporting measures	TC (CSA 2001, NORDREG)	Regulation	Maritime safety, maritime security, pollution prevention, pollution response, public health	Regional, subregional, local
Routeing systems	TC/CCG/ports and harbors (CSA 2001, CMA)	Regulation	Maritime safety, pollution prevention	Local
Search and rescue (SAR) zones and response	CCG/DND (OA, CSA 2001)	Provision of service, international cooperation	Maritime safety, provision of service	Regional, subregional
Shipping safety control zones (SSCZs) and *Arctic Ice Regime Shipping System* (AIRSS)	TC (AWPPA, SSCZ Order)	Regulation	Maritime safety, pollution prevention	Regional, subregional, local
St. Lawrence Seaway	St. Lawrence Seaway Management Corporation (CMA)	Provision of service, international cooperation	Maritime safety, trade facilitation	Regional

AWPPA Arctic Waters Pollution Prevention Act, *BC* British Columbia, *CHA* Canada Health Act (CHA, 1985), *CHS* Canadian Hydrographic Service, *CMA* Canada Marine Act, *CSA 2001* Canada Shipping Act 2001, *DND* Department of National Defence (Canada), *ECCC* Environment and Climate Change Canada, *GLWQA* agreement between Canada and the United States of America on Great Lakes Water Quality, *MTSA* Marine Transportation Security Act, *NORDREG* Northern Canada Vessel Traffic Services Zone Regulations, *OA* Oceans Act, *OPP* Oceans Protection Plan, *OTMA* Oil Tanker Moratorium Act, *PHAC* Public Health Agency of Canada, *SSCZ Order* shipping safety control zones order (2010), *TC* Transport Canada, *WAHVA* Wrecked, Abandoned or Hazardous Vessels Act, *PORCP* National Places of Refuge Contingency Plan (PORCP, 2007)

Also adopted under SOLAS Chapter V, reporting measures apply to defined areas and may serve multiple purposes, such as safety, pollution prevention, and security and may be adopted separately from or together with routeing measures.

Differently, METAREAS and NAVAREAS are not regulatory tools and are facilitated by WMO in concert with IMO for the provision of services and facilitation of international regional cooperation. They consist of 21 regions within which designated States are allocated reporting responsibilities under the Worldwide Met-Ocean Information and Warning Service and the Worldwide Navigation Warning Service (WWMIWS, 2022). Authorities in the designated States provide regional meteorological forecasts and navigational warning services to mariners. Search and rescue areas facilitated by the *International Convention on Maritime Search and Rescue,* 1979 (SAR Convention) and related regional agreements are also not

Table 2.3 Non-shipping-specific ABM tools impacting shipping in Canadian waters (in alphabetical order)

ABM tool	Responsible authority	Purpose	Function	Spatial scale
Critical habitats	DFO, ECCC (CWS), PCA (SARA)	Regulation	Marine conservation (habitats, species)	Subregional, local
Fish habitat sanctuaries/ reserves	DFO (FA)	Regulation	Marine conservation (habitats, species), pollution prevention	Local
Indigenous protected areas	Indigenous organizations (e.g., Haida Nation)	Regulation	Indigenous rights protection, marine environment protection, marine conservation	Local
Marine protected areas (MPAs) and networks	DFO (OA)	Regulation; Indigenous rights	Indigenous rights protection; marine conservation (ecosystems, species)	Regional, subregional, local
Marine spatial planning (MSP)	DFO (OA)	Planning	Marine environment protection, marine conservation, ocean development, ocean management	Regional
Marine wildlife areas	ECCC/CWS (CWA)	Regulation	Marine conservation (species)	Local
National marine conservation areas (NMCAs)	PCA (CNMCAA)	Regulation	Marine conservation (ecosystems, species), Indigenous rights protection	Local
Large ocean management areas	DFO (OA)	Planning	Marine environment protection, ocean development, ocean management,	Subregional
Migratory bird sanctuaries	MBSR	Regulation	Marine conservation (avifauna)	Local
National Park Reserves (e.g., Gwaii Haanas)	PCA (CNPA)	Regulation	Heritage conservation, Indigenous rights protection, marine conservation, marine environment protection	Subregional, local

CWA Canada Wildlife Act, *CNPA* Canada National Parks Act, *DFO* Department of Fisheries and Oceans, *ECCC (CWS)* Environment and Climate Change Canada (Canadian Wildlife Service), *FA* Fisheries Act (FA, 1985), *MBSR* Migratory Bird Sanctuary Regulations, *CNMCAA* Canada National Marine Conservation Areas Act, *OA* Oceans Act, *PCA* Parks Canada Agency, *SARA* Species at Risk Act regulatory instruments and rather facilitate international cooperation at those levels (SAR, 1979).

Except for some jurisdictions, such as the European Union, places of refuge for ships in need of assistance (including places of safety in salvage operations) are not regulated ABM designations in international maritime law (EU, 2002). Place of refuge, by definition, is at the local level and defined as "[a] place where a ship in need of assistance can take action to enable it to stabilize its condition and reduce the hazards to navigation, and to protect human life and the environment" (IMO, 2003). Despite an international customary norm concerning the provision of assistance to ships in distress, many coastal States are of the view that they are not bound by a legal obligation to provide an actual place of refuge beyond humanitarian assistance to passengers and crew (Chircop et al., 2006). While the *International Convention on Salvage,* 1989 is expected to consider that the completion of salvage requires the delivery of the vessel to a place of safety, there is no obligation to provide or an international regulation on such places (ISC, 1989, art 11). Conscious of this gap, IMO developed guidelines (updated in 2022) to assist coastal State authorities, masters, and salvors in assessing the risk and informing the decision to grant refuge, which can be a port or sheltered waters (IMO, 2003, 2022).

Although not strictly maritime ABM or safety specific, the World Health Organization (WHO) *International Health Regulations* provide for "'affected areas' in dealing with outbreaks of infectious diseases that also apply to shipping, and further contain rules for 'container loading areas'" (IHR, 2005, art 1). Affected areas "means a geographical location specifically for which health measures have been recommended by WHO under these Regulations" and container loading area "means a place or facility set aside for containers used in international traffic" (IHR, 2005, art 1). Container loading areas must be "kept free from sources of infection or contamination, including vectors and reservoirs" (IHR, 2005, art 34).

The principal international environmental ABM tools concern MARPOL emission control and special areas, Polar Code pollution prevention standards, PSSAs, places of refuge, and pollution emergency planning and response. MARPOL provides for the designation of special areas and emission control areas (ECAs) for the prevention of vessel-source pollution (MARPOL, 1973/78). Under MARPOL Annexes I (Chap. IV reg 34), II (Chap. V reg 13), IV (Chap. III reg 11), and V (Chap. I reg 6), IMO has designated and regulated numerous special areas restricting the discharge of oily wastes, noxious liquid substances, sewage, and garbage in designated marine regions (IMO, 2019b). Special area is defined as a "sea area where for recognized technical reasons in relation to its oceanographical and ecological condition and to the particular character of its traffic the adoption of special mandatory methods for the prevention of sea pollution by oil is required." The same definition applies to noxious liquid substances, sewage, and garbage (MARPOL Annex I Chap. I reg 1.11, Annex IV Chap. I reg 1.6, Annex V Chap. V reg 1.14; IMO, 2013).

Under Annex VI, IMO has further designated and regulated ECAs for the prevention of air pollution from ships. An ECA is an "area where the adoption of special mandatory measures for emissions from ships is required to prevent, reduce and control air pollution from nitrogen oxides (NOx) or sulphur oxides (SOx) and particulate matter or all three types of emissions and their attendant adverse impacts on human health and the environment" (MARPOL Annex VI). By way of example, the North American Emission Control Area (NAECA) was designated at the request of and based on a joint US-Canada proposal and provides heightened protection against emission of NOx, particulate matter (PM), and SOx (IMO, 2009). Although not establishing special areas, the Polar Code belongs to this category of ABM because it provides heightened standards of protection under MARPOL Annexes I, II, IV, and V (Polar Code Part II-A). However, prior to the adoption of the Polar Code, the Antarctic area had already been designated a special area under Annexes I, II, and V (MARPOL, 1973/78).

Separately from special areas and ECAs, and under the authority of the parent convention rather than MARPOL, IMO has adopted guidelines for the designation of PSSAs and has designated numerous such areas around the world to mitigate a range of impacts at regional, subregional, and local areas from specific impacts from shipping (IMO Convention, 1948; IMO, 2005). A PSSA is an "area that needs special protection through action by IMO because of its significance for recognized ecological, socioeconomic, or scientific attributes where such attributes may be vulnerable to damage by international shipping activities" (IMO, 2005). The designations are accompanied by selected or fashioned routeing or reporting measures, such as those described above, adopted under SOLAS Chapter V or measures authorized by other IMO conventions, and are regulated at the domestic level by proponent States (IMO, 2005).

Finally, places of refuge also belong to the environmental ABM tools because, in addition to ship safety considerations, the provision of places of refuge serves to protect the marine environment from the prospect of a ship casualty and the loss of its cargo and fuel. Further, and as a preventive ABM, the OPRC Convention and its HNS Protocol establish a framework for States to develop oil pollution emergency plans and capacity for response within their jurisdiction and in cooperation with other States (OPRC, 1990; OPRC-HNS, 2000). This type of ABM provides a service to shipping and coastal communities at the subregional and local levels, but it may also involve regulated duties for shipowners trading in oil, as in the case of Canada (CSA, 2001 s 167).

2.2.2.2 Canadian Maritime ABM Legal and Policy Tools

The ABM tools for shipping in Canada frequently reflect international counterparts but may also include measures unique to Canada's maritime context. This section sets out the tools for discussion in Table 2.2, which are not exhaustive and are chosen because they represent diverse uses. Again, they are discussed with respect to types of ABM tools, the authorities responsible for their administration and legislation and policy mandates, purposes and functions of tools, and their spatial scale. While the administration of most ABM tools in shipping is the responsibility of Transport Canada, several are the responsibility of or shared with the Canadian

Coast Guard (CCG) and other federal departments. Their purposes are generally regulatory, provision of services and pursuit of international cooperation. As in the case of the international tools, the functions tend to concern maritime safety, pollution prevention and response, marine conservation, maritime security, and protection of public health. They also operate at the regional, subregional, and local levels. The discussion next addresses these tools according to functions served.

The ABM approach is used to address maritime safety functions in various ways, including shipping safety control zones (SSCZs), Arctic Ice Regime Shipping System (AIRSS), icebreaking, low-impact corridors/Proactive Vessel Management (PVM), pilotage, places of refuge, reporting and routeing measures, and the governance of the St. Lawrence Seaway. Arctic waters as an entire region have long been defined and designated by the *Arctic Waters Pollution Prevention Act* (AWPPA) as a maritime region with heightened standards for construction, design, equipment, and operation of vessels (AWPPA, 1970). The region is divided into 16 SSCZs by an order under the AWPPA establishing navigable areas according to ice severity, vessel capability, and season, and to establish a zone-date system (SSCZ, 2010). Vessels navigating in the SSCZs must carry a valid Arctic Pollution Prevention Certificate. AIRSS was introduced to provide greater flexibility to extend the navigation season if ice conditions permit (Transport Canada, 2017). Following the implementation of the Polar Code through the *Arctic Shipping Safety Pollution Prevention Regulations* (ASSPPR), navigation in Canadian Arctic waters will gradually transition to the requirement for a polar ship certificate and the use of the Polar Operational Limit Assessment Risk Indexing System (POLARIS) which, while applying a regional standard to the safe navigation of ships based on ice conditions risk assessment, does not rely on safety zones (ASSPPR, 2017; Polar Code, 2014/15).

Transport Canada launched PVM as part of the Oceans Protection Plan (OPP) initiated in 2016 as a collaborative framework to facilitate the management of vessel traffic issues in Canadian waterways and to enhance maritime safety and environment protection (Canada, n.d.; Transport Canada, 2020). The actions include reduction of conflicting uses of waterways, including through routeing, speed restrictions, and areas to be avoided. The current pilot sites are Cambridge Bay in Arctic waters with the Government of Nunavut, Nunavut Tunngavik Incorporated, and the Nunavut Marine Council and in British Columbia waters with the North and Central Coast First Nations (ibid).

On a larger regional scale, for the last few years, the federal government has been in the process of developing low-impact shipping corridors in Arctic waters as a region, based on consultations with Indigenous communities and stakeholders active in the region (Chénier et al., 2017). The proposed corridors are based on historical use data, and establishing them will enable focusing of investments in infrastructure and services. At this time, the intention is for the corridors to be voluntary, and thus it is unclear whether they will also serve a regulatory function.

Also at the regional level, and as indicated above, NAECA applies to NOx, PM, and SOx emissions from ships in the waters under the jurisdiction of both states in the Atlantic (including Great Lakes and Seaway) and Pacific waters (VPDCR, 2012). The NAECA is a regulatory tool performing pollution prevention and public health functions by significantly tightening ship emissions in waters under Canadian and US jurisdiction. NAECA does not include Arctic waters; however, Canada recently submitted a proposal to the IMO Marine Environment Protection Committee (MEPC) to designate Canadian Arctic waters as an ECA with similar emission restrictions (IMO, 2023).

Separately from the PVM, recently Canada legislated the *Oil Tanker Moratorium Act* to introduce restrictions on the oil tanker trade in an area off the coast of British Columbia (OTMA, 2009).[1] As a pollution prevention measure, oil tankers carrying more than 12,500 metric tons of crude oil or persistent oil in bulk in their hold are prohibited from mooring or anchoring in ports or marine installations in the designated area. Further, ABM pollution prevention measures include reporting and routeing prescriptions, salvage and places of refuge (PORCP, 2007; WAHVA, 2019). ABM tools concerning reporting identified earlier with respect to maritime safety also perform a pollution response function, together with pollution emergency response. In Arctic waters, Canada has a mandatory ship reporting system for vessels entering, navigating through, and exiting those waters that serves both safety and environmental functions (NORDREG, 2010). Ships experiencing a pollution emergency in any waters are expected to notify Canadian authorities (VPDCR, 2012, s 132). In addition, and as part of Canada's polluter pays approach to oil pollution response, ships trading in oil are required to maintain standing agreements with private organizations certified by the CCG (CSA, 2001, s 167).

Routeing measures are usually associated with maritime safety, but in Canada they have also been applied to perform marine conservation functions in association with other protective measures, such as MPAs, or in emergencies. For example, at Canada's request, IMO designated a seasonal area to be avoided to protect the North Atlantic right whale in the Roseway Basin off Nova Scotia (IMO, 2019a). A system of zones (static zones, seasonal management areas, dynamic shipping zones, voluntary seasonal slowdown zone, and restricted area) and speed restrictions have also been designated in the Gulf of St. Lawrence to protect that species (Transport Canada, 2023). Speed measures have been further applied in the Strait of Georgia in BC waters to protect the Southern Resident killer whale in association with other measures (Government of Canada, 2023).

As part of decarbonization initiatives, some major ports in Canada have collaboratively designated green corridors with overseas partner ports. Montreal and Antwerp and Halifax and Hamburg concluded memorandums of understanding to facilitate the decarbonization of the transatlantic trade routes linking those ports through actions concerning bunkering, infrastructure, and renewable technologies in the respective ports (Chamber of Commerce, 2022; Port of Halifax, 2022). In addition, green corridors serve to facilitate international trade, and, in this respect, the management of the St. Lawrence Seaway is another form of ABM to enable the integrated management of the Canadian portion of the Seaway under the St.

[1] Located north of 50°53′00″ north latitude and west of 126°38′36″ west longitude

Lawrence Seaway Management Corporation and in coordination with its US counterpart (CMA, 1998, Part 3).

Reporting measures are also used to serve security functions and at times are tied to sovereignty protection. For example, NORDREG mandatory reporting in Arctic waters reinforces Canada's sovereignty (NORDREG, 2010). In other instances, pre-arrival information required from international shipping visiting Canadian ports serves security functions (MTSR, 2004, s 221).

Finally, ABM shipping environmental tools promote international cooperation, as in the case of green corridors and NAECA. Perhaps even more to the point, Canada and the United States have adopted cooperative arrangements under the authority of the *Great Lakers Water Quality Agreement* 1972 (GLWQA) to enable cooperation in pollution emergency response in the border areas of Atlantic, Arctic, and Pacific waters, as well as the Great Lakes (GLWQA, 1972).

2.2.2.3 Canadian Environmental Law and Management Tools

The last group of ABM tools to be considered are measures not dedicated to shipping per se but which impact shipping in pursuing larger environmental goals. The principal examples of these are listed in Table 2.3 as non-shipping-specific tools and discussed by type of tool, responsible authority and legislative mandate, purpose, functions served, and spatial scale application. The tools primarily concern the planning and management of ocean space and marine conservation.

In principle and as adopted under the ocean planning and management provisions of the *Oceans Act*, MSP and large ocean management areas (LOMAs) are the highest order ABMs in Canada's ocean space and serve as frameworks for ocean uses in the designated areas and therefore by implication serve as an umbrella for other more technical and local ABM tools. The *Oceans Act* designates the Minister of Fisheries and Oceans, and by implication the Department, as the lead to develop the national oceans strategy and integrated plans for ocean management in collaboration with other federal bodies, provincial and territorial governments, Indigenous organizations and bodies under land claims agreements, and coastal communities (OA, 1996, ss 29–33).

Most ABM tools in this section are measures to regulate marine conservation goals. To the layperson, they may all come across as MPAs, despite the nomenclature, but each class of ABM tool concerned with marine conservation tends to focus on habitats or species or both and for the specific purposes of the enabling act. Marine conservation aside, it is interesting to note that some ABM tools also protect Indigenous rights and heritage values. Irrespective of the function served, the tools described here are applied at various spatial scales and tend to affect shipping in an incidental manner because of actual or potential limitations on mobility in the areas concerned. The federal bodies concerned are varied and use ABM tools in legislation for which they are responsible.

While the Minister and Department of Fisheries and Oceans (DFO) lead ocean management, in practice, the various federal departments and agencies enjoy their own ABM mandates for the purposes of the legislation they are responsible for. While in theory they may pursue their own independent initiatives, in practice DFO, Parks Canada Agency (PCA), and Environment and Climate Change Canada (ECCC) consult and coordinate and have adopted a federal strategy (Government of Canada, 2017). Interestingly, this strategy focuses on the federal bodies that have express ABM powers for marine conservation, although other bodies, such as Transport Canada, also enjoy ABM powers. In this respect, the strategy anticipates that Transport Canada, as well as the Department of National Defence and Natural Resources Canada, will cooperate to enable these bodies to "incorporate the marine protected area objectives into their programs and activities" (ibid).

2.3 A Risk Perspective on ABM Tools and Processes

2.3.1 The Risk Concept as a Lens to Understand ABM Tools and Processes

In a shipping context, ABM tools as defined in Sect. 2.1 can be readily interpreted as measures to mitigate risks associated with the operation of ships in marine areas. Referring to the sociological conceptualization of present-day societies as "risk societies" in Chap. 1 of this book, ABM tools can be seen as an illustration of how societies concerned with risks and uncertainties conceptualize, organize, and operationalize concerns related to risks in ocean spaces. The functions of the various legal and policy tools presented in Sect. 2.2 (maritime safety, marine conservation, environmental protection, public health, and security) can be considered as high-level classes of risk-related objectives relating to ships and marine areas, necessitating risk characterization, management, and governance.

The basic definition of an ABM tool presented above shares the preoccupation on achieving a desired outcome with the widely used ISO 31000:2018 standard's risk definition as "the effect of uncertainty on objectives" (ISO, 2018). Conceptually, compared to the ABM definition, risk stresses the importance of uncertainty in achieving the desired outcomes, as highlighted also in the proposed definitions of risk by the influential Society for Risk Analysis (SRA) and the International Risk Governance Council (IRGC) as "uncertainty about the consequences of an activity or event with respect to something that humans value" (SRA, 2018; IRGC, 2017).

This conceptual focus on uncertainty and values in the definition of risk provides a nuanced perspective on ABM tools in two ways. First, the "uncertainty" dimension highlights that ABM measures often are decided upon based on incomplete information about the severity of the possible negative consequences of events occurring in various marine spaces. This uncertainty also relates to the possibility that ABM measures are not as effective after implementation as believed at the time they are decided upon. Second, the "values" dimension, which concerns principles or qualities that individuals or groups consider important and desirable, highlights the fact that different societal groups may prioritize different values, so that, for instance, some groups will prioritize environmental protection, while others will prioritize economic development.

Due to the multidisciplinary nature of risk research, there are various ways in which risk can be conceptualized (Althaus, 2005; Aven, 2012). For the present purposes, three risk lenses are selected as a basis for exploring ABM tools in terms of risk: (i) the risk object, (ii) the risk management phase, and (iii) the risk problem type for governing ABMs. These different conceptualizations are illustrated for selected ABM tools in the following sections. Selected implications and issues for the design and operational use of ABM tools are next discussed through a risk governance lens.

2.3.2 The Risk Object of ABM Tools

A first risk lens concerns the risk object which the ABM tool intends to manage. In general, two interrelated objects can be focused on when analyzing a system: the "risk agent" (the object causing the harm) and the "risk absorbing system" (the object being harmed). In a context of shipping and area-based management, the system can be conceived as consisting of a vessel (or vessels) operating in a particular marine space. Depending on the risk the ABM measure aims to address, either the vessel or the marine space can be regarded as risk agent or as risk-absorbing system. This is sometimes simplified as "risks to ships," for example, wave or ice conditions posing risks to the stability of a vessel, or its structural integrity, and "risk from ships," for example, risks from ship-induced oil pollution, or from ship-source noise to marine species (Kujala et al., 2019; Halliday and Dawson, 2021).

Some ABM tools aim to protect the vessel (here, the risk-absorbing system) from the environmental context of the marine space (here, the risk agent). An example of an internationally applicable ABM tool concerns the system of load line zones as mandated by the ICLL described above. This convention aims to prevent ships from being overloaded by requiring a minimum freeboard, ensuring the stability and safety of the ship, the people on board, and the cargo. Hence, the ICLL divides the world's waters into several zones, which are used to determine a ship's maximum allowable draft based on physical factors of the marine environment in those zones. Factors considered to delineate these zones include the water density, which varies with temperature and salinity and which affects a ship's buoyancy, and the seasonal variations in weather and sea conditions, which affect the ship's stability (Lewis, 1988). An example of an ABM tool in Canadian waters intended to protect the vessel concerns the SSCZ. The division of Canadian Arctic waters into 16 zones is accompanied by a tabulated zone/date system prescribing the opening and closing dates for each zone and distinguishing nine Arctic class ships and five ship types. These zones are based on typical prevailing ice conditions in different periods in the year, which consider the challenging ice conditions that can cause damage to a ship's hull and appendages and loss of stability (Riska et al., 2007).

Other ABM tools aim to protect the marine space (here, the risk-absorbing system) from the operation of a vessel in that space. An example of an internationally applicable ABM concerns MARPOL ECAs. The emission restrictions are established to reduce the impacts on the marine environment, for example, to prevent acidification and eutrophication, and to reduce health impacts of populations living near the ECAs (Maes et al., 2006). Ships can comply with these regulations through various means, including operationally switching to low-sulfur fuels before entering an ECA and installing exhaust gas cleaning systems (scrubbers) and selective catalytic reduction systems (Hassellöv, 2023). An example of an ABM tool in Canadian waters aimed to protect the marine space from vessels operating therein concerns the oil tanker moratorium, which prohibits the mooring, anchoring, loading, unloading, and transport to and from ports of vessels carrying more than 12,500 metric tons of crude or persistent oil in marine areas in northern British Columbia. With the environmental and sociocultural impacts of oil spills well-documented (Chang et al., 2014) and recognizing that accidental spills from smaller tankers are generally smaller than from larger ones (Klanac et al., 2010), limiting the size of tankers allowed to trade in this area clearly protects the marine environment while also having risk-reducing effects on economic and sociocultural activities in the related marine and coastal areas.

2.3.3 The Risk Management Phase in Focus of the ABM Tools

A second risk lens through which ABM tools can be approached concerns the risk management phase(s) that the ABM measure aims to affect. It is common to distinguish four (often interrelated) phases of managing risks: mitigation, preparedness, response, and recovery (Meyer and Reniers, 2022). Mitigation focuses on the activities and design and operational measures taken to identify, prevent, eliminate, or reduce the likelihood of an unwanted event occurring and/or to reduce its impact, should it occur. Preparedness focuses on actions taken to prepare for emergency response and recovery, that is, improving the readiness and capability of response systems in case an unwanted event occurs. Response addresses the risk management phase in which actions are taken in direct response to an imminent or already occurring unwanted event. This phase focuses on operational activities aimed at minimizing the loss of life, environmental, economic, and sociocultural impact of the emergency. A final risk management phase is recovery. For organizations, this phase concerns measures taken to restore operations and return to normalcy, which can be achieved through prioritizing the restoration of critical functions, assets, and systems. For marine environments, the recovery phase addresses the process of restoring ecosystems, habitats, and environmental services following a disruptive event, contamination, or prolonged degradation.

The Polar Code is an example of an ABM tool to mitigate shipping risks (Polar Code, 2014/15). The Code requires vessels intending to operate in Arctic and Antarctic waters to obtain a Polar Ship Certificate, which classifies vessels into three categories depending on the severity of sea ice conditions for which they are designed to operate. The Code includes various provisions aimed at mitigating risks to increase the safety of vessels and crew and protect the marine environment. An example of a ship design measure aimed at reducing the likelihood of accidents is the requirement for bridge windows to have means to clear melted ice, freezing rain, snow, mist, and spray. An example of an operational measure is the requirement for bridge crew to have completed appropriate training for operation of vessels in ice conditions. A measure aimed to eliminate certain types of environmental pollution includes the prohibition to discharge oil or oily mixtures, as well as sewage, unless an approved sewage treatment plant is installed: then discharge may occur only if far sufficiently far away from land, fast or shelf ice, or areas with specified ice concentration.

An example of an ABM tool aimed at preparedness and response risk management phases is search and rescue (SAR) zones, which are internationally agreed upon through the SAR Convention (1979) and implemented in Canada through the CSA 2001. State parties establish rescue coordination centers (RCCs) to coordinate SAR operations and facilitate appropriate preparedness and response capacities. Examples of preparedness measures to achieve this include emergency planning, establishing communication protocols, training and exercises, and stakeholder education, whereas response activities include firefighting, search and rescue, and provision of emergency medical assistance.

An example of an ABM tool which addresses recovery is the designation of critical habitats under SARA (2002, s 2). Aimed at protecting wildlife species at risk in their habitats, this is a non-shipping-specific ABM that can have implications for maritime shipping. For instance, in cases where critical habitats overlap with shipping routes, speed limits, navigation restrictions, or special reporting requirements may be put in place to facilitate the recovery of species at risk from past anthropogenic disturbances.

2.3.4 The Risk Problem Type for Governance of ABMs

A final risk lens through which ABM tools can be framed is the risk governance problem type. The IRGC risk governance framework (IRGC-RGF) is a comprehensive framework for understanding, analyzing, and managing risks in pluralistic democratic societies in cases where various actors are involved. This framework is based on extensive academic work (Renn et al., 2011) that has been introduced by the IRGC (2017) and has been applied in various contexts, including in the maritime domain (Goerlandt and Pelot, 2020).

The first phase of the IRGC-RGF concerns *pre-assessment*, which frames the problem in relation to issues that different societal actors may associate with the risk, setting the boundaries to achieve a common understanding of the risk issue, or to establish awareness of different risk perceptions. In the context of ABM in shipping, this implies gaining an understanding of what risks different stakeholders are concerned about in relation to a given marine space. This phase also includes performing prescreening to assign a risk to a suggested risk governance strategy. This is done by agreeing whether a risk is “simple,” “complex,” “uncertain,” or “ambiguous,” which is then used to devise risk governance strategies.

This is followed by a *risk appraisal* phase, which aims at enhancing understanding about the risk through knowledge-focused activities. This can concern a technical/scientific assessment of the risk, providing knowledge about causes and consequences of the risk and/or vulnerabilities, possible mitigation measures, and associated uncertainties. In an ABM context, use can be made of a variety of risk analysis techniques depending on the problem at hand, for example, those proposed in the IMO Formal Safety Assessment Guidelines (IMO, 2018) for ship design and equipment related risks, the Risk Management Toolbox by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) (2022) for navigational risk assessment in waterways, or using marine conservation analysis techniques such as Marxan (Ball et al., 2009). This phase also can include a concern assessment, providing insights into risk perceptions and addressing questions from societal actors about social and economic implications of the risk and identifying possible mitigation measures. For these aspects, social science research methods and economic analysis techniques can be applied (IRGC, 2017).

In the *characterization and evaluation* phase, a judgement is made about the acceptability of risk, bridging the knowledge and value dimensions of risk governance. Risks are considered acceptable when their occurrence likelihood and the consequence severity are limited, such that no risk reduction measures are required. If the risk is not considered acceptable, additional measures are required to reduce the occurrence likelihood or the consequence severity. In an ABM context, the type of risk, along with the knowledge from the risk appraisal phase, can be used to decide which ABM tool to implement or to decide on what specific measures should be implemented as part of the ABM.

The *risk management* phase addresses the concrete design and implementation of actions and measures to prevent, reduce, transfer, or increase preparedness for the risk. In an ABM context, this may, for instance, consist of developing and implementing a warning system for communicating whale sightings so that a ship’s officers can decrease speed to lessen the occurrence of ship strikes and lower their severity should a strike occur. Risk management can also include implementing monitoring systems to ensure compliance with the ABM measures, for example, through aerial surveillance campaigns to monitor compliance with SOx and NOx emission requirements (Van Roy et al., 2022).

As mentioned above, in the pre-assessment phase, a risk prescreening is performed by categorizing the risk problem as “simple,” “complex,” “uncertain,” or “ambiguous.” In this context, complexity is a characteristic of the analyzed system and refers to a condition where it is difficult to identify and analyze the causes of events and consequences. This can be due to the large number of causal factors with (possible) relevance to the event occurrence and its consequences, interactive effects among the causal factors including nonlinear 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 of an assessor or group of assessors in which the likelihood of adverse consequences, or the severity of these consequences, cannot be accurately described. This uncertainty can manifest due to limited relevant data being available, the existence of wide variations of expert estimates, significant simplifications and inaccurate results of models, or the important role of assumptions in the evidence base. Finally, ambiguity concerns the condition where there are significantly different concepts about what can be regarded as tolerable, acceptable, or equitable among the relevant stakeholder groups. A condition of ambiguity emerges where there are difficulties in agreeing on the appropriate values, priorities, or boundaries in defining possible consequences and analyzing risk, which is rooted in different stakeholder groups adhering to different worldviews and value systems. If none of these characteristics are present, a risk can be considered simple.

The main purpose of categorizing a risk in a risk governance problem type is to achieve a consensus among stakeholders about what risk governance strategy should be pursued. ABM tools have an effect on marine spaces, addressing risks about which multiple user and stakeholder groups likely have different concerns, views, and understanding. Decision-making and management of risks in such situations require interaction, coordination, and possibly reconciliation between various roles, perspectives, goals, and activities. In the IRGC-RGF, this is approached through a risk governance escalator, which suggests using different strategies for developing the mechanisms for the risk appraisal, characterization and evaluation, and management phases. Depending on the dominant risk category (simple, complex, uncertain, ambiguous), different approaches are recommended for the type of discourse to focus on, what actors to include in the risk governance processes, what types of conflicts may be expected to underlie different views on the risk severity and the acceptability of the risk, and what role is given to risk perception. The risk governance escalator is shown in Fig. 2.1 based on which a set of example ABM tools and measures are explored for the different routes associated with selected problem risk types to illustrate the concepts.

A risk in an ABM context may be characterized as complex, if there is a large number of causal factors, interindividual variations, interactive effects among causal factors, and/or long delay periods between cause and effect. However, the evidence for analyzing the risk is strong, involving good models, relevant expertise, and good data to analyze event occurrences and associated consequences. Moreover, there is a broad agreement among the key societal actors in framing the risk and what constitutes acceptable risk. An example ABM tool could be the design and implementation of ship routeing systems and reporting requirements. As evident from accident analyses (Puisa et al., 2018) and waterway risk methods (see Chap. 7 this volume), many factors can affect the occurrence of navigational accidents and control mechanisms to ensure navigation safety involves multiple actors and information flows. Available models and expertise can be applied to understand risks and propose mitigation measures. The main purpose of the analytical work is to understand causal mechanisms and obtain insights into the complexity, that is, the challenge is cognitive and the governance approach focuses on ontological and epistemological discourses. These

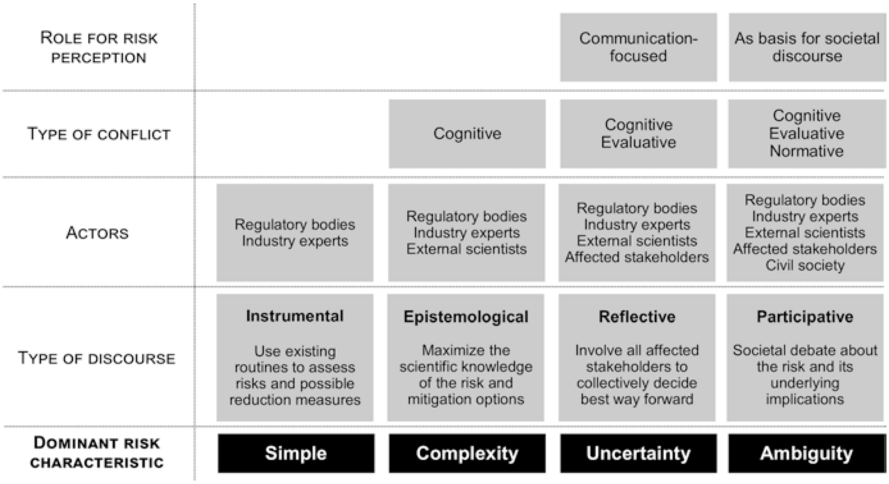

Fig. 2.1 International Risk Governance Council risk governance escalator. (Source: F. Goerlandt and R. Pelot, "An exploratory application of the International Risk Governance Council Risk Governance Framework to shipping risks in the Canadian Arctic", in Chircop, A., Goerlandt, F., Aporta, C. & Pelot, R. (eds.). *Governance of Arctic Shipping: Rethinking Risk, Human Impacts and Regulation* (Cham, Switzerland: Springer, 2020), 15–41)

involve various stakeholders, primarily regulatory bodies (e.g., aids to navigation authorities, port authorities) and industry experts (e.g., pilotage authorities, commercial fishing companies, and commercial ship operators). External scientists can support the analytical work by proposing new analysis techniques or by performing risk analysis and investigating the effectiveness of risk control measures.

The northern low-impact Arctic shipping corridors mentioned above are another example of an ABM tool in a risk governance context. In this context, Indigenous peoples are rightsholders and have a right to be involved in matters affecting their sovereignty, including impacts of shipping related to environmental and sociocultural aspects of marine space and the related use and spiritual connection of Indigenous peoples to that space (Boyd and Lorefice, 2018). Indigenous worldviews differ substantially from standard western scientific paradigms, view humans as indivisible from nature, include values related to relational accountability in knowledge systems, and rely on participatory and knowledge-inclusive methodologies, to understand multiple socially constructed realities to achieve collective well-being. In contrast, western scientific worldviews often see humans as detached from or in control of nature, focus on aiming to understand a single knowable reality, aim to exclude non-epistemic values in the pursuit of knowledge, and rely on experimental and deductive methods. In such contexts, shipping risks can be categorized as ambiguous. While scientific models can be used to understand complexities and risks of operating vessels in Arctic environments (see, e.g., Fu et al., 2021), there is a need to address the Indigenous and local community concerns, knowledge, perspectives, and priorities, for example, through community-based participatory mapping work (Dawson et al., 2020).

2.4 Social License of ABM Tools

Social license, entailing society or community endorsement of the balance between risks and benefits, is necessary in the design and application of ABM tools in the marine environment. Social license as a concept originated in the mining industry in the late 1990s, mostly as the industry's response to public resistance to new projects, with the objective of gaining social acceptance and approval of mining developments (Bice & Moffat, 2014). Gradually, the concept became more broadly defined, and it was adapted and adopted to a variety of social and environmental assessments beyond mining (Ibid.).

The shipping industry does not often fully appreciate that navigation routes may occur in areas of vital interest to Indigenous and coastal communities, including their homelands. While the employment of ABM tools serves to mitigate potential impacts, obtaining a social license for them is crucial for specific coastal and marine management areas. The concept extends beyond simply gaining permissions from communities through mere consultations. Rather, it involves strategies and efforts to properly engage with local (often vulnerable) communities and stakeholders, often in cross-cultural settings. ABM approaches in shipping should indeed engage local actors whose interests and livelihoods are affected (positively and/or negatively) by shipping activities.

In the Canadian context, the *Oceans Act* and subsequent Canada's Oceans Strategy promote participatory approaches and local engagement as integral parts of the legal and policy basis for planning and decision-making in ocean and coastal waters, implicitly introducing community engagement as a requirement for ABM (OA, 1996; Oceans Strategy, 2002). The *Oceans Act* prescribed *collaboration* as a governance model for integrated management, including among federal agencies, provincial and territorial governments, coastal communities, and Indigenous organizations. The Oceans Strategy proposed "inclusiveness" in planning, decision-making, and implementation of policies through the establishment of collaborative frameworks for ocean governance:

> In Coastal Management Areas, local community groups and individuals will play essential roles in helping to understand the management area and issues, ensuring that the planning process and associated actions are relevant to the area, and providing "on the ground" expertise and capacity for plan implementation, monitoring and compliance promotion. (Fisheries and Oceans Canada, 2002: 13)

Canada has been developing a particular approach to governing shipping activities, which aligns with these broader ocean policy frameworks, ultimately advancing toward integrated, area-based, and participatory governance approaches. The latest iteration of this approach was clearly laid out in the OPP, which established directions for the implementation of comprehensive measures to further enhance safety in Canadian waters (Canada, n.d.).

The OPP's PVM initiative is itself a collaborative framework to facilitate the management of vessel traffic in Canadian waters, and it clearly articulates the nature and mechanisms of the engagement with local actors:

> Transport Canada will work with partners to develop regulatory and other tools to engage Indigenous and coastal communities to better respond to local marine traffic issues.
>
> While the national interest and economic drivers would still be considered, Indigenous and coastal communities could, for instance, request restrictions on speed and routing of certain sizes and classes of ships to minimize safety risks, establish areas to be avoided around sensitive sites, prohibit sewer discharges near harvesting areas, and other measures that would contribute to safety and environmental protection objectives. (Canada, n.d.: 2)

Concerning Indigenous peoples, the pursuit of social license is a legal obligation on public authorities, as Indigenous rights are defined and protected under sect. 35 of the *Constitution Act*, *1982* (CA, 1982), as well as land claims agreements, treaties, and Supreme Court of Canada decisions. The federal government's acceptance of the recommendations of the Truth and Reconciliation Commission Report and Canada's implementation of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) through the *United Nations Declaration on the Rights of Indigenous Peoples Act* are fundamentally impacting the relationship between Canada and its Indigenous peoples (*UNDRIP Act,* 2021).

While Canadian courts have articulated the federal government's duty to consult Indigenous peoples on matters affecting their rights, UNDRIP introduced the broader concept of Free, Prior, and Informed Consent (FPIC), which is characterized by the Food and Agriculture Organization of the United Nations (FAO) as "an international human rights standard that derives from the collective rights of indigenous peoples to self-determination and to their lands, territories and other properties [including] the right "to give or withhold their consent prior to the approval by government, industry or other outside party of any project that may affect the lands, territories and resources" (FAO, 2014: 4). In the Canadian Arctic, where all coastal communities are predominantly Indigenous, the Inuit Nunangat Declaration on Inuit-Crown Partnership established the basis for "entering into a bilateral partnership with the Government of Canada to take action on shared priorities" (Canada, 2017).

Establishing and obtaining social license affects not only the acceptability but also the sustainability of ABM initiatives. Interventions regarding shipping governance (including routing, speed measures, places of refuges, SAR, prevention of oil spills, implementation of ECAs, pollution emergency response, etc.) have significant impacts on local communities and require community support and engagement not only to be effectively implemented but also to increase the protection of sensitive environmental and cultural areas and to benefit local communities. As explained in the previous section, risk conceptualizations, perceptions, and assessments must also consider the points of views and sensitivities of local affected communities. This is especially relevant for risk problems that are characterized as ambiguous.

There are several challenges and obstacles in securing a social license in ABM, including community mistrust, cultural differences, perceptions of inequity, and disagreements about the potential environmental impacts of projects. When involving Indigenous peoples, some of the challenges also relate to the broader historical background of colonialism, cultural loss, and marginalization. The context of shipping governance is not foreign to these issues, as shipping traffic can impact not only local activities and environments but also the livelihood and food security of coastal communities. At the same time, ABM can potentially become an instrument for good governance and engagement if properly defined and implemented, particularly if the process of engagement is included in all planning stages (see Chap. 6, this volume).

Some examples of collaboration in shipping measures in the context of ABM are promising. They include strategies for local participation and engagement that, in principle, seem to align with FPIC. The Enhanced Maritime Situational Awareness (EMSA) initiative, which was introduced through the OPP, is a collaborative initiative between Indigenous partners, industry, and Transport Canada. The Canadian Arctic Shipping Risk Assessment System (CASRAS) was also developed through collaborations to allow Arctic stakeholders to access different kinds of information relevant to marine safety in the Canadian Arctic (Kubat et al., 2017). The Arctic Corridors and Northern Voices (ACNV) program is meant to document Inuit perspectives on shipping governance, and it is expected to influence Canada's low-impact shipping corridors (Dawson et al., 2020).

There are also examples of proper community engagement in ABM initiatives that are broader than shipping. They include MPAs (e.g., Tarium Niryutait in the Inuvialuit Settlement Region), national marine conservation areas (e.g., Tallurutiup Imanga), and MSP (e.g., the Marine Plan Partnership for the North Pacific Coast (MaPP)). MaPP, in particular, is considered groundbreaking in establishing co-governance models involving Indigenous peoples (Diggon et al., 2020; Wang et al., 2022; Wang, 2023).

In the Nunatsiavut Region, the Imappivut Marine Plan is explicitly formulated to be guided by the values, knowledge, and interests of Labrador Inuit and conceptualizes the national marine conservation area as an Inuit Protected Area. This initiative, through the integration of local knowledge, scientific models, and new technology, is leading to the discovery of "deep-water hidden biodiversity toward the advancement of both local Indigenous and global conservation goals" (Cote et al., 2023). It shows that local engagement can result in better ways to create base data, assess risks, mitigate effects, and create governance frameworks that are not only inclusive but also more effective and connected to local realities.

The bottom line for ABM in general and shipping governance in particular is that without public acceptance and support, even legally sanctioned projects may face operational issues, opposition, and potential failure, points that are amplified in the context of Arctic waters, where the environment and communities are more vulnerable to impacts and where geographic remoteness presents significant logistic and infrastructure challenges. The development of partnerships between government, industry, and local communities and organizations, in this context, is essential. But such partnerships must be conceived through collaborative processes, built on trust, and they must account for local views, knowledge, and conceptualizations.

It is also crucial that ABM initiatives offer clear and tangible benefits for coastal communities, which could include job creation, conservation of resources, increase of local capacity, and improved infrastructure. The planning process should be dynamic and responsive to the needs and concerns of local stakeholders and rightsholders, accommodating their input wherever possible. Incorporating these elements into the planning process can significantly enhance the legitimacy of plans, not only in terms of garnering support and acceptance from affected communities and stakeholders but also by creating positive change and improving governance.

It has been noted that in the realm of impact assessments, unlike biophysical impacts (which only start when new activities or developments start), "social impacts happen the moment there are rumours about a potential project" (Vanclay, 2012). This is particularly important in the context of Arctic waters, where projections of shipping traffic and speculation of new activities and developments vary widely, mostly in connection to the trajectories of climatic changes and sea ice loss, generating anxiety, anticipation, and speculation. Projections of increasing activities, however important for the shipping industry and the economic and geopolitical situation of Canada, will be most impactful for local communities, whose resilience has been historically proven but relatively untested to the speed and scale of the present trajectory of climate transformation.

As early as 2005, Sheila Watt-Cloutier stated at the Inter-American Commission on Human Rights that climate change, in the Inuit context, was a human rights issue and that countries contributing to climate change were violating the human rights of Arctic peoples (Watt-Cloutier, 2005). In a sense, proper community engagement in ABM has also become a human rights issue given the current vulnerability of communities to external factors that may affect livelihoods and sustainability.

2.5 Conclusion

Like terrestrial areas, ocean space within national jurisdiction is subject to complementary and competitive human uses that require management to minimize conflicts and promote complementarities to the extent possible. While the use of terrestrial space is multifarious and not dependent on any one transportation platform, most industrial uses of ocean space require the use of ships as platforms to enable actual ocean use. Hence, the distinctive characteristic of ocean use regulation to not only concern the actual extractive and non-extractive uses but also to address the platforms that enable those uses, namely, ships. By extension, hence, is the importance of ABM of shipping for the management of ocean space.

This chapter has demonstrated that there is no one individual ABM tool for regulating the movements of shipping, because the different ocean uses have different needs and employ ships in various ways to enable extractive and non-extractive activities. The regulation and management of ocean uses reveals the use of a wide variety of tools to promote development, safety, security, and environmental protection of each use, giving rise to complexity. However, diversity and complexity of ABM tools are not necessarily negative attributes, but rather there is a rich array of risk-informed tools to support ocean uses and prevent, manage, or respond to problems at sea. Indeed, ocean managers and maritime administrators have at their disposal a rich toolbox of spatial tools that they can use in a nimble manner.

Nonetheless, given the diversity of ABM tools, the utility of developing an understanding of the big picture of ABM shipping tools to support both marine transportation and other ocean uses is clear. This comprehensive survey of ABM tools used in shipping clarifies the purpose and scope of these tools and how they address the interrelated risk, spatial definition, functions, and social license embedded in them, using Canadian practices as context and for examples against the backdrop of international rules and standards. The taxonomy of ABM tools used in shipping and in support of ocean uses has been clarified.

Several useful insights into ABM design are underscored. First, while the importance of an overarching integrated ocean management framework and the use of MSP as its core tool in the context of multiple competing and complementary ocean uses cannot be underestimated, the value of ABM tools in targeting problems should be highlighted. Second, although consistency in managing ocean uses is understandable and desirable in the interests of efficiency and equity, the practice of ABM tools demonstrates nimbleness and flexibility. ABM tool design should be informed by the risk or problem aimed at and as such does not need to be necessarily standardized for all uses in all situations. Rather, they should be fashioned according to the functions they are expected to perform and the actual spatial application and temporal scope needed. The practice and approaches considered here underscore the importance of proportionality of the tool to the problem addressed, the contingent costs for shipping and other ocean uses, and their effectiveness in terms of the outcomes achieved. Third, and lastly, ABM tool design should not simply be considered as a scientific and management exercise conducted by experts but must also be informed by the rightsholders and stakeholders affected. The legitimacy and effectiveness of ABM tools are dependent on social license.

Appendix

Glossary of ABM Terms

1. **Shipping-specific**

Area-based management. An area-based (or spatial) management tool is an approach that enables the application of management measures to a specific area to achieve a desired policy outcome (UN Environment, 2018).

Area-based management tool (BBNJ context). A tool, including a marine protected area, for a geographically defined area through which one or several sectors or activities are managed with the aim of achieving particular conservation and sustainable use objectives in accordance with this Agreement (BBNJ Agreement, 2023, art 1(3)).

Area to be avoided. An area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships or by certain classes of ships (IMO, 1985).

Compulsory pilotage area (Canada). An area of water in which ships are subject to compulsory pilotage (*Pilotage Act,* 1985).

Deep-water route. A route within defined limits which has been accurately surveyed for clearance of sea bottom and submerged articles (IMO, 1985).

Emission control area (ECA). An area where the adoption of special mandatory measures for emissions from ships is required to prevent, reduce, and control air pollution from NOx or SOx and particulate matter or all three types of emissions and their attendant adverse impacts on human health and the environment (MARPOL, 1973/78 Annex VI).

Established direction of traffic flow. A traffic flow pattern indicating the directional movement of traffic as established within a traffic separation scheme (IMO, 1985).

Inshore traffic area. A routeing measure comprising a designated area between the landward boundary of a traffic separation scheme and the adjacent coast, to be used in accordance with the provisions of rule 10(d), as amended, of the *International Regulations for Preventing Collisions at Sea (Collision Regulations), 1972* (IMO, 1985).

Load line zones, areas, and seasonal periods. These are listed in ICLL as Northern Winter Seasonal Zones and Area, Southern Winter Seasonal Zone, Tropical Zone, Seasonal Tropical Areas, Summer Zones, Enclosed Seas, and Winter North Atlantic Load Line (ICLL, 1988 Annex II, regs 46–52).

METAREA. One of 21 marine geographical regions for the purpose of coordinating the transmission of meteorological information to mariners on international voyages through international and territorial waters (WWMIWS, 2022).

NAVAREA. One of 16 areas into which the world ocean is divided by IMO for dissemination of navigation and meteorological warnings (IAMSAR Manual, 2019).

No Anchoring Area. A routeing measure comprising an area within defined limits where anchoring is hazardous or could result in unacceptable damage to the marine environment (IMO, 1985).

Particularly sensitive sea area (PSSA). An area that needs special protection through action by IMO because of its significance for recognized ecological, socio-economic, or scientific attributes where such attributes may be vulnerable to damage by international shipping activities (IMO, 2005).

Place of refuge. A place where a ship in need of assistance can take action to enable it to stabilize its condition and reduce the hazards to navigation and to protect human life and the environment (IMO, 2003, 2022).

Port facility. A location, as determined by a government authority where the ship/port interface takes place. This includes areas such as anchorages, waiting berths, and approaches from seaward, as appropriate (ISPS Code, 2005).

Precautionary area. An area within defined limits where ships must navigate with particular caution and within which the direction of flow of traffic may be recommended (IMO, 1985).

Recommended route. A route of undefined width, for the convenience of ships in transit, which is often marked by centerline buoys (IMO, 1985).

Recommended direction of traffic flow. A traffic flow pattern indicating a recommended directional movement of traffic where it is impractical or unnecessary to adopt an established direction of traffic flow (IMO, 1985).

Recommended track. A route which has been specially examined to ensure so far as possible that it is free of dangers and along which ships are advised to navigate (IMO, 1985).

Roundabout. A routeing measure comprising a separation point or circular separation zone and a circular traffic lane within defined limits. Traffic within the roundabout is separated by moving in a counterclockwise direction around the separation point or zone (IMO, 1985).

Routeing system. Any system of one or more routes or routeing measures aimed at reducing the risk of casualties; it includes traffic separation schemes, two-way routes, recommended tracks, areas to be avoided, inshore traffic zones, roundabouts, precautionary areas, and deep-water routes (IMO, 1985).

Search and rescue region. An area of defined dimensions associated with a rescue coordination center within which search and rescue services are provided (SAR, 1979).

Separation zone or line. A zone or line separating traffic lanes in which ships are proceeding in opposite or nearly opposite directions or separating a traffic lane from the adjacent sea area or separating traffic lanes designated for particular classes of ship proceeding in the same direction (IMO, 1985).

Special area. A sea area where for recognized technical reasons in relation to its oceanographical and ecological condition and to the particular character of its traffic, the adoption of special mandatory methods for the prevention of sea pollution by oil is required (MARPOL Annexes I, IV & V; IMO, 2013).

Traffic lane. An area within defined limits in which one-way traffic is established. Natural obstacles, including those forming separation zones, may constitute a boundary (IMO, 1985).

Traffic separation scheme. A routeing measure aimed at the separation of opposing streams of traffic by appropriate means and by the establishment of traffic lanes (IMO, 1985).

Two-way route. A route within defined limits inside which two-way traffic is established, aimed at providing safe passage of ships through waters where navigation is difficult or dangerous (IMO, 1985).

Weather routeing. Advice available to shipping in the form of recommended optimum routes for individual crossings of the ocean for the benefit of ship operations and safety as well as to their crews and cargoes (IMO, 1983).

2. **Marine conservation**

Critical habitat (Canada). The habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species (SARA, 2002, s 2).

Marine conservation area (Canada). A national marine conservation area of Canada named and described in Schedule 1 of the *Canada National Marine Conservation Areas Act* (CNMCAA, 2002).

Marine protected area (Canada). A marine protected area is an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada, or the exclusive economic zone of Canada and has been designated under this section or Sect. 35.1 for special protection for one or more conservation reasons set out in the *Oceans Act* (OA, 1996).

Protected area. "A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." The IUCN categories of protected areas include (Ia) strict nature reserve, (Ib) wilderness area, (II) national park, (III) natural monument or feature, (IV) habitat/species management area, (V) protected landscape or seascape, and (VI) protected areas with sustainable use of natural resources (Day et al., 2019).

Protected marine area (Canada). A protected marine area in any area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada, or the exclusive economic zone of Canada established under the *Canada Wildlife Act* (CWA, 1985, s 4.1).

Migratory birds protection areas (Canada). Areas for migratory birds and nests and for the control and management of those areas prescribed by regulation (MBSR, 1994, ss 2–3).

National park (Canada). *A* national park of Canada named and described in Schedule 1 of the *National Parks Act* (CNPA, 2000, s 2).

National park reserve (Canada). *A* national park reserve of Canada named and described in Schedule 2 of the National Parks Act (CNPA, 2000, s 2).

National wildlife area (Canada). An area of public lands set out in Schedule I of the *Wildlife Area Regulations* (WAR, 2020, s 2).

Natural heritage sites. Natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the esthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation; natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation, or natural beauty (CPWCNH, 1972, art 2).

3. **Ocean management**

Large ocean management area (LOMA) (Canada). A large scale area designated by DFO under the *Oceans Act* for integrated management planning of all activities or measures in or affecting estuaries, coastal waters, and marine waters that form part of Canada (OA, 1996).

Marine spatial planning. A public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that have been specified through a political process (Ehler & Douvere, 2009).

Safety zones. Areas of up to a distance of 500 meters around artificial islands, installations, or structures and related to their nature and function, measured from their outer edge, except as authorized by generally accepted international standards or as recommended by the competent international organization (UNCLOS, 1982, art 60(5)).

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Chapter 3
Addressing the Cumulative Effects of Marine Shipping Through Area-Based Management Approaches

Paula Doucette and Samuel Mansfield

Abstract Canada's Oceans Protection Plan (OPP) is a comprehensive initiative launched by the Government of Canada to enhance marine safety, protect marine ecosystems, engage with coastal communities, and improve evidence-based decision-making. The OPP focuses on safeguarding Canadian coasts and waterways by implementing measures to prevent and respond to marine incidents, supporting research and innovation, and establishing stronger Indigenous partnerships to address maritime concerns and promote sustainable marine practices. Under the Oceans Protection Plan, Transport Canada's Cumulative Effects of Marine Shipping (CEMS) initiative has been working in seven regions of Canada to assess and address the regional cumulative effects of marine shipping, in partnership with Indigenous peoples and guided by the principles of reconciliation. The goal of this chapter is to showcase how area-based management (ABM) is applied in the CEMS initiative by first providing background on the CEMS initiative from a broad perspective and then examining linkages between the initiative and ABM approaches. A case study is described from one regional CEMS assessment being conducted along a section of the Northwest Passage in southern Victoria Island, Nunavut, which resulted in the development of a voluntary measure using an ABM approach to mitigate the impacts of icebreaking activities on caribou migration and hunter safety.

Keywords Cumulative effects of marine shipping · Regional cumulative effects assessment · Impact assessment · Decision-making · Management · Mitigation · Collaborative governance · Indigenous peoples · Area-based management

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3.1 Introduction

Marine shipping is a vital part of Canada's economy, culture, environment, and security (Council of Canadian Academies, 2017). It is essential for trade growth and prosperity as shipping often remains the only viable mode of transporting goods to domestic and international markets. Each of Canada's three coasts, as well as the Great Lakes and Canada's inland waterways, has experienced continuous growth in marine traffic, and this trend is predicted to persist into the future (Council of Canadian Academies, 2017; Clear Seas, 2020; Kochanowicz et al., 2020). In recognition of Canada's reliance on shipping and the growing presence of vessels, from small recreational boats to large commercial ships, there is a need to effectively manage marine traffic within Canadian waters.

Transport Canada (TC) plays a leadership role for the Government of Canada (GoC) in ensuring that all components of Canada's marine transportation system work together in an efficient, safe, and environmentally sustainable manner. In 2016, the GoC announced the Oceans Protection Plan (OPP) with the mandate of protecting coasts and waterways under Canadian jurisdiction (Transport Canada, 2024). The priorities of the OPP include enhancing marine safety, preserving and restoring marine ecosystems, engaging with coastal communities, and building a stronger evidence base for decision-making. As a reflection of the GoC's commitment to working toward reconciliation with Indigenous peoples, a foundational component of the OPP is to also create stronger Indigenous partnerships and collaboratively address the marine shipping concerns of Indigenous communities. As Canada's lead department on policies and regulations related to the safety and security of marine transportation, TC has responsibilities to develop and administer various initiatives under the OPP, including the Cumulative Effects of Marine Shipping (CEMS) initiative.

The purpose of the CEMS initiative is to establish shared approaches to better understand the potential cumulative effects (CE) of regional marine shipping activities on the environment and coastal communities. Many Indigenous and non-Indigenous coastal communities have expressed concerns regarding the experienced impacts and perceived risks of shipping activities on coastal and marine environments and Indigenous ways of life. Such concerns are often raised during project-level impact assessments (e.g., resource extraction projects and/or port infrastructure development), but the process of assessing CE for such projects does not always provide a thorough understanding of CE at a regional scale. Since 2018, TC has been working alongside Indigenous peoples in seven "pilot" areas throughout Canada's three coasts to undertake regional CE assessments that aim to better understand and address the interactions between marine shipping activities and their effects. These areas are referred to as "pilot areas" since TC is developing a novel approach to assess the CE of marine shipping on a regional basis, beyond the scope of individual project-level impact assessments. Use of the term "pilot" enables the exploration of innovative strategies, methodologies, and new collaborative engagement models to collect and document valuable insights for completing such work.

These pilot areas include Cambridge Bay, Nunavut; the Northern Shelf Bioregion, British Columbia (BC); South Coast, BC; St. Lawrence and Saguenay Rivers, Quebec; Great Lakes, Ontario; Bay of Fundy, New Brunswick and Nova Scotia; and Placentia Bay, Newfoundland and Labrador (Fig. 3.1).

A key deliverable of the CEMS initiative is the development of a National CEMS Framework that provides flexible guidance in assessing the regional cumulative effects of marine shipping based on the steps taken and lessons learned through the implementation of national and regional CEMS work (Transport Canada, 2022). The National CEMS Framework provides a description of the key activities and outcomes that are involved in completing a CEMS assessment, as summarized in Fig. 3.2. Flexibility is embedded within each phase of the CEMS process to respond to unique priorities and needs in each pilot area and to respect the preferences of regional partners. As such, a key insight gained through the pilot work to date is that there is no one-size-fits-all approach for assessing regional cumulative effects of marine shipping across different regions of Canada.

While there are common stressors from marine shipping activities across the pilot areas (e.g., wake disturbance), the understanding of regional CE is shaped by the historical and present-day contexts of associated impacts to culture, socioeconomics, and the environment that are distinct to each area. It is therefore essential to establish a thorough and holistic understanding of marine shipping activities of concern and their associated impacts for each area to inform effective and comprehensive management recommendations that can be applied to current vessel operations and/or considered in future project-level impact assessments. The development of management recommendations must be informed by the desired outcomes of

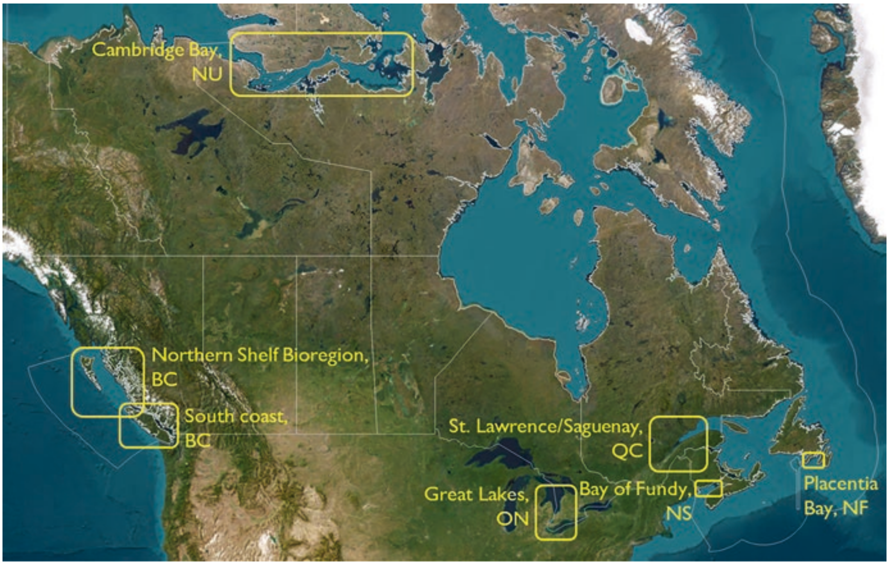

Fig. 3.1 Map depicting the locations of CEMS pilot areas

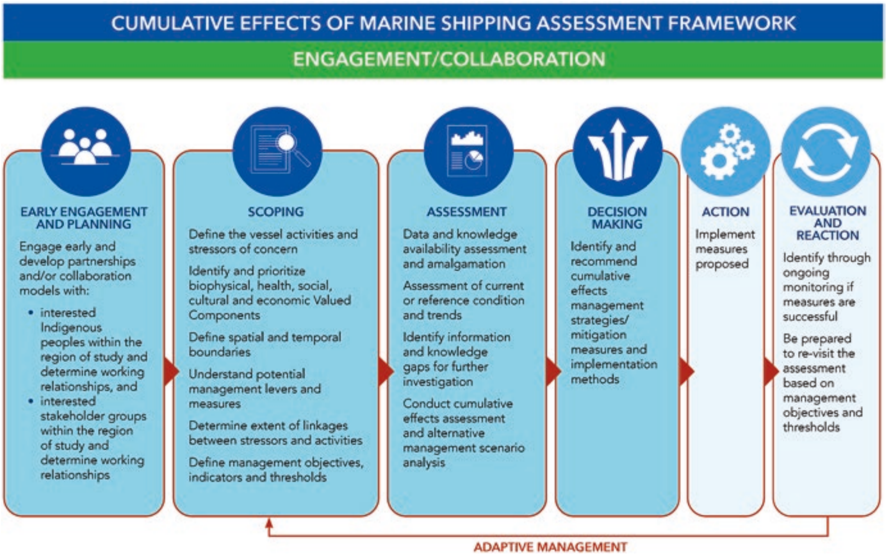

Fig. 3.2 Transport Canada's Cumulative Effects of Marine Shipping (CEMS) Assessment Framework under the Oceans Protection Plan (OPP) (Transport Canada, 2022). In the first phase of the OPP (2016–2022), the CEMS initiative put an emphasis on completing the first four steps (in blue) of this framework. The last two steps (pale blue) are being explored through the recent renewal and ongoing implementation of OPP (2023 onward)

regional CEMS partners and collaborators in terms of whether the anticipated changes to marine shipping activities are likely to address their concerns. The requirements and preferences of other marine stakeholders and users of the waterways must also be factored into this decision-making process to ensure the expectations of all parties are aligned and for the management recommendations to be optimally effective and feasible. To assist with this process, CEMS has compiled a list of legislation, regulations, policies, programs, or voluntary tools ("management levers") that could be used to mitigate or manage the effects of marine shipping activities under different levels of jurisdiction (see Appendix IV of Transport Canada, 2022).

Area-based management (ABM) is an approach for managing anthropogenic stressors in an area that can be applied to a marine shipping context (Dalhousie University et al., 2022). In consideration of the complex and dynamic nature of marine shipping in Canada, the goal of this chapter is to explain how ABM strategies can be applied in the context of the CEMS initiative to help overcome challenges with effectively managing the potential effects associated with such activities. The purpose of Sect. 3.2 is to identify and explain the various linkages between the CEMS initiative and ABM, both in terms of how ABM is related to CEMS as well as how CEMS can inform efforts by other researchers in applying ABM strategies. It will also describe how TC is working toward reconciliation with Indigenous peoples in Canada with the development of various collaborative governance frameworks that have been applied in CEMS. Section 3.3 will then provide a case study of how the CEMS initiative used an ABM, regional and collaborative approach to establish a Notice to Mariners in Cambridge Bay, Nunavut, which is a voluntary ABM tool to mitigate the impacts of icebreakers on caribou migration and hunter safety.

3.2 Application of Area-Based Management Strategies in CEMS

3.2.1 Using an Area-Based Management Approach in CEMS

Transport Canada's National CEMS Framework defines a CE assessment as a systematic process that identifies, analyzes, and evaluates changes in the environment caused by interactions between human activities and natural processes over time and space. Guidelines put forward by the Canadian Council of Ministers of the Environment (CCME) state that regional CE assessments involve understanding and analyzing past, current, and future conditions, and their interactions, through an agreed-upon process (CCME, 2009). Lastly, the Government of Canada's definition of CE includes the combined effects from past, present, and reasonably foreseeable future activities and natural processes. It goes on to state that specific definitions vary among different parties and under different legislation and policies, but the term generally refers to effects that may be individually minor, but collectively significant. Effects can be adverse (e.g., decreased water quality) or positive (e.g., economic growth opportunities for a community). Overall, these definitions collectively emphasize a structured, comprehensive, and collaborative approach to understanding the complex and interrelated impacts of human activities and natural processes, which can have significant implications for the environment and people.

The CEMS initiative is an example of an activity-based and area-based management approach to decision-making—the "activity" being marine shipping and the "area" being the coastal region being assessed (i.e., CEMS pilot areas). Before embarking on the development of the National CEMS Framework, TC commissioned a "Literature Review of Cumulative Effects Management Concepts and International Frameworks" (Lerner, 2018). A takeaway from this review was that Canada is joined by other countries around the world in looking at the identification and management of impacts from marine shipping on the ocean environment in a regional or area-based context. Under the *International Convention for the Safety of Life at Sea* (SOLAS, 1974), the International Maritime Organization (IMO) may adopt a number of ship routeing measures in an area to ensure safe navigation and marine environmental protection, including areas to be avoided, traffic separation schemes, two-way routes, recommended tracks, no-anchoring areas, inshore traffic zones, roundabouts, precautionary areas, and deep-water routes (NOAA, 2020). Activity-based assessments are also being used around the world such as in Norway

(Barents Sea Integrated Management Plan), Australia (Great Barrier Reef Strategic Environmental Assessment), and New Zealand (Mauri Model Decision-making Framework in post-Rena assessment), to evaluate the CE of stressors on the marine environment (Lerner, 2018). Within these examples found in the literature, many types of tools and models are being used to help identify and organize cause-and-effect linkages between activities and CE on components of the environment. Some examples of these tools include causal frameworks (e.g., the Drivers-Pressures-State-Change-Impact-Response framework and pathways of effects models), ecological risk assessment frameworks, and cumulative impact mapping (Lerner, 2018).

Regional assessments, when looked at from a broad perspective, such as through the lens of the Impact Assessment Agency of Canada (IAAC), are extensive studies conducted in areas with existing or anticipated development that can guide land and marine planning efforts. They are adaptable and diverse, involving a range of approaches, and can encompass various activities, sectors, or specific activities within a region, ultimately enhancing impact assessment processes and decisions to better understand and manage effects (IAAC, 2022). Since regional assessments also provide strategic and comprehensive information for decision-making, they can be useful for and linked to other ABM approaches such as marine spatial planning (MSP) and marine protected area (MPA) management.

MSP is a tool used to establish a comprehensive and integrated approach to the management of activities in marine areas. It can consider ecological, social, and economic aspects and aims to balance the competing uses of marine spaces. MPA management focuses on the protection and conservation of a specific marine area to maintain its ecological integrity and the biodiversity found within. Within MPA management, zoning may be established to restrict human activities to allow for the protection of the marine ecosystems and species present. Since regional CE assessments look at the cumulative effects of human activities on environmental, cultural, social, and economic conditions, they can inform both MSP and MPA processes to help manage activities that may be causing harm to the marine space itself (e.g., reducing biodiversity) and use of that space (e.g., by Indigenous and coastal communities). Regional CE assessments can also inform other linked processes such as monitoring and/or restoration programs, help identify knowledge and data gaps that can inform further research, as well as enable Indigenous peoples and other groups (e.g., academia and environmental nongovernment organizations) in collecting information to support their involvement in MSP or MPA management processes.

Besides informing MSP or MPA management, regional CE assessments can also help to inform ongoing project-level impact assessments such as those under Canada's *Impact Assessment Act* (2019) or other reviews subject to a provincial or territorial impact assessment process (e.g., Inuvialuit Final Agreement (1984), *Nunavut Planning and Project Assessment Act* (2013), *Yukon Environmental Socio-Economic Act* (2003), and *Mackenzie Valley Resource Management Act* (1998)). Regional CE assessments can provide valuable information for project-level impact assessments by:

- Identifying potential CE that may not have been considered in isolation of a single project
- Identifying existing environmental and social conditions in a region such as the presence of sensitive habitats or culturally significant areas
- Identifying regional mitigation measures that can be considered during project-level impact assessments and incorporated into project design and planning
- Informing decision-making processes related to project approvals and permitting by providing the broader context for understanding potential impacts and CE
- Helping to ensure that project-level impact assessments are conducted in a comprehensive and informed manner, considering the broader environmental and social context in which the project is situated

3.2.2 Advancing Reconciliation with Indigenous Peoples in Canada Through CEMS

The GoC is committed to working toward reconciliation with Indigenous peoples (First Nations, Inuit, and Métis) through renewed, Nation-to-Nation, government-to-government, and Inuit-Crown relationships based on the recognition of rights, respect, cooperation, and partnerships. Indigenous peoples are key partners in the OPP, as coastal environments are intrinsic to the identities and ways of life for these communities. Indigenous peoples have invaluable traditional and local knowledge, which can inform the marine safety system and expand the western scientific understanding of ecosystems. Indigenous participation is especially important in Canada, which has a legal context of constitutionally protected Aboriginal rights, treaty rights, and title. The CEMS initiative relies on regional partnerships, collaboration, and engagement in each of the regional CE assessments underway and with national organizations where possible and appropriate. TC has developed several types of models for strengthened collaboration with Indigenous peoples aimed at improving the quality and legitimacy of CEMS assessments (Transport Canada, 2022).

CEMS pilot area assessments are heavily influenced by the principles of reconciliation, as they are being conducted in partnership with Indigenous peoples and coastal communities. Therefore, the development of effective solutions in addressing concerns arising from CEMS assessments is also shaped by the principles of reconciliation, as agreed to in the regionally specific collaborative governance frameworks. The solutions should be culturally appropriate, respect Indigenous rights and knowledge, and contribute to the well-being of Indigenous peoples. In Canada, there are several other examples of ABM-type initiatives that have been developed in partnership with Indigenous communities, including the resulting culturally appropriate management strategies. Examples include the Victoria Island Waterway Safety Committee in Nunavut and the Marine Area Planning Partnership in BC (MaPP, 2024). These initiatives represent key steps toward reconciliation and a more inclusive and sustainable approach to managing Canada's natural resources in partnership with Indigenous peoples.

To establish a more holistic understanding of the issues associated with marine shipping activities, the CEMS process provides flexibility for bringing together western science and Indigenous knowledge. As part of the CEMS initiative, there is recognition of the uniqueness and significance of Indigenous and western knowledge systems, and efforts are deliberately made in the conduct of CEMS assessments to create synergies across these diverse knowledge systems. Doing so provides invaluable insights for understanding the externalities of marine shipping activities on local communities regarding their environment and ways of living. Furthermore, by utilizing both knowledge systems, recommendations to mitigate the impacts of marine shipping identified through CEMS assessments are inherently more comprehensive. Such management recommendations can then serve as a reliable compass to inform the development of strategies for mitigation that fully consider the cumulative effects of marine shipping activities within a region.

3.2.3 Collaboration Models in CEMS

Each of the seven CEMS pilot sites has progressed differently since each area has unique regional realities and priorities. As a result, there are notable differences in their collaboration models, engagement strategies, and assessment methodologies, as each is tailored to the region in focus. As documented in the National CEMS Framework, the diversity of approaches used for completing work at each CEMS pilot site highlights the importance of being flexible while conducting activity-based and area-based assessments. Maintaining this flexibility is crucial for several reasons including the following:

1. Different regions of Canada have unique cultural, socioeconomic, and environmental characteristics that require tailored approaches to address their specific needs and challenges. A flexible approach allows local communities and other parties to have input from the beginning to codevelop the planning and decision-making processes, as well as encourage collaboration from interested parties, which results in a more effective and culturally appropriate management approach.
2. A flexible approach allows for the process to be adaptive, which is critical in responding to changing environmental and social conditions or unexpected events (e.g., adjusting the expectations and work scheduling due to COVID-19).
3. A flexible approach enables the incorporation of new knowledge as it becomes available, which also promotes more effective adaptive management strategies.
4. A flexible approach can also facilitate reconciliation with Indigenous peoples by acknowledging and incorporating their perspectives, values, and knowledge into CE assessment approaches and management decisions. Furthermore, this approach recognizes the important and necessary role of Indigenous peoples in

managing the land and waters and can lead to more equitable management approaches.

There have been many lessons learned from utilizing collaborative governance models for implementing the CEMS initiative that could be considered by other groups or researchers when completing similar regional or area-based work that involves Indigenous peoples and/or Indigenous organizations. It is important to note the term "collaborative governance" means different things to different people. It is a complex term, and the arrangements themselves can be varied depending on the needs and parties involved. In this regard, the lessons learned to this point by the CEMS initiative (and documented in the National CEMS Framework) include the following:

- Commit to early and ongoing relationship building.
- Build partnerships based on open dialog and trust.
- Understand the macroscopic environment to realize synergies.
- Plan to incorporate local issues and be guided by Indigenous principles.
- Link CEMS work with other ongoing initiatives where possible and appropriate.
- Embrace a flexible and collaborative approach from the initial planning stages that isn't restricted by preconceived notions.
- Respect the Nation-to-Nation relationship.
- Facilitate opportunities for meaningful two-way dialog.
- Proactively provide capacity support.
- Devote effort to project management best practices.

Regardless of the collaborative governance model being used, the CEMS initiative has found it important to invest time in understanding the concerns, interests, and current practices of local and Indigenous communities; improve the communication and coordination of CEMS work with other regional initiatives being undertaken in the same general area; and understand the importance of the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP, 2007) and the Truth and Reconciliation Commission of Canada Calls to Action (TRCC, 2012), especially in the context of partnership-building.

3.3 CEMS Case Study in Cambridge Bay, Nunavut

3.3.1 Background on the Cambridge Bay Pilot Area

Located on the Arctic coastline of Canada's Northwest Passage, Iqaluktuutiaq (or Cambridge Bay, as it was renamed by settlers) is a hamlet on the southeastern shore of Victoria Island within the Kitikmeot region of Nunavut. For centuries, the community of Cambridge Bay has stewarded their lands and waters and, in doing so, holds Inuit Qaujimajatuqangit (Inuit traditional knowledge, also commonly referred to as "IQ") of the actions that must be taken to protect the area and to continue their traditional ways of life. From 1990 to 2015, Cambridge Bay had the third highest increase in vessel traffic in Nunavut due to an increasing number of passenger vessels, cargo vessels, tankers, and pleasure vessels navigating the Northwest Passage (Dawson et al., 2018). In response, residents of Cambridge Bay, and those in other Arctic communities that have witnessed similar changes, have voiced a need to better understand the CE of marine shipping activities in the region and to identify management strategies that will effectively mitigate both current and anticipated impacts.

In 2018, the local Ekaluktutiak Hunters & Trappers Organization (EHTO) agreed to partner with TC and Oceans North (an environmental nongovernment organization) to collaborate on conducting the CEMS Cambridge Bay pilot area assessment. The Victoria Island Waterways Safety Committee (VIWSC) was formed under the authority of the EHTO to guide the development and implementation of the CEMS project. Representation on the VIWSC consists of Cambridge Bay community members (including hunters and Elders), relevant Inuit organizations, and various territorial and federal government organizations, and the VIWSC serves as a forum for collaborative decision-making. After the VIWSC was formed, terms of reference (TOR) were codeveloped to consolidate the collaborative governance structure, specify the diverse mandates of the VIWSC members, and outline the preferred decision-making approach and process. In addition, the TOR highlights the shared goals of the VIWSC, which are focused on developing management recommendations and identifying best practices for ensuring a safe, efficient, and predictable operating environment for all waterway users.

The VIWSC also guides the implementation of two other OPP initiatives that have been active in Cambridge Bay since 2018: the Proactive Vessel Management (PVM) and the Enhanced Maritime Situational Awareness (EMSA) initiatives. Although each OPP initiative in Cambridge Bay (i.e., CEMS, PVM, and EMSA) has distinct roles and objectives, the decision to have them operate simultaneously was intentional as there are clear synergies and benefits in doing so:

- CEMS provides a process to collaboratively identify all regional marine shipping issues of concern, gather relevant knowledge and data for evaluating the levels of CE occurring, and use that information to support evidence-informed decision-making.
- PVM is a partnership among Indigenous communities, federal maritime authorities, industry, environmental nongovernment organizations, and other marine stakeholders to address impacts of commercial shipping that conflict with Indigenous users in local and regional waterways. The nature of PVM is designed for regional and local flexibility, allowing for each table to identify priority concerns, gather existing information, and codevelop the best approach to address the issues (e.g. voluntary management measures, vessel routing, speed controls, communication protocols, etc).
- EMSA is a web-based geographic information system that provides near-real-time vessel information across Canada. TC partners with 13 Indigenous communities, including Cambridge Bay, to continuously codevelop the EMSA

system. The system provides access to near real time maritime vessel traffic data and when combined with environmental information, the system deepens maritime domain awareness. This common operating picture of the maritime environment can be used in a number of ways to support collaborative planning and decision-making processes. The system can be used to understand activities occurring in and around traditional territories and sensitive areas and can also be used to monitor and evaluate whether vessel management measures are achieving desired outcomes.

Through early discussions at the VIWSC, the following marine shipping impacts and activities were prioritized to be included in the scope of the Cambridge Bay CEMS regional assessment:

- Impacts of icebreaking activities on caribou migration, food security, and hunter safety
- Impacts of vessel wake on coastal erosion as well as marine mammal haulouts, and calving areas
- Impacts of accidental oil spills on coastal shorelines, marine mammals, fish, and cultural sites
- Impacts of underwater noise on marine mammal distribution and behavior

At the time of writing, the assessments for each pathway of effect are at various stages of completion. The advancement of each assessment has been heavily influenced by the availability (or lack thereof) of knowledge and data to inform an understanding of baseline conditions and effects. As such, a crucial step of CEMS (as well as PVM and EMSA) has been to continually build long-lasting local capacity for the EHTO and VIWSC to collect relevant information and to be actively involved in long-term CE assessment work such as CEMS.

Examples of the ways capacity is being provided to assist with the assessment of CE include the collaboration with other departments to access and/or leverage equipment for the EHTO to collect data. This involves using hydrophones to gather underwater acoustic data, utilizing drones and training to capture baseline information on shoreline conditions, and employing trail cameras and training to set up equipment for monitoring shoreline erosion. Additionally, the approach involves establishing collaborations with researchers to offer assistance and training in data collection. Furthermore, service agreements and/or capacity funding is provided to cover costs associated with fieldwork and project management. This funding also contributes to enhancing resources necessary to facilitate community engagement and the collection of local knowledge when appropriate. People in the Cambridge Bay community are stewards of their land and waters, so it is important to consider that building capacity should be responsive to the needs of the community and done in a way that reflects the preferences of the region. Doing so has helped to build a holistic and shared understanding of CE as well as encourage collaborative governance and decision-making.

The impacts of icebreaking activities on caribou migration, food security, and hunter safety emerged as a top priority issue when the VIWSC was first established.

In response, immediate efforts were put toward addressing those concerns and developing a solution to mitigate those impacts. The following subsections will detail the steps involved and outcomes of that process, which showcase how ABM has been applied through OPP work in the region.

3.3.2 Identifying Area-Based Solutions for Managing Ship Traffic in Cambridge Bay

Each autumn, as sea ice starts to form around Cambridge Bay, the Dolphin and Union caribou herds commence their yearly migration across the frozen, intact waterways linking Victoria Island and the mainland, which also serve as travel routes for local hunters seeking their traditional food source (Dumond et al., 2013). The waterways also provide safe connections between residents of neighboring Arctic communities, allowing Inuit to maintain cultural connections, customs, and traditional ways of life.

The potential for icebreaking to obstruct caribou migration or impact people on sea ice has been documented for many years as a potential problem across the Arctic and specifically within the Kitikmeot region (ICC, 2014; Kochanowicz et al., 2020). In 2015, two icebreakers were transiting eastward from the Chukchi Sea in Alaska with the original intent to pass north of Victoria Island, but ice conditions prevented use of that route. In the meantime, a local hunter had been tracking a caribou herd and, upon returning home, noticed the icebreakers transiting through the very frozen pathways he had traversed on his snowmobile the previous day. Had the icebreakers passed through a little earlier, the hunter would have been stranded from his community until the ice could freeze over again, possibly weeks later. The hunter's encounter highlighted an urgent need to improve two-way communication between vessels and local authorities to prevent unexpected encounters with wildlife or people on the sea ice. As such, the VIWSC quickly reached consensus to conduct a comprehensive assessment on the impacts of icebreaking activities and to formulate and implement mitigation actions (using a PVM approach).

In October 2019, the EHTO hosted a series of "icebreaking" workshops that gathered over 40 participants representing various voices from the local and surrounding communities of the Kitikmeot region (including Elders), federal and territorial governments, nongovernment organizations, academia, industry, and other marine stakeholders. Through group discussions, presentations, and interactive mapping exercises, relevant scientific evidence and IQ was brought forward to pinpoint seasonal periods and locations where caribou and people are expected to utilize sea ice, and ship operators traveling through the region should be made aware of. As Inuit identity, knowledge, and livelihoods are strongly linked to the seasonal cycles of sea ice and wildlife harvesting, it was critical to integrate these perspectives with those of scientists and industry to build a shared picture and context for the issue. This was evidenced throughout the workshop as the observations of Elders and hunters clearly aligned with the scientific evidence concerning seasonal patterns of sea ice and caribou, which helped allocate more effort toward developing solutions.

Given the urgency of needing to address the issue, participants recognized the advantages of developing voluntary measures that could be more readily implemented. There was also recognition that the agreed-upon solution should not involve outright banning of icebreaking or shipping activities given the critical role these activities play in supporting local economies and providing essential services in the region such as community resupply. With these considerations in mind, participants agreed that a *Notice to Mariners* (NOTMAR) was the most effective communication and management tool to quickly convey these considerations to mariners. Additionally, given the development of new safety protocols for activities in the Arctic, such as the International Maritime Organization's Polar Code (2014/15), there were opportunities for locally relevant information within a NOTMAR to be included in mandated voyage planning.

3.3.3 Implementation of ABM in Cambridge Bay

An outcome of the icebreaking workshops was the development of the *Notice to Mariners for Vessels Intending to Navigate the Kitikmeot Region in Canada's Northern Waters* (hereby referred to as the "NOTMAR Notice 7C") that has been in place since 2020 (see Fig. 3.3) (NOTMAR, 2020a). In 2023, the NOTMAR Notice

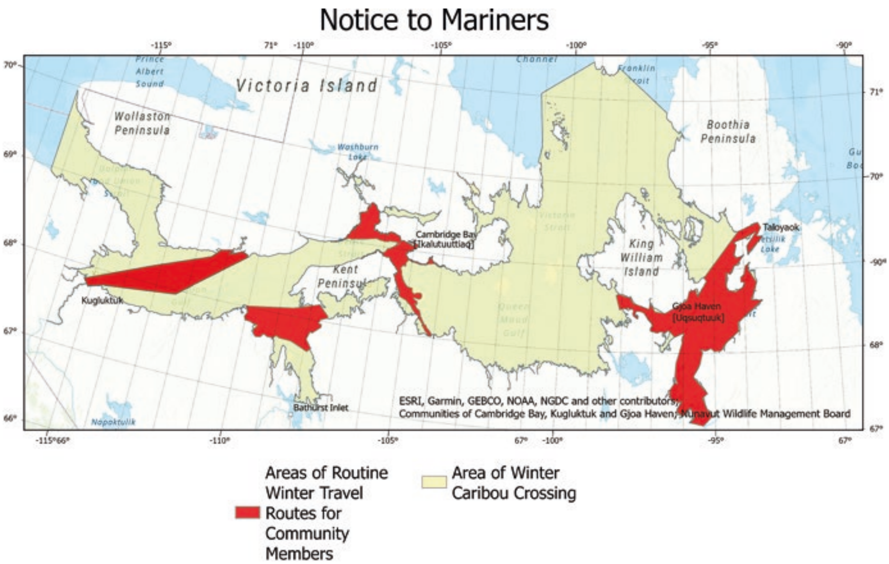

Fig. 3.3 Overview of the spatial boundaries and considerations included in the *Notice to Mariners for Vessels Intending to Navigate the Kitikmeot Region in Canada's Norther Waters*. Source: https://www.notmar.gc.ca/publications/annual-annuel/section-a/a7c-en.php

7C was updated to include inputs gathered from the neighboring communities of Kugluktuk and Gjoa Haven, as both communities use the same waterways as Cambridge Bay and rely on the same caribou herds for their food security (Paquette, 2020). With the NOTMAR Notice 7C in effect from April through November each year, vessels must provide 1 week's notice of their passage over the phone to a list of contacts and follow-up 24 hours in advance. The NOTMAR Notice 7C also outlines voluntary measures that request vessels slow down to minimum safe speeds if people or caribou are encountered while transiting and to refrain from opening multiple leads through the open ice. By improving communication with ships in real time and before their arrival, vessel operators and the communities of Cambridge Bay, Kugluktuk, and Gjoa Haven, can keep each other well-informed about their respective activities.

In addition to addressing the potential impacts caused by icebreakers, the NOTMAR Notice 7C applies to all vessels transiting through the identified protection zone. Furthermore, TC also recently amended *Notice 7A Voyage Planning for Vessels Intending to Navigate in Canada's Northern Waters* to better reflect the department's regulatory requirements regarding the Polar Code and voyage planning in the Arctic (NOTMAR, 2022). NOTMAR Notice 7A is now published and includes recommended measures to mitigate the impacts of shipping on traditional hunting and fishing, environmentally sensitive areas, marine mammals, and caribou migration in the Canadian Arctic. It also explicitly mentions the NOTMAR Notice 7C as it must be considered by the master of a vessel before embarking on a voyage through Arctic waters and documented in their voyage plans if transiting through the identified protection zone. These voyage plans are submitted for review by TC Marine Safety & Security in advance of a voyage as required by the Polar Code.

Due to travel restrictions caused by COVID-19 whereby nonessential vessels were not permitted to transit through Arctic waters in 2020–2022, there has not yet been an extensive evaluation of the adherence of vessels to the NOTMAR Notice 7C voluntary measures under normal traffic conditions. However, in 2022, essential Canadian Coast Guard icebreaking vessels adhered to the NOTMAR voluntary measures and reporting protocols. TC is leveraging opportunities to continually raise awareness of the NOTMAR Notice 7C measures through industry forums (e.g., Canadian Marine Advisory Council—Prairie and Northern Region), direct engagement with regional ship operators and other local authorities, to encourage mariners to follow the recommended voluntary measures. The EMSA platform will also be used to monitor vessel activity and help determine the efficacy of the NOTMAR Notice 7C.

Moving forward, the VIWSC will continue to serve as a forum for collaborative decision-making in determining whether adjustments are needed to improve the NOTMAR Notice 7C by adapting it to changes in local conditions and the timing of the seasons or migration periods or to consider new knowledge. The NOTMAR 7C could also be broadened to address other issues prioritized through CEMS such as the impacts of underwater noise on marine mammals. For instance, measures have been developed through a NOTMAR in the Inuvialuit Settlement Region to identify voluntary avoidance and slowdown areas to protect beluga and bowhead whale populations (NOTMAR, 2020b). As such, the NOTMAR, established through a joint effort between the EHTO, VIWSC, CEMS, PVM, and EMSA, is a flexible communication tool that can support ABM and address concerns of the Cambridge Bay community by effectively mitigating the risks of shipping to wildlife and people using the waterways, in a precautionary and proactive manner.

3.4 Conclusion

In 2016, the OPP was launched to safeguard Canadian coasts and waterways, which includes the CEMS initiative. The CEMS initiative involves using novel approaches that aim to understand the CE of regional marine shipping activities on the environment and Indigenous communities and should be viewed as an example of an initiative that utilizes ABM approaches. The outcomes of CEMS assessments can inform the development of policies, regulations, and mitigation strategies that consider the CE of all marine shipping activities in a region. TC has partnered with Indigenous peoples in seven pilot areas in Canada to evaluate regional CE and explore new collaborative engagement models for a comprehensive understanding of CE issues and for collaborative decision-making. This chapter highlighted an example of how CEMS applied ABM approaches through the CEMS regional assessment in Cambridge Bay, Nunavut, that is being completed in partnership with the EHTO and Oceans North. Specifically, the collaborative development of the NOTMAR Notice 7C showcases how an ABM strategy was developed to address the community's concerns regarding the impacts of icebreaking activities on caribou and people traveling on the sea ice. Other such tools and ABM approaches are in development, not only through CEMS in Cambridge Bay but also through the other six ongoing CEMS pilot areas, which are described in the CEMS National Framework.

It is important to acknowledge that the process of identifying and understanding the CE of marine shipping activities in Canada is complex. Recognition of this complexity led to the development of inclusive, flexible, and adaptive approaches to understand and address marine shipping impacts in a manner that embraces Indigenous knowledge and western science. Furthermore, a foundational component of CEMS (and OPP) is grounding the work through the commitment of the Government of Canada for reconciliation with Indigenous peoples. Efforts are also made through the CEMS initiative to shift decision-making to a more collaborative approach with Indigenous peoples as recognized by the adoption of UNDRIP by the federal government of Canada. Having the CEMS initiative grounded in the principles of reconciliation and collaborative governance has continuously helped advance the initiative in true partnership with Indigenous peoples. The authors of this report wish to thank the EHTO for their continued efforts in the OPP-CEMS initiative and at the VIWSC table.

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Chapter 4
The International Legal Framework for Area-Based Marine Management Tools

Nele Matz-Lück and Shams Al-Hajjaji

Abstract Area-based management tools (ABMTs) for the marine realm can comprise a multitude of different concepts. They have in common that their main purpose is the conservation of the marine environment and the balancing of different ocean uses. Although marine protected areas (MPAs) are a widely discussed concept and part of ABMTs, the latter term goes further. This is exemplified by the *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction* (BBNJ Agreement) that includes a definition of ABMTs. Many such tools address specific human ocean uses in a geographically defined area, for example, shipping, fisheries, seabed mining, and other resource extraction. Others are designed to be cross-sectoral and pursue a broader objective such as balancing (all) relevant uses as part of marine spatial planning or more comprehensive protection of biological diversity. This chapter focuses upon international legal agreements that employ area-based management which addresses or potentially affects shipping to explore and compare their scope and purposes. This includes treaties with a global scope (e.g., UNCLOS, MARPOL, SOLAS, BBNJ Agreement) but also some regionally limited instruments (e.g., regional fisheries agreements). One of the leading questions is to what extent the international legal framework on ABMTs is set up in a coherent manner or whether—due to different purposes of ABMTs from different agreements and disconnection—it places burdens upon the shipping sector that are not necessarily justified to enhance sustainability in ocean governance.

Keywords Area-based management tools · MPAs · UNCLOS · IMO · Shipping · Vessel-based pollution

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4.1 Introduction

The ocean is vital for human life on the planet. In addition to being the prime stabilizing entity for the world's climate, it is also being used for a variety of essential human activities. Coastal and high seas fisheries, the extraction of nonliving resources from the seabed and subsoil, the generation of renewable energy, and the transportation of goods and persons by ships are just some of them. Although area-based management tools (ABMTs) for the marine realm can comprise a multitude of different concepts and instruments, they have in common that their main purpose is the conservation of the marine environment and the associated sectoral or cross-sectoral regulation of different ocean uses. These objectives are inherently restrictive. The degree to which human activities are limited by relevant regulations depends upon the specific mechanism.

Navigation is one of the uses that can be targeted or at least affected by ABMTs. Those mechanisms with the clearest impact on shipping are those that specifically address vessel pollution or the safety of navigation. Often they require compliance with measures concerning the technical equipment or operation of the ship, for example, the use of particular fuels or scrubbers or compliance with speed limits. Other ABMTs, for example, concerning fisheries, could also affect navigation if they restricted vessel traffic through certain areas. Likewise, the establishment of marine protected areas (MPAs) to conserve biological diversity could include restrictions, for example, on anchoring or other vessel activities. The extent to which ABMTs affect navigation also depends upon the degree of jurisdiction that is exercised over different parts of the ocean and the authority that such instruments have over vessels flying the flags of third states, that is, nonmembers to a particular global or regional agreement.

Due to the horizontal approach to lawmaking on the international level, one likely presumption could be that ABMTs stemming from different instruments are not necessarily set up in a mutually reinforcing manner but lead to inconsistencies that impose additional burdens on global shipping. This hypothesis is, however, challenged from the outset as far as area-based restrictions explicitly target shipping. This is due to the institutional setup with the IMO being the primary competent organization to restrict the freedom of navigation by international agreements with a global scope. Nevertheless, questions remain, if different ABMT regimes can overlap, if incoherence could possibly affect shipping, and if implementation of the *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction* (BBNJ Agreement, 2023) may add to a fragmented approach to ABMTs on the high seas.

This contribution assesses how the international legal framework for ABMTs, as established by different legal instruments at the global and regional levels, addresses or affects shipping. It does so by defining ABMTs (Sect. 4.2.1) and discussing their legal basis in the law of the sea (Sect. 4.2.2), before offering some background on the spatial dimension of jurisdiction over the ocean (Sect. 4.2.3). This is followed by a discussion of the role of the IMO in the context of standard-setting for global shipping (Sect. 4.3.1), different sector-specific ABMTs that address vessel-based pollution (Sect. 4.3.2), as well as other ABMTs relevant for navigation (Sect. 4.3.3). ABMTs with a potentially more indirect effect on maritime transportation, that is, those related to the conservation of marine living resources (Sect. 4.4.1), the exploration and exploitation of nonliving resources (Sect. 4.4.2), and the BBNJ Agreement (Sect. 4.4.3), are then reviewed. This is followed by conclusions on legal framework and the degree to which legal instruments may develop in the future for ABMTs on the high seas (Sect. 4.5)

4.2 The Legal Background of ABMTs

4.2.1 Definitions

Until the conclusion of the BBNJ Agreement, 2023, there was no legal definition of ABMTs in an international treaty. The *United Nations Convention on the Law of the Sea* (UNCLOS) itself neither defines nor mentions ABMTs (UNCLOS, 1982). In contrast, Article 1(1) of the BBNJ Agreement defines "area-based management tool" as follows:

> a tool, including marine protected areas, for a geographically defined area through which one or several sectors or activities are managed with the aim of achieving particular conservation and sustainable use objectives in accordance with this Agreement.

This definition clarifies that the designation of MPAs is one possible element of ABMTs and not a synonym. Indeed, the BBNJ Agreement defines an MPA for the purposes of the treaty in Article 1(9) as follows:

> a geographically defined marine area that is designated and managed to achieve specific long-term biological diversity conservation objectives and may allow, where appropriate, sustainable use provided it is consistent with the conservation objectives.

While this underlines that the notion of ABMTs is wider than that of MPAs and has a slightly different notion (Johnson et al., 2018: 112), they have in common that both concern a geographically defined area and both include higher standards of environmental protection when compared to the surrounding waters.

The general objective of enhanced protection of the marine environment from one or more specific human uses is a commonly accepted characteristic of ABMTs, although this is not the only aim that is being pursued by area-based approaches toward the ocean. There are international treaties that include area-specific instruments and do not relate to the marine environment, for example, the establishment of search and rescue zones under the *International Convention on Maritime Search and Rescue* (SAR Convention, 1979). International instruments on the safety of navigation, for example, ships' routeing established in accordance with Regulation V/10 under the *International Convention on Safety of Life at Sea* (SOLAS) and traffic separation schemes (TSS) as expressly provided for in Regulation 10 of the *International Regulations for Preventing Collisions at Sea 1972* (COLREGs), serve two distinct but complementary objectives: preventing harm to humans at sea as well as environmental protection from the consequences of accidents (SOLAS, 1974; COLREGs, 1972). The scope of the International Code for Ships Operating in Polar Waters (Polar Code) is a rare example of an area-specific approach to standard-setting for vessels for northern and southern polar waters (Scott, 2019: 166–167), where the Code is mandatory both under the SOLAS Convention with the focus on maritime safety and under the *International Convention for the Prevention of Pollution from Ships* (MARPOL) in regard to the prevention of vessel-based pollution (Polar Code, 2014/15; MARPOL, 1973/1978).

Another relevant criterion is that ABMTs are sector-specific. A sector-specific approach, for example, concerning fisheries, vessel traffic, or commercial whaling in designated whale sanctuaries under the *International Convention for the Regulation of Whaling* (ICRW), does not necessarily mean that a management tool must be limited to just one sector (ICRW, 1946). The definition of ABMTs in the BBNJ Agreement consequently refers to "one or several sectors." In contrast, an MPA, in principle, targets an area as such and not just a particular activity from one or more sectors of ocean use. In practice, however, such a division of objectives by ABMTs and MPAs is not always clearly displayed. The establishment of the Ross Sea MPA under the framework of the *Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR) seems sector-specific (CCAMLR, 1980). While the conservation objectives of this MPA go beyond resource recovery, the adopted measures in paragraph 7 of the Conservation Measure 91–05 only target the fishing sector by prohibiting or restricting fishing activities in the different conservation zones (CCAMLR, 2016).

There is currently no global legal instrument other than the BBNJ Agreement that defines the term "marine protected area." Even regional conventions designed to deal with MPAs, such as the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1995), refrain from including a definition in the treaty text (SPA Protocol, 1995). However, institutions like the Food and Agriculture Organization of the United Nations (FAO) and nongovernmental organizations (NGOs), such as the International Union for Conservation of Nature (IUCN), take other approaches to definition (Jakobsen, 2016: 6 et seq; see also Nocito et al., 2022: 3). The definition adopted by the Commission for the *Convention for the Protection of the Marine Environment of the North-East Atlantic* (OSPAR) (OSPAR, 1992) in Recommendation 2003/3 is a further example showing that the approach for defining an MPA is considerably narrower than a definition of ABMTs:

> 'Marine protected area' means an area within the maritime area for which protective, conservation, restorative or precautionary measures, consistent with international law have been instituted for the purpose of protecting and conserving species, habitats, ecosystems or ecological processes of the marine environment. (OSPAR, 2003: para 1.1)

Comparing this narrow approach with the more general one for ABMTs, it becomes apparent that an MPA is more specifically focused upon measures of protection, conservation, restoration, or precaution on the one hand and species, habitats, ecosystems, and ecological processes on the other. In essence, MPAs focus on preservation, while conservation and sustainable use of marine areas under other ABMTs generally allow for a more flexible sector-specific approach. A further observation on the relationship between MPAs and ABMTs is that the establishment of an MPA can be a particularly viable approach to the protection of a specific area of the marine environment, if they are implemented and developed as part of a broader management strategy including further ABMTs.

4.2.2 Legal Basis in the International Law of the Sea

Despite the lack of an explicit reference, UNCLOS provides the legal basis of ABMTs (Caldeira et al., 2023: 2). As the "constitution of the ocean," UNCLOS serves as the general foundation for more specific international regulations on the law of the sea. It establishes the legal framework defining the rights and responsibilities of states concerning the use of the ocean. While UNCLOS specifically dedicates Part XII to environmental protection—creating a framework for further, more specific regulations—it largely acts as a broad legal scaffold by establishing maritime zones with differing degrees of jurisdiction over the ocean. This creates a solid basis for other specialized organizations and standard-setting on the global and regional levels, since rights, obligations, and the jurisdiction to regulate and to enforce are clarified. The division of jurisdiction affects ABMTs for shipping. This may establish obstacles to a more integrated approach to environmental protection on the one hand and a lack of coherence in what is expected from vessels navigating through different zones on the other. Ecosystems exist independently from the human division of the ocean into jurisdictional zones. A vulnerable area that is protected by the establishment of an MPA within the exclusive economic zone (EEZ) of a coastal state may well extend to the high seas and would be more comprehensively protected by an integrated approach that restricts, for example, noise by vessel traffic in the adjacent high sea waters. However, it would need an international organization to take actions for this part of the area because the coastal state has no regulatory power. At the same time, shipping in areas that includes passing through high seas as well as different EEZs, and eventually the landing in ports, requires compliance with different sets of restrictions, for example, switching to fuel with a lower sulfur content when entering a Sulphur Emission Control Area or a European Union port.

Article 194(5) of UNCLOS on the protection of ecosystems and habitats indicates an area-based approach to environmental conservation without explicitly referring to specific tools. Likewise, for other parts of UNCLOS, ABMTs are a plausible approach to regulating ocean use, for example, with a view to implementing Article 145(b) on "the protection and conservation of the natural resources of the Area and the prevention of damage to the flora and fauna of the marine environment." Yet, UNCLOS is unspecific, which, in turn, grants flexibility to global and regional organizations to promote their environmental objectives through ABMTs. Again, the spatial dimension of the authority to regulate and enforce is of particular relevance in this context.

4.2.3 The Spatial Dimension of Jurisdiction over the Ocean

Tensions between sovereignty over ocean space and the exercise of traditional freedoms, such as the freedom of navigation, result in the need for balancing ocean uses in the different maritime zones. A sharp distinction exists between areas under national jurisdiction and the high seas in regard to states' jurisdiction to regulate and enforce. Spatial jurisdiction in territorial waters and specific sovereign rights in the EEZ and for the continental shelf stand in contrast to flag state jurisdiction for the high seas. This distinction also affects the use of ABMTs and the enforcement of associated measures to the extent that they impose restrictions upon the freedom of navigation and the operation of ships in different areas of the ocean.

The scope of an international agreement at the "global" or "regional" level does not predetermine whether it is applicable to marine areas beyond or within national jurisdiction. Agreements with a regional scope, such as the OSPAR Convention (1992), may well employ ABMTs for the high seas—as is actually the practice with the network of OSPAR high seas MPAs—whereas IMO instruments with a global scope such as MARPOL (Annex VI) allow for the establishment of emission control areas (ECAs), which are currently all situated in waters under national jurisdiction, such as the Baltic and the EEZs of the United States and Canada.

As mentioned above, UNCLOS has few provisions that imply the possible use of tools for area-based management, for example, Article 194(5) on measures to protect and preserve rare or fragile ecosystems. The spatial dimension of the provision does not limit an area-based approach to a particular maritime zone.

In the territorial sea, the development and implementation of ABMTs is part of the exercise of coastal states' sovereignty. While the right to innocent passage grants navigational rights to ships flying the flag of other states, Article 21 of UNCLOS provides authority for coastal state legislation for, inter alia, maritime safety, protection of navigational aids, fisheries, environmental protection, and pollution control. In addition to national legislation, Article 21(4) of UNCLOS requires foreign ships exercising innocent passage to comply with "generally accepted international regulations relating to the prevention of collisions at sea."

While the contrast between sovereignty over the territorial sea by a coastal state and archipelagic waters of an archipelagic state and the freedoms of the high seas may be easy to explain, the status of the EEZ as an area with limited and purpose-specific sovereign rights is more complex. The area does not form part of the territory of the coastal state, and for some purposes, for example, search and rescue, the waters are treated like the high seas. For other purposes, the coastal state enjoys exclusive sovereign rights, for example, concerning living resources. Such rights are supported by regulatory powers which can restrict shipping. Here, the coastal state can employ ABMTs based upon either national or international law, which then needs to be balanced with the freedom of navigation and other legitimate interests of other states, such as the laying of submarine cables and pipelines. In the EEZ, coastal state sovereign rights are limited to exercising specific functional rights (Article 56 of UNCLOS). Concerning the rights of other states, Article 58(1) of UNCLOS explicitly refers to the freedoms accepted for the high seas, in accordance with Article 87. The crucial balancing of interests in this context is contained in Articles 56 and 58(3) with their references to “due regard” and respect for the laws and regulations of the coastal states which may also include the use of ABMTs. The regulatory jurisdiction by the coastal state, in addition to the sovereign rights listed in Article 56(1)(a), extends to, inter alia, the protection and preservation of the marine environment (Article 56(1)(b)(iii)) as well as to artificial islands and installations (Articles 56(1)(b)(i) and 60). Jurisdiction to enforce national laws that are in accordance with UNCLOS is granted by Article 73. In addition to ABMTs allowed or granted under international agreements, the coastal state can hence adopt area-based measures based upon national law within the competencies UNCLOS establishes for functional jurisdiction in the EEZ.

In contrast to the spatial jurisdiction and sovereign rights to regulate and enforce measures for enhanced environmental protection, including ABMTs that affect shipping, flag state jurisdiction is the prevailing principle governing navigation in ABNJ. The coastal state is still obliged to protect the marine environment in accordance with Part XII of UNCLOS, but there is no central authority that regulates and enforces measures against ships, and, with few exceptions, only the flag state is responsible for compliance control. A common misunderstanding in this context refers to the alleged lack of legal regulation applicable to the high seas. Adoption of the BBNJ Agreement was accompanied by implications in the media that it was the first international legally binding instrument applicable to marine areas beyond national jurisdiction. That the agreement is popularly dubbed the “High Seas Treaty” is telling in this respect. This narrative does not take into account the fact that the 1958 *Geneva Convention on the High Seas*, UNCLOS, as well as other treaties, for example, on the protection of the marine environment, maritime search and rescue, maritime safety, and international customary law, are and have been applicable to the high seas long before the adoption of the BBNJ Agreement.

The high seas are not an unregulated space despite the reliance upon flag state jurisdiction for vessels. Neither are the high seas free from concepts of spatial management. As a result of the broad framework and flexibility in UNCLOS, organizations acting under different international treaties, with either a global and regional scope, can employ ABMTs for parts of the high seas. This would be the means to achieve their objectives, mainly concerning the protection and preservation of the marine environment including the conservation of living resources. One effect of a sectoral approach to ABNJ can be that each “regime has its own distinctive protection mechanisms,” which leads to “a plethora of distinct sectoral regimes designed to protect specific areas of the ocean from individual sector-specific risks" (Freestone, 2016: 231, 236). However, in practice, sectoral ABMTs for the high seas are the exception. Most ABMTs, as well as the majority of MPAs, are established in areas under national jurisdiction (Nocito et al., 2022: 2).

Notable exceptions of high seas MPAs, which are mainly based upon regional initiatives, include the MPAs in the Southern Ocean under CCAMLR (1980) and the *Madrid Protocol on Environmental Protection to the Antarctic Treaty* (1995); the whale sanctuaries adopted under the ICRW (1946); the network of OSPAR high seas MPAs (OSPAR, n.d.); high seas protected areas in accordance with the *Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean* (Barcelona Convention, 1995); vulnerable marine ecosystems (VMEs), for example, those managed by the North-East Atlantic Fisheries Commission (NEAFC, n.d.); and Areas of Particular Environmental Interest (APEIs) on the deep seabed (ISA, 2011, paras 25–30). These regions have all made considerable progress compared to the lack of a global approach before the adoption of the BBNJ Agreement and compared to the majority of marine regions (Freestone, 2016: 231, 240). The *Convention on Biological Diversity* (CBD), despite the limitation of its spatial scope concerning biodiversity to areas under national jurisdiction in accordance with Article 4(lit. a), initiated the process to identify ecologically or biologically significant marine areas (EBSAs), which are not limited to waters under full or partial national jurisdiction but can include high seas (Lyons et al., 2019: 214–216; CBD, 1992). While the request for cooperation by states and international organizations concerning the management of such areas has been elaborated upon under the CBD process, there are no restrictions associated with the identification of such sites, since the freedom of navigation under UNCLOS prevails.

The limited competencies in regard to restrictions concerning the freedom of navigation are crucial. They have the effect that international instruments differ considerably in regard to the impact they may have on shipping on the high seas. They have in common that they must rely upon international law and international cooperation because no single state exercises spatial sovereignty over the area beyond national jurisdiction. Agreements must also respect the prohibition of third-party effect as established by the customary international law of treaties and codified in Article 34 of the *Vienna Convention on the Law of Treaties* (Vienna Convention, 1969). This results in the establishment of binding obligations only for states who gave consent to be bound (Scott, 2019: 173). Only a truly universal agreement for ABMTs would overcome these inherent limitations.

The IMO as the competent international organization is the main actor in setting legal standards for the regulation of shipping. Regulations adopted in agreements under the auspices of the IMO have substantive binding effect for all parties to UNCLOS as they are introduced into the scope of the Convention as internationally accepted standards. This gives the IMO a unique role and already indicates that none of the other ABMTs established under UNCLOS, as far as seabed mining is concerned, and regional arrangements, such as OSPAR or the Mediterranean Action

Plan, can put restrictions on shipping that reach beyond the parties to such an agreement. The mandate of the BBNJ Agreement to establish restrictive measures, including on shipping as part of highs seas ABMTs and MPAs, is subject to interpretation. In the absence of a specific institutional architecture, it will most likely require measures by the IMO to implement relevant restrictions.

4.3 Sector-Specific ABMTs with Direct Relevance for Shipping

The first category of international legal instruments that rely upon ABMTs with relevance for navigation are those that are sector-specific and target shipping to achieve the objective of enhanced environmental conservation. For maritime transportation, differing area-specific standards during a voyage place additional pressure on legal compliance, potentially the technical equipment on board and the operation of the vessel without necessarily resulting in a coherent and sufficient level of environmental protection from pollution associated with shipping. The tension between shipping as a necessary economic activity and environmental concerns becomes apparent in this context. On the one hand, the development of ABMTs with direct relevance for vessels routeing or operation has to take account of the significance of maritime transportation for the world economy. On the other hand, the significant contribution to marine pollution by shipping adds pressure to the deterioration of marine ecosystems and calls for international standards, including ABMTs, to protect vulnerable areas (see Krabbe, 2023: 394 with further references).

4.3.1 Maritime Transportation and the Role of the IMO

The shipping industry is a vital component of the global economy, facilitating trade across international waters and amounting to over 80% share of the world's trade in goods (Krabbe, 2023: 392 with further references). So far, however, this essential service often comes at a significant environmental cost, affecting marine biodiversity and water quality and contributing to air pollution and climate change. Compared to other means of transportation of goods, the sector provides a relatively environmentally friendly means of transportation, but the real environmental costs are not internalized. The example of oil pollution from ships serves as one example of the capability of causing serious harm to the marine environment by transport at sea (see also Harrison, 2017: 114). The greening of the shipping sector, pollution control, research into alternative fuels, and ambitious plans, for example, by the European Union, to become carbon neutral point toward innovation and potentially a cleaner and more sustainable way forward. In an effort to address the negative impacts on the environment by shipping, different sets of ABMTs have been developed within different international legal frameworks.

UNCLOS itself does not provide for ABMTs which directly affect shipping. The IMO is the relevant organization for standard-setting in regard to pollution from vessels, including technical standards and the prevention of collisions and other accidents. The organization has a broad mandate to deal with maritime transportation. In this sense, UNCLOS and the IMO serve complementary roles. UNCLOS provides the foundational legal architecture, while the IMO provides additional layers of technical specifications and recommendations specifically designed for maritime activities by vessels, for example, specific ABMTs that address the unique challenges posed by shipping. However, it is essential to note the limitation of the IMO in that it primarily serves as a facilitator for regulations, for example, agreements and guidelines, which typically lack the capability for direct monitoring or enforcement (O'Leary et al., 2020: 7).

While the IMO is not explicitly mentioned in UNCLOS, the frequent reference to the "competent international organization" in the singular, for example, in Articles 22(3)(a) and 41(4)–(5) on the designation of sea lanes and traffic separation schemes and in Article 211(1) on pollution from vessels, is commonly understood as mandating the IMO to draft the necessary regulations. Moreover, the standards agreed upon under the umbrella of IMO are in turn incorporated back into UNCLOS as the "generally accepted international standards" that were established by the "competent international organization," as in Article 60(3), and which state parties have to take into account. Hence, applicability reaches beyond the parties to particular IMO conventions. This adds to filling the framework deliberately left by UNCLOS concerning the specific details of vessel traffic, the safety of navigation, and the prevention of marine pollution. Effectively, global standards to prevent vessel-based pollution are primarily set by the IMO, with MARPOL being the most prominent treaty framework to address different sources and substances of pollution (MARPOL 73/78).

4.3.2 Area-Based Prevention and Reduction of Vessel-Based Pollution

Within the MARPOL regime, the IMO has already adopted different ABMTs to address vessel-based pollution, even if this applies to only a relatively small part of the ocean and, so far, with very few exceptions, for example, in Antarctic waters, not to the high seas. The IMO has established different areas with a higher level of protection and, hence, stricter sector-specific requirements for shipping. The designation of special areas under MARPOL, including emission control areas, and the establishment of particularly sensitive sea areas (PSSAs) under the authority of the *Convention on the International Maritime Organization* (IMO Convention, 1948; IMO, 2005) are at the core of IMO initiatives to adopt an area-based approach to prevent and reduce pollution from ships. By integrating measures like discharge regulations or mandating cleaner technologies for ships upon entering a specific area, ABMTs are part of an antipollution strategy. Other mechanisms, such as instruments to prevent collisions, likewise serve to prevent large-scale pollution associated with accidents, as well as enhancing safety for seafarers.

Under MARPOL annexes, the designation of special areas serves to impose stricter measures for pollution control, for example, Annex I (oil pollution), Annex II (noxious liquid substances), Annex IV (sewage), and Annex V (garbage). The establishment of ECAs under Annex VI is another example of the designation of special areas granting a higher level of protection by imposing restrictions upon the operation of vessels (IMO, n.d.).

Likewise, the designation of PSSAs aims at enhanced protection of the marine environment in the relevant area. While there is no fixed catalog of measures, so-called associate protective measures, which apply to all PSSAs, include routeing measures, strict application of discharge and equipment requirements under MARPOL, the installation of vessel traffic services, and regulations on speed limits to prevent collisions and mitigate the environmental risks associated with shipping activities. In this respect, the management of PSSAs can use an even larger and more diverse range of measures compared to other IMO ABMTs while at the same time being “less complicated” to declare (Krabbe, 2023: 402). The IMO is competent to declare PSSAs on the high seas, but has not yet done so (Roberts et al., 2010: 487; Scott, 2019: 167). In particular, there is potential for PSSAs to contribute to various Sustainable Development Goals (SDGs) in addition to SDG 14 (Gissi et al., 2022: 5–6).

One of the potentially most effective ABMTs concerning pollution control in certain parts of the ocean is the designation of ECAs due to an elaborated system of very specific restrictions. Incorporated into MARPOL Annex VI, ECAs aim to mitigate air pollution caused by shipping activities. ECAs are established in geographically sensitive or heavily trafficked waters where air and water quality is a significant concern. In these areas, stricter limits can be imposed on the emissions of sulfur oxides (SOx), nitrogen oxides (NOx), and/or particulate matter, depending upon the vulnerability of the area. In addition to this area-based approach, the IMO established strict global sulfur caps for marine fuels in a multiple step procedure over several years. ECAs in waters under national jurisdiction are designated upon proposal by the relevant coastal states. In November and December 2023, respectively, Canada (IMO, 2023a) and Norway (IMO, 2023b) submitted proposals to designate Arctic waters under their relevant jurisdiction as emission control areas. There are currently no ECAs on the high seas.

Since the criteria for the identification of either of these areas are not mutually exclusive, the designations of special areas, including ECAs, and PSSAs may well overlap so that a PSSA is established within a special area or vice versa. The Baltic and the North Sea are examples where there are special areas, ECAs, and, in the Baltic and the Wadden Sea, PSSAs. For the Baltic and some waters of the North Sea, regional organizations, namely, the OSPAR Commission for the North Sea as part of the North-East Atlantic and HELCOM for the Baltic, play an important role in implementation and monitoring.

Not all pollution (e.g., underwater noise) that could be subject to ABMTs is addressed by legal instruments. Existing instruments such as special areas or PSSAs could, in principle, be used to lower noise emissions (O'Leary et al., 2020: 7). To enhance protection of the marine environment from underwater radiated noise (URN) emissions from commercial shipping, the IMO adopted revised guidelines in 2023 (IMO, 2023c). However, as member states are "invited" to use the guidelines, they cannot be considered to have legally binding effect. Neither do the guidelines take a spatial approach. Rather they address the ship as such and describe noise reduction management in paragraph 3.3. as "a tool that may be applied to the operation, design, construction and modification of ships." A reference to spatial planning is made in paragraph 6.20, which states that "[h]ydrographic offices and maritime administrations should consider marking and updating national and international designated protected areas in charts to enable the seafarers and harbour users to plan voyages to minimize the impact of their ship's URN on marine life."

Regional agreements like OSPAR for the North Atlantic or the *Convention on the Protection of the Marine Environment of the Baltic Sea Area (*Helsinki Convention, 1994) use area-based tools for pollution control, but they cannot impose restrictions on shipping with third-party effect beyond the regulatory powers of the coastal states in areas under their respective jurisdiction. There are considerations by the OSPAR Commission concerning underwater noise, which may include area-based tools to address vessel noise, for example, by designating certain shipping lanes to keep certain areas free from this kind of pollution or other spatial-temporal restrictions or exclusions to protect species in a certain time of their life cycles (OSPAR Commission, 2020: 6). Yet, again, the jurisdictional limits are decisive for effectiveness. To the extent that MPAs in the network designated under OSPAR are located in areas beyond national jurisdiction, coordination with other international organizations is necessary to restrict human activities such as shipping, fishing, or seabed mining with effect beyond the OSPAR parties.

Speed reduction in certain marine areas is another ABMT to mitigate the environmental impacts of shipping. In ports and other areas under national jurisdiction, mandatory speed limits are standard. There is, however, no international convention that adopts an area-based approach to vessel speed beyond specific measures in PSSAs. Reduction of vessel speed could be a strategy with a multifaceted significance that would primarily deal with reducing greenhouse gas (GHG) emissions but would also cover maritime safety and sustainable tourism. So far, speed optimization is one factor that can be addressed by ships to enhance their rating concerning their Carbon Intensity Indicator (CII) in accordance with the 2021 amendments to MARPOL Annex VI, which entered into force November 1, 2022 (IMO, 2021), and the 2023 IMO Strategy on the Reduction of GHG Emissions from Ships (IMO, 2023d). This, however, is not an ABMT but a vessel-specific approach. Within the IMO, discussions on a mandatory speed reduction across the global shipping fleet have not been successful and no longer feature prominently on the IMO agenda. Moreover, such a general global measure would not be considered an ABMT. While speed regulations in certain areas offer substantial promise for achieving a variety of objectives, including safety and accident prevention, they are no longer included in the 2023 IMO Greenhouse Gas Emission Strategy (IMO, 2023d). If the current Strategy is successfully implemented by switching to zero GHG emission fuels, restrictions of speed as a measure of emission reduction will be obsolete. Speed reductions could, however, remain a valid measure for accident prevention and, particularly, noise reduction in certain areas.

4.3.3 Other ABMTs Directed at Shipping

The prevention of accidents at sea serves a double purpose: enhancing safety for ships and seafarers as well as preventing environmental harm. Under the SOLAS Convention Regulation V/8, the IMO is the only international organization with the competence to establish international measures on the routeing of vessels. The COLREGs apply to the high seas and all other waters connected thereto which are navigable (COLREGs, 1972). In Rule 1 (lit. d), traffic separation schemes are mentioned as one mechanism to pursue the objectives of the Convention. Since the amount of vessel traffic is one criterion for the establishment of special areas under the different MARPOL annexes, areas may overlap in which routeing and traffic separation schemes are established, particularly, since in practice these areas are located within national jurisdiction. With the IMO as the relevant international organization establishing such schemes and monitoring effectiveness, inconsistencies and the assessment of the effectiveness should rest with this organization.

4.4 ABMTs with a Potentially Indirect Effect on Shipping

Sector-specific ABMTs for the exploration and exploitation of marine resources only address a certain activity, for example, fishing or seabed mining. As a result, the implications for shipping are currently irrelevant. However, since ABMTs, including MPAs, can theoretically address several sectors or even have a cross-sectoral approach, international instruments dealing with marine resources could have potential relevance for maritime transportation. It should be noted that cross-sectoral approaches to ABMTs, such as marine spatial planning or integrated coastal zone management, currently are not applied to ABNJ. A cross-sectoral approach for the high seas would require a significant amount of cooperation between institutions (Zhao, 2021: 19). The following observations mainly serve as the basis for assessment of future developments addressing more than one sector, particularly in ABNJ and in accordance with the BBNJ Treaty.

4.4.1 ABMTs for the Conservation of Living Resources

ABMTs can offer a strategic approach to mitigate some of the challenges associated with high seas fisheries, namely, overfishing; illegal, unreported, and unregulated (IUU) fishing; access inequality; and negative environmental impacts. First, establishing MPAs in regions known for overfishing can act as biological "savings accounts," providing fish stocks the time and space needed to recover. Implementing seasonal closures, for example, during breeding seasons, can help maintain the reproductive viability of fish stocks. Second, it is easier to monitor and enforce regulations concerning IUU fishing within areas in which ABMTs are established than across the entirety of the high seas. Technological measures like satellite monitoring can be concentrated in these zones for more effective oversight. ABMTs often require more rigorous data reporting, making IUU fishing activities more transparent and easier to act upon. Third, ABMTs can be structured to allocate specific fishing zones for smaller and developing nations, ensuring they have equitable access to fish stocks. Developing states can be included in the governance of ABMTs, allowing them a say in the management and utilization of these high seas resources. Fourth, some ABMTs can specifically target ecologically sensitive areas such as coral reefs or seamounts that are most affected by destructive fishing practices like bottom trawling and restrict harmful activities, for example, bottom fishing in VMEs. By taking into account the entire ecosystem and not just individual species or habitat, ABMTs can offer more holistic solutions that mitigate broader environmental impacts. If and to the extent that they cover more than one sector, such benefits would potentially be enhanced. Yet, this would also require enhanced cooperation and coordination to maintain a balance with global shipping interests.

Currently, most fishing activities take place in the EEZs of states. Due to the functional nature of this zone, coastal states do not enjoy full sovereignty but only sovereign rights over living resources. This includes the regulation of access to and protection of living resources in these waters, including the establishment of MPAs with restrictions on fisheries and navigation therein. A comparison on national rules, however, is beyond the scope of this chapter, and there is no international legal instrument calling for the use of ABMTs in regard to fisheries in areas under national jurisdiction.

On the high seas, UNCLOS guarantees the freedom of navigation, the freedom of fishing, and further freedoms. The relationship between the different high seas freedoms is one of "due regard." Articles 87 and 116–120 of UNCLOS specifically outline the freedoms and responsibilities connected with high seas fishing. Area-based approaches to living resources could theoretically interfere with the freedom of navigation, if restrictions upon vessel traffic—in contrast to restrictions on fishing activities only—were imposed. This, however, is beyond the mandate of international institutions establishing ABMTs in relation to high seas fisheries, particularly for flag states other than those who are parties to the relevant regional agreement.

As a global treaty on living resources, the 1995 UN Fish Stocks Agreement adds regulations on straddling and highly migratory fish stocks to UNCLOS and applies to ABNJ and, subject to Articles 6 and 7 of the Agreement, to areas under national jurisdiction (UN Fish Stocks Agreement, 1995 art 3(1)). Despite the global scope of the Agreement, the establishment of MPAs and other ABMTs with restrictions on fisheries on the high seas is largely governed by organizations with a regional scope. Neither UNCLOS nor the UN Fish Stocks Agreement adopts a spatial approach to conservation measures for living resources. The UN Fish Stocks Agreement, by establishing duties of member states to cooperate, transfers particular power to regional fisheries management organizations (RFMOS), subregional organizations, and comparable arrangements. These organizations may adopt ABMTs for the conservation and sustainable use of marine resources, including ABNJ (Scott, 2019: 166). At the same time, ABMTs imposed by other organizations could overlap with the regional scope of the RFMO and, instead of focusing on a specific living resource, may address other activities for the purpose of protecting a broader scope of marine ecosystems. In current practice, however, this is not generally the case.

Area-based elements of fisheries regulation include no-fishing zones or other special management areas, for example, vulnerable marine ecosystems, that address either all fishing activities with a general or temporal scope or specific fishing activities such as bottom trawling. As such, restrictions do not affect shipping, unless the IMO designates measures under, for example, a PSSA in the same region, which in turn would affect only the ships' mobility and not be integrated with other conservation objectives. From the perspective of noise reduction in areas that are relevant for certain fish stocks, measures encompassing both fisheries and shipping with at least a temporal scope could be beneficial to achieve a higher conservation status. Depending upon the location of the area, such measures could put an additional burden on shipping routes. The effective functioning of ABMTs beyond the regulatory scope of an RFMO and their area-based management would require a certain level of coordination and collaboration between different actors such as the IMO for shipping and an RFMO for fisheries, especially when their objectives and areas of operation overlap.

Two regional initiatives are particularly noteworthy, although neither includes restrictions on shipping: CCAMLR and NEAFC. The world's largest marine MPA has been established under CCAMLR in the Antarctic. Parties have adopted particularly strict restrictions on fisheries but not on vessel traffic. The vessel monitoring system in place for the convention area applies to fishing vessels and monitors compliance with conservation measures, but does not document or restrict other maritime traffic. The NEAFC is a good example of a RFMO that uses closures of areas for fishing and protects VME from bottom fishing. Again, the adopted measures do not concern maritime transportation. The entering into arrangements and memoranda of understanding with other organizations, such as the OSPAR Commission and the International Seabed Authority (ISA), is evidence of cooperation and coordination efforts that could eventually lead to ABMTs with measures that address more than one sector.

4.4.2 Exploration and Extraction of Nonliving Resources

Marine nonliving resources are part of what constitutes the "blue economy." Their responsible management is crucial for global development as well as sustainability. This involves a balance between exploitation and conservation, and ABMTs can be a crucial element in the framework to strike this balance (Blanchard and Gollner, 2022: 2–4). ABMTs could offer a multifaceted approach to the governance of nonliving marine resources by establishing zones for resource extraction while protecting ecologically sensitive areas, guide best practices, and provide the necessary legal framework for international cooperation. If accompanied by monitoring and adaptive management, dynamic ABMTs allow for responses to emerging challenges and technologies, making them an indispensable tool in the responsible management of nonliving resources in the ocean.

The current approach to employing ABMTs for nonliving marine resources is sectoral and does not target shipping. In regard to navigation, UNCLOS allows for the establishment of safety zones around platforms and installations in the EEZ in accordance with Article 60(4–6). While such a zone certainly contributes to the prevention of accidents and, as a result, can prevent pollution, it is not a strategic instrument to enhance the protection of the marine environment.

The development of commercial deep-sea mining for minerals like polymetallic nodules or sulfides has gained considerable attention for its economic potential but also raises serious environmental concerns (Blanchard and Gollner, 2022: 2–4). In regard to seabed mining in the Area, there are different approaches to ABMTs, including the establishment of APEIs as well as buffer zones and reference zones. The approach, however, remains sectoral. The ISA plays the decisive role in regulating mineral-related activities in the Area. It employs ABMTs as part of its mandate to establish a governance framework that not only allows for exploration and exploitation but also reserves sites of particular environmental value. The main difficulty is the lack of scientific insight on the viability of such area-based approaches. ABMTs, for example, as reference sites, can contribute to establishing standardized assessment criteria for environmental impacts and social implications of deep-sea mining operations (Ibid).

ABMTs include "no-mining zones," for example, around ecologically sensitive areas like hydrothermal vent systems, which are rich in biodiversity (Christiansen et al., 2022: 4). This also protects the integrity of the surrounding marine environment (Harrison, 2017). The ISA does not grant licenses for exploration or exploitation of mineral resources in APEIs. Despite the considerable lack of knowledge, such proactive measures could have long-term benefits, including preserving these areas for scientific research and maintaining the health and balance of marine ecosystems (Ibid). With regard to the freedom of navigation, however, these areas do not impose any restrictions. This could change if different organizations, including the IMO, take a coordinated approach to ABMTs for specific areas of the ocean in the implementation process for the BBNJ Agreement.

Theoretically, ABMTs could also extend to Antarctica's significant nonliving resources, that is, minerals and fossil fuels, serving as a governance tool for future extraction debates (Rogers et al., 2021: 2 et seq). In this context, the Antarctic Treaty System is an example of a framework under which potential ABMTs specifically designed to protect biological diversity in accordance with the BBNJ Agreement could contribute to an even higher protections status (Gardiner, 2020: 2). Though the applicable treaties currently prohibit any commercial exploitation on nonliving resources, this might change in the future (ibid). In regard to shipping, the lack of competence of organizations within the Antarctic Treaty System to restrict navigation in certain areas prevents a multiple or even cross-sectoral approach.

4.4.3 ABMTs under the BBNJ Agreement

The use of ABMTs in marine areas beyond national jurisdiction to better protect marine biological diversity is one of the four pillars of the BBNJ Agreement. It has been argued that the establishment of ABMTs, including MPAs, under the BBNJ Agreement will not only fill certain gaps in prior agreements but also promote comprehensiveness, coherence, and consistency of marine ABMTs (Duan, 2024: 2). The issue of consistency has two elements, namely, from the perspective of adjacent MPAs under the jurisdiction by the coastal state and with regard to the potential overlap of the BBNJ Agreement's mandate with other international organizations.

It is a question of interpretation as to whether there is a mandate under the BBNJ Agreement to adopt measures as part of ABMTs, even if this duplicates or overlaps with the mandate of other regimes (Duan, 2024: 4–5). The crucial terms in Article 22(2) of the BBNJ Agreement are "respect the competencies of" and "not undermine" existing legal instruments and bodies on the global, regional, and subregional scale and sectoral bodies. The negotiations did not lead to the establishment of new institutions. Rather the Agreement relies upon existing institutional frameworks. One can conclude from this that preference must be given to a limited mandate that requires a high degree of cooperation with other existing organizations and bodies. In any case, far-reaching restrictive measures with a potential global impact on shipping, for example, closures of certain areas to transit, certainly cannot be implemented by the Conference of Parties of the BBNJ Agreement alone. The freedom of navigation on the high seas has not lost any of its legal relevance, and the BBNJ Agreement as an implementing agreement to UNCLOS does not implicitly override one of its basic principles. The last decades have seen the concentration of regulatory power with the IMO, and this is not undermined by the language of the BBNJ Agreement.

Since the BBNJ Treaty does not offer a new institutional architecture but instead relies on existing institutions, it will most likely again be the IMO with the relevant experience and "toolbox" to cooperate on and implement potential restrictions on international navigation. The IMO is explicitly named as one of the organizations participating in the clearinghouse mechanism established by the Agreement to facilitate the exchange of information as the basis for closer cooperation. Given the current reluctance of the IMO to designate further PSSAs or special areas in ABNJ, one may question whether there will be an increase in such areas or other restrictions on shipping in the implementation of the BBNJ Agreement. Accordingly, some scholars urge for a broad interpretation of the BBNJ mandate (Duan, 2024: 5 with further references). While this more ambitious approach is justified by the need to better protect biodiversity in ABNJ, the compromise that states have reached with the adoption of the treaty does not necessarily support this view.

4.5 Conclusion

For the use of the ocean for the purpose of transportation of goods and passengers, ABMTs have emerged as one legal approach to balance economic and environmental interests. To this end, the involvement of multiple stakeholders, such as shipping companies and NGOs, is crucial for effective implementation but also adds complexity and potential conflicts of interest. Despite their potential, ABMTs face legal and practical challenges that require coordinated international efforts for successful implementation and enforcement by the competent international organizations.

Some stressors for marine ecosystems cannot be addressed by ABMTs alone. The effects of climate change, such as a rise in ocean temperature and acidification, cannot be addressed by MPAs or other area-based tools. However, by restricting human uses in certain particularly important or vulnerable areas, additional stress can be alleviated on these marine ecosystems. This may include restrictions on shipping with a view to prevent pollution, including noise emissions, in areas under national jurisdiction and beyond.

So far there are no cross-sectoral ABMTs for areas beyond national jurisdiction, and even ABMTs for more than one sector are currently not imposed by one organization alone. The fragmented nature of establishing current MPAs makes an integrated approach more difficult (Krabbe, 2023: 396). They would need to result from coordinated efforts, for example, by the OSPAR Commission establishing an MPA, the NEAFC restricting fisheries in the same area, and the ISA prohibiting seabed mining by designating the seafloor an APEI. The extent to which the BBNJ Agreement will lead to more cooperation and coordination remains to be seen when the treaty enters not only into force but reaches the implementation stage.

Currently, coherence and complementarity of ABMTs is primarily being discussed from the point of view of the new BBNJ Agreement and its implementation once it enters into force. If there are to be further sectoral ABMTs for the high seas, it is expected that they will be discussed and decided upon within this new framework. The crucial element for establishing ABMTs on the high seas that are targeted at a high conservation status by addressing more than one sector of human activities or even adopting a cross-sectoral approach will be cooperation between the actors with different competencies who need to be involved in the process. For shipping, the prime responsibility rests, again, with the IMO. It already has the authority to establish high seas MPAs and apply other ABMTs, for example, as high seas PSSAs.

If there is no exchange of information or streamlined efforts between institutions, there is the risk that uses like shipping will be restricted in a manner not justified by the ecological benefits. The BBNJ Clearing House Mechanism is one important platform to provide such information services. Likewise, other arrangements on a bilateral or multilateral level between organizations acting within the same marine area, such as the cooperation agreements between NEAFC and OSPAR, can provide necessary structures for an exchange of information.

At the same time, apart from ABMTs, the greening of the shipping sector is more important than ever. ABMTs targeted at maritime transportation are a comparably small element in preventing pollution from shipping. The general greening of shipping and the transformation efforts concerning use of alternative fuels to reduce GHG emissions should be the priority rather than fragmenting the ocean with uncoordinated ABMTs.

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Chapter 5
The Canadian Regulatory Framework for Area-Based Marine Management of Shipping

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Abstract Canada has a well-developed framework for the management of shipping through area-based management (ABM) approaches which operates in direct and indirect ways. Regulatory tools available for the direct spatial management of shipping are used by federal government and port authorities, followed by indirect ways of spatial management of shipping undertaken by federal agencies through the designation of marine protected areas, national marine conservation areas, marine wildlife areas, marine bird sanctuaries, and fisheries habitat sanctuaries, whose principal purpose is marine conservation, which have incidental effects on shipping. The chapter assesses federal government ABM practices from the perspectives of purposes and functions, implementation of international commitments, allocation of ocean space, and considerations for the integrated approach in ocean management, followed by concluding observations on marine spatial planning and the likelihood that Canada will continue to manage its ocean spaces by using shipping ABM tools on a problem-by-problem basis.

Keywords Ballast water management · Fisheries conservation areas · Load lines · Marine conservation areas · Marine protected areas · Marine spatial planning · Migratory birds sanctuaries · Pilotage · Places of refuge · Pollution prevention · Pollution response · Port authorities · Port management areas · Regulation ·

The views in this chapter are strictly those of the authors and do not purport to represent the views of the organizations they are part of. The authors are grateful for comments and suggestions received from Donavan Jacobsen, Transport Canada.

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Routeing · Security zones · Small craft harbors · Shipping safety control zones · Species at risk · Speed restrictions · Vessel traffic services · Wildlife areas

5.1 Introduction

Area-based regulation of ocean uses has a long history in Canada. The aquaculture, fisheries, energy, and shipping industries have long depended on zonal approaches for licensing, offshore installation safety during operations and supply, and international navigation safety. Much of this practice has tended to be sectoral and reflected the needs of the individual industries concerned. In the last three decades, and in Canada most especially following the enactment of the *Oceans Act* in 1996, the concept of integrated ocean management (IOM) emerged in response to the need to consider the multisectoral dimensions of ocean uses and spaces at large and small scales (Oceans Act, 1996; Cicin-Sain & Knecht, 1998). In more recent years, IOM has evolved into marine spatial planning (MSP), a process that aims at conflict avoidance or mitigation and ecosystem-based management (Government of Canada, 2023a). Parallel to and at the same time also as part of this process in Canada, there has been growing attention on ABM in shipping at different scales and mostly at the local level to address growing conflicts between shipping and other ocean uses, impacts of shipping on endangered species and sensitive environments, impacts on the rights of Indigenous peoples, and a growing demand for more inclusive governance of marine spaces (Dalhousie University et al., 2022).

This chapter explores and discusses the Canadian regulatory framework for ABM in shipping in view of identifying discernible trends, ascertaining coherence of practices, and analyzing issues that may require policy and management attention. The focus on shipping is justified because ships tend to be the common platform used by the industrial uses of ocean space. The focus will be on maritime safety, pollution prevention, marine conservation, public health of coastal communities, and maritime security because these are some of the most pressing concerns in the orderly and safe use of ocean space. The chapter further explains the interface of mandates and regulatory initiatives and identifies issues and gaps. The chapter starts by discussing the nature and scope of ABM regulation and the pertinent regulatory authorities. Next, the chapter surveys direct and indirect forms of area-based regulation and its purposes, followed by a discussion of Canadian practices on maritime safety, pollution prevention, marine conservation, public health, and maritime security. This is followed by an assessment and concluding observations.

5.2 Area-Based Management Regulation

In conceptualizing risk governance in ABM in shipping, it is useful to distinguish between shipping-specific ABM tools and non-shipping-specific ABM tools that have an impact on shipping (see Chap. 2, this volume). The former concern spatially and functionally defined tools used at different scales and ship-specific measures, and the latter, while also employed at different scales, are not exclusively aimed at shipping and address larger IOM and MSP concerns, marine protected areas (MPAs), and other forms of protected areas such as for Indigenous uses and historic and cultural heritage sites. This conceptual differentiation is useful to understand the regulation of shipping and the extent of control needed through general or specific directions and spatially defined and temporally determined area-based measures.

The instruments concerned are formal regulations, executive instructions by public authorities, and other guidance instruments. Formal regulations are issued by government and industry, executive instructions by government, and guidance instruments by government, industry, and nongovernmental organizations. Regulations set out mandatory rules and standards and are enacted in primary legislation (statutes) and subsidiary legislation (ministerial regulation). Executive instructions are issued through notifications (e.g., navigational warnings and notices to mariners in the case of government and unified class requirements in the case of industry) (Government of Canada, 2023b). Guidance instruments are varied and include recommended practices.

The purposes of these instruments include maritime safety, maritime and port security, pollution prevention, protection and conservation of species and habitats, public health, and protection of Indigenous interests. The control exerted ranges from prohibiting or promoting specified conduct in particular operations to ensure safety at sea, pollution prevention and species conservation, raising awareness, and encouraging voluntary compliance. Shipping ABM tools often implement or reflect international standards and may also apply exclusively domestic standards. The regulatory strategies employed are mostly prescriptive but may also be goal-based. Prescriptive regulation sets out the exact conduct expected to meet a prescribed standard, the failure of which triggers enforcement (Baldwin et al., 2011). Goal-based regulation establishes goals rather than prescribing standards, leaving the operator options on how to comply with the goal and thereby minimize enforcement (ibid).

While not addressed in this chapter, it is useful to note that guidance instruments issued by industry, Indigenous organizations, and nongovernmental organizations do not carry the equivalent peremptory weight of regulations issued by public authorities but are still helpful because they tend to inform and facilitate compliance. In summary, ABM tools may be described as consisting of both mandatory and recommended standards of conduct.

5.3 Regulatory Authorities

5.3.1 Transport Canada and Port Authorities

The federal *Department of Transport Act* established Transport Canada (TC) as the national maritime administration (NMA) (DOTA, 1985). International maritime conventions designate NMAs as national focal points, thus enabling TC to serve as the domestic implementation conduit of instruments adopted by the International Maritime Organization (IMO), a specialized agency of the United Nations and the competent international organization for international shipping under the *United Nations Convention on the Law of the Sea*, 1982 (IMO Convention, 1948; UNCLOS, 1982). TC derives its authority from its own constitutive act as well as other major shipping legislation empowering ABM, such as the *Canada Shipping Act, 2001* (CSA, 2001), *Canada Marine Act* (CMA), and *Arctic Waters Pollution Prevention Act* (AWPPA), and numerous regulations under their respective remits (CSA, 2001; CMA, 1998; AWPPA, 1970).

TC operates through five major administrative regions, namely, the Atlantic, Ontario, Quebec, Pacific, and Prairie and Northern regions, with the latter including the Arctic shipping division. It consults stakeholders in the Canadian Marine Advisory Council (CMAC), convened at the national and regional levels, and calls for submissions in dedicated regulatory consultations (Government of Canada, 2010; CMAC, 2010). In contrast, consultations with Indigenous peoples are guided by the Crown's fiduciary duty to consult on matters affecting Indigenous rights, which arguably applies to the ongoing process of federal designation of low-impact shipping corridors (*Haida Nation v. British Columbia*, 2004; *Taku River Tlingit First Nation v. British Columbia*, 2004; *Mikisew Cree First Nation v. Canada*, 2005). The ABM powers of TC mostly concern vessel traffic management, including ship routeing (e.g., traffic separation schemes), spatial designations for specific purposes (e.g., places of refuge), issuance of directions to ships (e.g., to proceed to a specific anchorage), and setting requirements for ship reporting (CSA, 2001, s 126; VTSZR, 1989). These powers are accompanied by enforcement powers, for example, directing the movement of ships, ship inspections, issuing clearances, investigations, detention (including foreign ships contravening international rules and standards), enforcement of pollution offences, and the forced sale of ships (VTSZR, 1989).

Major ports in the National Port System enjoy extensive jurisdiction over coastal and inshore waters and adjacent lands. ABM-related powers include the development and implementation of land use plans and vessel traffic services zones (CMA, 1998, s 56). More specifically, port authorities may issue traffic clearances, direct the master or officer on watch or pilot on board to provide information on the ship, direct the ship to use specified radio frequencies in communications with the port station or other ships, and specify the time for ships to arrive and leave berth, leave or refrain from entering any area, or proceed to or remain at a specified location (ibid, s 58(1)). However, there must be reasonable grounds for requiring a vessel to proceed to or stay at a particular location, and such instruction must be founded on specified circumstances. These include the following: a berth might not be available; there is pollution or a reasonable apprehension of pollution in the traffic control zone; the proximity of animals to the ship whose well-being could be endangered by the ship; an obstruction to navigation in the traffic control zone exists; presence of a ship in apparent difficulty or presenting a pollution threat or other hazard to life or property; proximity of a ship navigating in an unsafe manner or that is unseaworthy; vessel traffic congestion posing risks; and efficiency of port operations could be compromised (ibid, s 58(2)). Ships are required to follow the directions issued (ibid, s 58(3)). A port's vessel traffic services are expected to be consistent with national standards and practices established under the CSA 2001 (ibid, s 56(3); VTSZR, 1989).

5.3.2 Fisheries and Oceans Canada and the Canadian Coast Guard

Fisheries and Oceans Canada (DFO) manages Canada's fisheries and safeguards its waters by sustainably managing fisheries and aquaculture, working with fishers and coastal and Indigenous communities to enable prosperity from fish and seafood, ensuring Canada's ocean and other aquatic ecosystems are protected from negative impacts, ensuring commercial vessels and recreational boaters navigate safely, saving lives, and protecting the environment during emergencies (DFOA, 1985, s 4; Oceans Act, 1996, s 41(1)). Area-based regulation and management measures include the designation of fisheries management zones, fisheries closures, marine refuges/other effective area-based conservation measures under the *Fisheries Act*, MPAs under the *Oceans Act*, and critical habitat areas under the *Species at Risk Act* (SARA) (Fisheries Act, 1985, ss 7–9.1; Oceans Act, 1996, s 35; SARA, 2002, ss 56–59).

With authority under the *Oceans Act* and *CSA 2001*, the Canadian Coast Guard (CCG) is a special operating agency under DFO and is responsible for operating the federal civilian vessel fleet. It also provides maritime services, aids to navigation, channel maintenance, marine search and rescue, marine pollution response, icebreaking, marine communications, and traffic management services and provides support to other government departments with ships and aircraft (Oceans Act, 1996, s 41(1); CSA, 2001, s 175.1(2)). An ABM measure implemented by the CCG is the declaration of emergency zones for marine pollution response under the CSA 2001 that precludes vessels from entering or leaving polluted waters. An emergency zone declaration also triggers closure by DFO of commercial and Indigenous fishing operating within or adjacent to polluted emergency zones.

Small craft harbors are administered differently from ports under TC's oversight. The DFO Small Craft Harbours Branch manages coastal harbors critical to the fishing and aquaculture industries that are managed by local harbor authorities (core fishing harbors), harbors that support fishing and aquaculture industries not managed by harbor authorities (non-core fishing harbors), and harbors that support recreational activity (recreational harbors) (Government of Canada, 2022a). DFO

Small Craft Harbours operates under the *Fishing and Recreational Harbours Act* and the *Federal Real Property and Federal Immovables Act* and issues small craft harbor leases to the local harbor authorities for the land that the physical infrastructure and assets are located on, as well as for adjacent water lots consisting of seabed but not the water column (FRHA, 1985; FRPFIA, 1991). ABM measures used by Small Craft Harbours include "harbor property," defined in the *Fishing and Recreational Harbours Regulations* as "any real property at a harbour, including marine facilities" (FRHR, 1978, s 2). Schedule I of the Regulations sets out additional geographical information about a harbor or its location.

DFO is also required under the *Oceans Act* to lead and develop marine spatial plans for large-scale areas in the Atlantic and Pacific regions to support social, economic, and ecological goals (Oceans Act, 1996, s 32; Government of Canada, 2023a). The plans should enable the assessment of the cumulative effects of physical activities, contribute to impact assessment processes, and plan for the sustainable use of ocean space. The membership of the federal inter-departmental Atlantic MSP Coordination Table includes representatives from DFO (Maritimes, NL, and Gulf Regions), Natural Resources Canada, Environment and Climate Change Canada (ECCC), TC, Parks Canada Agency, the Impact Assessment Agency of Canada, and the Atlantic Canada Opportunities Agency (Atlantic MSP Coordination, 2023). Due to jurisdictional overlaps, MSP does not replace existing authorities or management arrangements in the marine environment; rather, it seeks to add value to decision-making processes and to improve inter-departmental and intergovernmental coordination.

A federal Director General-level Interdepartmental Committee on Oceans (DGICO) was formed in 2006 composed of DFO, ECCC, and the Parks Canada Agency that met informally to coordinate implementation of the federal Marine Protected Areas Strategy and to advance inter-departmental program elements related to Canada's marine conservation mandates and targets (Government of Canada, 2018). As of March 2022, two DFO-led Interdepartmental Committees on Oceans (ICOs) now exist—the Assistant Deputy Minister's ICO (ADMICO) and at the DGICO—to support discussion and joint action on the development and implementation of federal ocean-related programs and initiatives. ADMICO and DGICO membership includes over 20 federal departments and agencies involved in policies, programs, services, regulations, and activities in the ocean sector (ICO, 2022).

5.3.3 Environment and Climate Change Canada and the Parks Canada Agency

ECCC is the lead federal department on environmental issues (DOEA, 1985). ECCC addresses these issues through various actions, including implementation of a Pan-Canadian Framework on Clean Growth and Climate Change; engaging with partners including provinces, territories, and Indigenous communities and organizations; monitoring; science-based research; policy and regulatory development; and environmental law enforcement. ECCC's programs focus on minimizing threats to Canadians and their environment from pollution; equipping Canadians to make informed decisions on weather, water, and climate conditions; and conserving and restoring the natural environment (Government of Canada, 2021). ECCC's ABM tools include national marine conservation areas and reserves, national wildlife areas, and migratory bird sanctuaries (ibid).

Falling under the oversight of the ECCC Minister, the Parks Canada Agency's mandate includes policy implementation with respect to national parks, national historic sites, national marine conservation areas, other protected heritage areas and heritage protection programs, as well as their negotiation and acquisition (PCAA, 1998). It protects nationally significant examples of natural and cultural heritage and fosters public understanding to ensure ecological integrity for present and future generations. The Agency oversees five national marine conservation areas across Canada discussed in Sect. 5.2.

5.4 Direct Area-Based Regulation of Shipping

5.4.1 Jurisdiction for ABMs in Shipping

The *Oceans Act* provides a framework for direct and indirect regulatory ABM tools with respect to shipping. The Act implements Canada's rights and duties under UNCLOS and sets out its maritime zones and jurisdictions. Canada's maritime zones include internal waters, territorial sea, contiguous zone, exclusive economic zone (EEZ), and continental shelf, each of which permits a varying degree of jurisdiction over international shipping in accordance with UNCLOS (Oceans Act, 1996, ss 4, 13, 17). Within the EEZ and on the continental shelf, Canada may designate safety zones around offshore installations and structures for safety purposes (ibid, s 20). Canada enjoys full sovereignty over internal waters permitting full use of ABM powers over domestic and international shipping, sovereignty subject to the international right of innocent passage in the territorial sea accompanied by limitations to jurisdiction over international shipping, jurisdiction in the contiguous zone subject to the international freedom of navigation, and sovereign rights and jurisdiction over the EEZ and continental shelf subject to the international freedom of navigation limiting the exercise of jurisdiction over international shipping. Hence, in using ABM tools with impacts on international shipping, Canada must take into consideration the limitations of prescriptive as well as enforcement jurisdiction. For Canada to prescribe ABM measures with respect to international shipping in the territorial sea, contiguous zone, EEZ, and continental shelf, it would have to make a submission to IMO as the organization to which UNCLOS bestows competence over international shipping to designate such measures and which Canada would domesticate in turn.

In addition to the jurisdictional framework, UNCLOS also sets out the framework for the adoption and implementation of the national ocean management strategy and integrated management plans for estuarine, coastal, and marine ecosystems in marine areas within Canada's jurisdiction (ibid, ss 29, 31). Although these instruments are generally for ocean management purposes, ABM in shipping is necessarily included within their ambit, as no ocean use is excluded. Hence, in developing integrated management plans, the Minister of Fisheries and Oceans and the Canadian Coast Guard (DFO Minister) have a duty to coordinate with other ministers, including the Minister of Transport (ibid, s 32(b)).

5.4.2 Maritime Safety

5.4.2.1 Vessel Traffic Services

The CSA 2001 confers on the Minister of Transport regulatory authority for the establishment of vessel traffic services (VTS) zones, under which general regulations and specific regulations for Eastern and Northern Canada have been adopted (CSA, 2001, ss 136(1)(a); VTSZR, 1989; ECVTSZR, 1989; NORDREG, 2010). Once established, a VTS zone stipulates that ships require clearance before they enter, leave, or proceed within the zone and may not proceed unless they are able to maintain direct marine communications with a VTS center (CSA, 2001, s 136(1)). The VTS officer is empowered to grant clearances; direct the captain, pilot, or officer on watch to provide any information on the vessel; direct ships to use radio frequencies in communications; and provide specific directions to leave or not enter the VTS zone or specified areas or to proceed or anchor within the zone (ibid, s 136(3)). Some navigable waters are subject to a ship reporting system (SRS), as in the case of the Arctic Canada Traffic Zone (NORDREG Zone)) under the *Northern Canada Vessel Traffic Services Zone Regulations* (NORDREG, 2010). The NORDREG Zone is subject to a mandatory SRS established to protect the unique Arctic environment by requiring vessels of 300 gross tonnage or more to file reports on entering, while navigating, and before exiting Arctic waters.

5.4.2.2 Routeing, No Anchorage, and Speed Restrictions

The CSA 2001 implements the *International Regulations for Preventing Collisions at Sea*, 1972 (COLREGs), which set out international rules for the safe movement of ships in all marine spaces (COLREGs, 1972). Dedicated regulations implement the rules in their entirety, provide for Canadian modifications, and set out a system of ABMs for safe navigation (Collision Regulations, 2008). The rules provide for inshore traffic zones for local small traffic (vessels of less than 20 meters), consisting of routeing measures on the landward side of a traffic separation scheme (TSS)

(Collision Regulations, 2008, s 1(1)). Routes are defined,[1] and multiple routes may form a routeing system that includes "any system of one or more routes or routing measures which systems may include traffic separation schemes, two-way routes, recommended tracks, areas to be avoided, inshore traffic zones, roundabouts, precautionary areas and deep water routes" (ibid). A route may include a traffic separation zone, a routeing measure that provides for the separation of opposing streams of traffic, thus requiring vessels to maintain one direction of traffic flow and bypass each other safely in separate lanes (ibid). Routeing measures are set out in IMO regulations and designated by it (IMO, 1985).

Of particular interest is Regulation 10 of the COLREGs, which provides a strict regime for navigation in a TSS. Ships must proceed in the appropriate traffic lane in the general direction of traffic flow for that lane while keeping clear of the traffic separation zone, joining, or leaving traffic at the termination of the lane and at as small angle of the traffic flow as practicable. Naturally, vessels may traverse an inshore traffic zone for port entry or exit purposes to take on a pilot or to avoid danger. Separation zones can only be entered in cases of emergency to avoid immediate danger or to engage in fishing as appropriate.

In addition to routeing measures, ABM measures may include no anchorage sites for prohibited waters, such as in bays, channels, and canals (NSR, 2020, s 301, scheme 5). Such areas may be subject to navigational instructions or restrictions or other shipping measures contained in Notices to Mariners and navigational warnings (ibid, s 302). Some areas, such as the Burlington Canal, are also subject to size, speed, and overtaking restrictions (ibid, ss 303–304, 306–308). Navigable rivers may also be subject to similar ABMs, such as the Detroit, St. Clair, and Rouge Rivers, and specified channels (ibid, ss 312, 315, 317, 319). Similar ABMs apply to a range of other inland navigable waters, such as lakes (VORR, 2008, schemes 1–4, 5–9).

Differently from the designation of ABMs to control shipping, navigable waters themselves receive protection from works, defined as structures, dumping, or fill. The Minister of Transport may designate an area contiguous to a work to ensure the safety of persons and navigation, and the Governor in Council may designate areas where no works are to be constructed or take place (CNWA, 1985, ss 7(11), 13.1).

5.4.2.3 Load Line Zones and Areas

Other geographical designations for maritime safety purposes are applied in a variety of contexts. For example, Canada applies an international convention concerning load lines that establishes rules about loading and freeboard determined

[1] Route means "an area within which there are, at any point, one or two directions of traffic flow and that is delineated on two sides by separation lines, separation zones, natural obstacles or dashed tinted lines except that the continuity of such lines or zones may be interrupted where the route merges with, diverges from or crosses another route" (Collision Regulations, 2008, s 1(1)).

according to navigation seasonal zones, areas, and periods (LLR, 2007, s 7; ICLL, 1966, Annex II).

5.4.2.4 Pilotage Areas

Pilotage is another type of safety measure based on ABM. Canada has four major pilotage regions—Atlantic, Great Lakes, Laurentian, and Pacific—each of which provides mandatory and voluntary pilotage depending on the area concerned. The service is provided by a pilotage authority for each region established as a Crown body under the *Pilotage Act* (Pilotage Act, 1985). There is no pilotage authority for Arctic waters. Compulsory pilotage areas within each region are established by regulation, and, with very few exceptions (e.g., a regular member of the ship's complement has a pilotage certificate for the area concerned), they prescribe pilotage under a licensed pilot for all commercial visiting vessels (ibid, ss 38.01, 52 and sch; GPR, 2000, scheme 2–5). Transport Canada also issues Interim Orders Respecting Compulsory Pilotage as needed (Transport Canada, 2023e). Further, pilotage authorities are responsible for regulating the pilotage profession and provision of pilots for eligible vessels (Pilotage Act, 1985).

5.4.3 Places of Refuge for Ships, Salvage, and Wreck

Vessels in need of assistance because of the stress of weather and fire on board or when damaged in a collision may be directed by the Minister of Transport to a place of refuge, which can be a port or other sheltered waters (CSA, 2001, s 189). Under commercial salvage, the salvor completes the contract on delivering the stricken vessel to the owner at a place of safety (ISC, 1989, art 8; WAHVA, 2019, scheme 2). It is possible that places of refuge are predesignated by public authorities for situations where the salvaged vessel is deemed to pose no risks to coastal communities, amenities, or the environment. Defined consistently with the IMO guidelines on the subject, a place of refuge is "a place where a ship in need of assistance can take action to enable it to stabilize its condition and reduce the hazards to navigation, and to protect human life and the environment" (IMO, 2004). Canada has designated anchorages and anchorage sites that could be places of refuge (Government of Canada, n.d.). However, unlike some other jurisdictions, Canada has not predesignated places of refuge for such ships, and the decision to grant or refuse refuge rests with TC Marine Safety Regional Directors based on the National Places of Refuge Contingency Plan and its regional iterations (PORCP, 2007). The Plan enables risk-based decision-making to direct the ship operator and salvor on hand to a place designated by TC. At the same time, it is worth noting that while TC has exclusive authority over granting a place of refuge under the authority of the CSA 2001, under the CMA, port authorities also have power to direct traffic (CSA, 2001, s 662(1)(f); CMA, 1998, ss 56, 58). A port authority's powers in this regard should be read against the expectation that port practices and procedures concerning traffic zones must not be inconsistent with national standards and practices for marine vessel traffic services under the CSA, 2001 (CMA, 1998, s 56(3)).

In situations where a vessel or a wreck poses a grave and imminent safety or environmental hazard, the DFO Minister may declare an emergency zone of a size that is reasonably commensurate with the risk (WAHVA, 2019, s 67(4)). Within that zone, the Minister may direct vessels to report their positions, deny exit from or exclude entry into the zone, and provide directions to vessels with respect to routes, speed limits, pilotage, and equipment requirements (ibid).

5.4.4 Pollution Prevention Areas

5.4.4.1 General

The IMO has long used large-scale ABM tools for pollution prevention, most notably through the *International Convention for the Prevention of Pollution from Ships*, 1973/78 (MARPOL) (MARPOL, 1973/78). This instrument provides basic pollution prevention standards applicable to all marine areas and designates special areas with even higher standards to control waste management and discharge.

Oily waters may only be discharged in compliance with MARPOL Annex I. Canada further distinguishes between Section I waters and Section II waters (VPDCR, 2012).[2] Discharge limits are stricter for inland waters than other Canadian waters, setting different limits for each, with Section I inland waters having a 5 ppm limit and other waters having a 15 ppm limit (ibid, s 30). In Annex II, the discharge of noxious liquid substances in ballast water is regulated according to the type of substances (X, Y, and Z). Discharges are permissible if they satisfy specified criteria, such as distance from the shore, discharge rate, speed during discharge, and depth (ibid, ss 66–67). Ships may discharge sewage in designated sewage areas in Canadian waters listed in Schedule 2 of the Regulations only if the sewage is sanitized and has the prescribed low coliform count (VPDCR, 2012, s 95). Discharges in other areas of Canadian waters must occur either at least 12 nautical miles (M) from shore at a speed of at least 4 knots or, if the sewage is comminuted and disinfected, at least 3 M from shore (ibid). Canadian vessels operating in non-Canadian waters must comply with MARPOL Annex IV standards implemented in the Regulations. The discharge of garbage under Annex V is similarly subject to distance rules, as well as the type of garbage. For example, dunnage that does not

[2] Section I waters: "fishing zone 1, fishing zone 2, fishing zone 3 and (a) for the purposes of Division 1 of Part 2, any other portion of the internal waters of Canada that is not in arctic waters; and (b) for the purposes of Divisions 4, 5 and 7 of Part 2, any other portion of the internal waters of Canada that is not in a shipping safety control zone." Section II waters: "waters under Canadian jurisdiction that are not in (a) fishing zone 1, fishing zone 2, fishing zone 3 or any other portion of the internal waters of Canada; or (b) arctic waters" (VPDCR, 2012, s 1)

contain plastics is to be discharged as far as feasible from land and at least 25 M from the nearest land, while other garbage is at least at 12 M and comminuted or ground garbage at 3 M (ibid). Cargo residues are also subject to distance requirements on the Great Lakes (ibid, s 102). Stricter rules apply to the Lake Superior and Six Fathom Scarp Mid-Lake special protection areas (ibid, ss 98, 102).

Except for emission control areas, MARPOL Annex VI regulates air pollution at the global level; however, while Canada applies Annex VI standards, it also applies additional measures with local application. For example, the *Vessel Pollution and Dangerous Chemicals Regulations* (VPDCR) regulate particulate matter in emissions through prescribed distances for the emission of smoke from vessels in Canadian waters within 1 M from shore (VPDCR, 2012, ss 117–118). In another instance, an ABM measure has been used in Canadian waters, although it is not prescribed in the counterpart IMO regulation. This has occurred with respect to exhaust gas cleaning systems (scrubbers). MARPOL Annex VI permits compliance with the sulfur oxide (SOx) emission standard through an alternative compliance mechanism certified by the NMA (i.e., TC) (MARPOL, 1973/78, Annex VI reg 4). Canada permits the use of scrubbers as a compliance mechanism, having implemented the IMO 2015 Guidelines for Exhaust Gas Cleaning Systems (IMO, 2015). However, due to the pollution concern over the discharge of scrubber washwater, some Canadian ports have moved to restrict the use of scrubbers by ships at anchor within their jurisdiction; therefore, vessels must switch to compliant fuel or use shore power (VFPA, 2022, s 14.4).

Canada has implemented MARPOL-designated special areas for oily wastes, hazardous and noxious substances and garbage, and air emission control areas in the VPDCR (VPDCR, 2012, s 7). While none of the IMO-designated special areas apply to Canadian waters, Canada implemented the North American Emission Control Area (NAECA) designated under MARPOL Annex VI (MARPOL, 1973/78, Annex VI regs 13–14; Appendix VII). NAECA applies to marine areas up to the EEZ limits off the east and west coasts for the purpose of controlling SOx and nitrogen oxide (NOx) emissions. Ships operating in these waters must use fuel with sulfur content that meets the SOx standard to not exceed 0.10% m/m (mass by mass) and must comply with the strict NOx Tier III emission standard. Additionally in this case, ships using heavy fuel oil must switch to NAECA-compliant fuel before entering Canada's EEZ. NAECA emission standards do not apply to waters north of 60 degrees North, although the designation of northern waters as a similar emission control area is under consideration at the IMO (Chircop, 2020).

5.4.4.2 Arctic Waters and Shipping Safety Control Zones

Arctic waters constitute the first region-specific ABM regulation of shipping in Canada with the enactment of the AWPPA. In the definition of Arctic waters, the Act included internal waters, territorial sea, and EEZ north of 60 degrees North and bounded to the west by the 141st meridian and to the east by the international maritime boundary with Greenland (AWPPA, 1970, s 2). The Act further creates a system of 16 Shipping Safety Control Zones for the purpose of regulating ship design, construction, equipment, crewing, cargo carriage, supplies, navigational information, and vessel operational standards, including navigation based on risk assessment of ice and weather conditions utilizing the Arctic Ice Regime Shipping System (AIRSS) (ibid, s 11(1); SSCZO, 2010). The Act established high standards for pollution prevention, including a zero-discharge regime for oil and strict controls of other waste generated on board.

When Canada implemented the International Code for Ships Operating in Polar Waters (Polar Code) and related amendments to MARPOL and the *International Convention for the Safety of Life at Sea* 1974 (SOLAS) in 2017 by enacting the *Arctic Shipping Safety and Pollution Prevention Regulations* (ASSPPR) under the authority of both AWPPA and CSA 2001, it largely maintained the ABM approach for Arctic waters (Polar Code, 2014/15; SOLAS, 1974; ASSPPR, 2017). The Polar Code elevated the pollution prevention standards in Arctic waters to a level comparable to that of MARPOL special areas but without designating the region a special area. The most significant measure in the Code that affects the AWPPA is the introduction of the Polar Operational Limit Assessment Risk Indexing System (POLARIS), which over time will replace the AIRSS and zone system to determine the risk faced by ships of different polar classes.

In the NORDREG Zone, a regional approach to mandatory ship reporting in Arctic waters applies (NORDREG, 2010). The NORDREG zone covers an area larger than the Polar Code area[3] and includes reporting requirements for prescribed classes of vessels before entry into the zone while navigating and before exiting Canadian Arctic waters.

5.4.4.3 Pacific Oil Tanker Moratorium

An unusual pollution prevention ABM in Canada is the *Oil Tanker Moratorium Act* applicable to the Pacific (OTMA, 2019). It consists of a single ABM measure applicable to a single class of ship—the oil tanker—prohibiting the carrying in bulk or loading of crude or persistent oil to an amount greater than 12.5 MT or anchoring at a port or marine installation on the coast of British Columbia north of 50°53′00″ N and west of 126°38′36″ W (ibid, s 4). This is unusual because the Act, although regional in scope, is significantly more limited than the AWPPA. A regulation of a scope limited to a class of ship and in a designated geographical area would

[3] The NORDREG Zone includes the Polar Code area covered by the SSCZs as well as several bays and estuaries: "(a) the shipping safety control zones prescribed by the *Shipping Safety Control Zones Order*; (b) the waters of Ungava Bay, Hudson Bay and Kugmallit Bay that are not in a shipping safety control zone; (c) the waters of James Bay; (d) the waters of the Koksoak River from Ungava Bay to Kuujjuaq; (e) the waters of Feuilles Bay from Ungava Bay to Tasiujaq; (f) the waters of Chesterfield Inlet that are not within a shipping safety control zone, and the waters of Baker Lake; and (g) the waters of the Moose River from James Bay to Moosonee" (NORDREG, 2010, s 2).

normally be included in existing regulations, such as the VPDCR under the CSA 2001. The explanation for the legal form of this measure likely rests more with regional politics than normal NMA and ABM practice.

5.4.5 Pollution Response Areas

Canada has a regional system for oil pollution response based on TC-certified standing response organizations located in the major shipping regions (CSA, 2001, s 169(1)). At this time, the following organizations have been certified on a regional basis: Western Canada Marine Response Corporation, Eastern Canada Response Corporation, Point Tupper Marine Services, and Atlantic Environmental Response Team (Transport Canada, 2023a; ROR, 1995). There are no certified response organizations in Arctic waters. Under this regional system, ships of a specified tonnage that trade in oil in Canadian waters (e.g., oil tankers) are required to have a standing arrangement with a certified response organization in the region where the ship trades (CSA, 2001, s 167(1); ERR, 2019, s 2). The requirement does not apply to foreign vessels simply exercising the right of innocent passage through the territorial sea (ERR, 2019, s 3). The pollution prevention system extends to oil handling facilities loading and unloading oil, which are required to have pollution prevention plans (ibid, s 5 *et seq*.).

5.4.6 Ballast Water Management and Exchange Areas

In 2010, Canada acceded to the *International Convention for the Control and Management of Ships' Ballast Water and Sediments* 2004 (BWM Convention) requiring ships to manage vessel ballast water (BWM Convention, 2004). Canada recently passed new ballast water regulations that entered into force on June 3, 2021, and that apply to Canadian vessels globally and to foreign vessels in Canadian waters (BWR, 2021). The 2021 *Ballast Water Regulations* give effect to Canada's obligations under the BWM Convention to protect Canadian waters from the introduction and spread of aquatic invasive species and pathogens by Canadian and foreign vessels. They require vessels on international voyages to comply with the BWM Convention's requirements and standards. Key requirements include meeting a performance standard that limits the number of organisms capable of reproducing to reduce the risk of aquatic invasive species,[4] and vessels are expected to use

[4] The D-1 ballast water management standard requires ships to exchange ballast water at least 200 nautical miles from land and in water at least 200 meters deep. The D-2 standard specifies the maximum amount of viable organisms allowed to be discharged, including specified indicator microbes harmful to human health.

onboard ballast water management systems to meet the performance standard.[5] Furthermore, foreign vessels must exchange and flush ballast tanks in addition to meeting the performance standard when travelling to freshwaters in Canada from waters beyond Canadian jurisdiction, the Great Lakes, and the high seas. The Regulations and the BWM Convention require foreign vessels in transit and built on or after September 8, 2017, to meet the performance standard when the vessel is launched.[6]

Canadian Alternate Ballast Water Exchange Areas are described in TC's policy TP-13617e-2021 (Transport Canada, 2021). The only ballast exchange area that directly avoids an MPA is the exclusion of the SGaan Kinghlas-Bowie Seamount Marine Protected Area off Haida Gwaii, British Columbia, from the Pacific Canada Alternate Ballast Water Exchange Area. The Pacific exchange area avoidance distance of this MPA ranges from a maximum of 36 M down to abutting the northern MPA boundary. Spatial overlap exists between the Gulf of St. Lawrence Alternate Ballast Water Exchange Area (Laurentian Channel) and two *Oceans Act* MPAs, that is, St. Anns Bank Marine Protected Area and the Laurentian Channel Marine Protected Area. The Atlantic Canada Alternate Ballast Water Exchange Area is only 5 M south of the Gully MPA boundary. There are also several marine refuges/other effective area-based conservation measures (OECMs) that overlap with alternate ballast water exchange areas, including the Offshore Pacific Seamounts and Vents Closure, Eastern Canyons, Corsair and Georges Canyons, and six coral and sponge conservation areas in the Gulf of St. Lawrence. Marine refuges/OECMs established pursuant to the *Fisheries Act* via variation orders and/or conditions of license also have no impact on commercial navigation rights.

5.4.7 Marine Conservation ABM Tools

5.4.7.1 Gulf of St. Lawrence

Since August 2017, Transport Canada has issued annual Interim Orders with speed restrictions for the protection of North Atlantic right whales (NARW, *Eubalaena glacialis*) in the Gulf of St. Lawrence. The 2023 Interim Order states that vessels greater than 13 meters have speed restrictions in effect during April 19 to November 15, 2023, in a static zone divided into northern and southern zones. Vessels must not exceed 10 knots in static zones in the Gulf of St. Lawrence (Transport Canada, 2023d).

[5] Ballast water management systems include treatment options such as water separation and filtration; the application of ozone, electrical currents, or UV radiation; or biocides and chlorination.

[6] Vessels built before September 8, 2017, are required to meet the performance standard using a phased-in approach from 2019 to 2024. Domestic and Great Lakes vessels are required to comply with the same performance standard requirements as vessels operating globally. However, domestic vessels constructed in or after 2009 have until September 8, 2024, to comply with the performance standard, while vessels constructed before 2009 have until September 8, 2030, to be compliant.

Temporary speed restrictions of 10 knots for vessels greater than 13 meters could be enforced in dynamic shipping zones north and south of Anticosti Island. Dynamic shipping zones coincide with vessel traffic separation schemes designated by Transport Canada, and speed restrictions are applied in these zones when at least one NARW is detected in any zone north and/or south of Anticosti Island, 5 M south of the dynamic shipping zones, or 2.5 M from the eastern and western edges of these zones. Ten-knot speed restrictions are in effect for 15 days starting on the detection date. If NARWs are not detected during the last 7 days of a 15-day period, the speed restriction is lifted at the end of the period (Transport Canada, 2023d).

A mandatory restricted area is in effect in or near Shediac Valley, an area east of New Brunswick and northwest of Prince Edward Island, where vessels greater than 13 meters must avoid the area unless exempted under the 2023 Interim Order. Furthermore, voluntary vessel slowdowns in the Cabot Strait are in effect for April 19 to June 27, 2023, and September 27 to November 15, 2023. During these periods, vessels greater than 13 meters are asked to voluntarily reduce their speed to not exceed 10 knots. Compliance with the Interim Order is conducted via the issuance of navigational warnings and the review of automatic identification system (AIS) data provided by CCG's terrestrial AIS data receivers (Government of Canada, 2023b). Vessel owners could face penalties of up to CDN$250,000 and/or a penal sanction under the CSA 2001, liable on summary conviction to a fine of up to CDN$1,000,000 or imprisonment up to 18 months, or both. Violations for noncompliance with the 2022 Interim Order were issued to three bulk carriers under the flags of Singapore, Panama, and the Marshall Islands, with the penalties totaling CDN$24,975 (Transport Canada, 2023b). A key deterrent of noncompliance is to set fines for offenses higher than the incremental fuel costs of transiting above speed limits and the cost savings by port arrivals and departures not being delayed by speed and area restrictions. Since the 2023 Interim Order came into effect on April 19, 2023, another 317 vessels have been observed at speeds above the limit or entering the restricted area as of October 27, 2023 (Transport Canada, 2023c).

5.4.7.2 Southern British Columbia

In 2019, the first Interim Order Respecting the Protection of Killer Whales (*Orcinus orca*) in the Waters of Southern British Columbia in the Salish Sea was issued. More recently, the Interim Order released on June 1, 2023, aims to reduce underwater vessel noise and physical disturbance from vessel traffic for killer whales, focusing on key foraging areas for Southern Resident killer whales listed as endangered under the SARA (Transport Canada, 2023f).

The Interim Order prohibits vessels, subject to exceptions, from approaching killer whales at less than 400 meters in Southern Resident killer whale critical habitat designated under SARA and in British Columbia coastal waters between Campbell River (Cape Mudge) and Malaspina Peninsula (Sarah Point), including Howe Sound, to just north of Ucluelet, including Barkley Sound. In these waters, the Order prohibits positioning vessels such that they are in the path of a killer whale. Two interim sanctuary zones are created where vessel traffic is prohibited, including fishing or recreational boating, from June 1 to November 30, 2023, with some exceptions. The two zones are off the southwest coast of Pender Island and southeast end of Saturna Island. Finally, the Order creates two speed-restricted zones, subject to exceptions, implementing a mandatory speed limit of 10 knots in areas around Swiftsure Bank, during June 1 to November 30, 2023. The first area is located at the mouth of the Nitinat River, and the second is located at Swiftsure Bank.

The shipping lanes in the Salish Sea are established under both Canadian and US legislation, and vessels must transit these lanes for navigation safety. Transport Canada cannot unilaterally prohibit vessels from using the traffic separation scheme because the lanes overlap both jurisdictions and the Interim Order only applies to Canadian waters, so voluntary measures are used to reduce acoustic and physical disturbance from commercial vessels in important sections of the traffic separation scheme.

Violations for noncompliance with the 2022 and 2023 Interim Orders were issued to 15 pleasure craft vessels in southern British Columbia, with penalties ranging from CDN$500 to CDN$3,375 and totaling CDN$15,940 (Transport Canada, 2023b). A study of vessel compliance with minimum distance regulations in the Salish Sea indicated approximately 80% compliance, with recreational boats being significantly noncompliant with distance regulations and boaters being more likely to be noncompliant around killer whales by not adhering to the 400-meter whale avoidance distance (Fraser et al., 2020).

5.4.8 Security Zones

In addition to safety and environmental purposes, ABM tools also have been used to ensure the security of ships, ports, and other marine facilities. Canada has implemented the IMO International Ship and Port Facilities Code which provides for the designation of restricted areas, defined as "an area established under any regulation, security measure or security rule to which access is restricted to authorized persons," thus limiting public or unauthorized access (MTSA, 1994, s 2). The various marine security (MARSEC) levels designated by the Minister of Transport vary to reflect the threat environment for vessels, marine facilities, and ports (MTSR, 2004, s 1). In addition to vessel security plans, ships entering Canadian ports are required to give advance notice of arrival (ibid, s 221). Marine facilities are also required to have security plans, accompanied by MARSEC levels, and ensure controlled and restricted access to their areas (ibid, s 322).

5.4.9 Port Management Areas and St. Lawrence Seaway

A port authority's powers include the promotion of safety and environmental protection in port waters. This requires monitoring ships in or entering port waters, establishing vessel practices and procedures, requiring ships to have the capacity to use specified radio frequencies, and establishing traffic control zones (CMA, 1998, s 56(1)). Port vessel traffic management powers consist of required notices of arrival, requesting certain information from vessels to directing port entry, departure, anchoring, berthing, and movement, to proceed at a certain speed or to use the assistance of towage where appropriate and to avoid certain areas (ibid). Typically, port areas tend to be subject to mandatory pilotage regulated by the regional pilotage authorities established under the *Pilotage Act* and regulations. Under the Regulations, pilots must have knowledge of the harbor and other marine regulations that apply in the pilotage area in which they are licensed (GPR, 2000, ss 22.21, 22.30).

Port authorities have the discretion to use vessel traffic management powers to help prevent or mitigate the impacts of navigating vessels on marine species in port and harbor waters under their jurisdiction, including in areas other than MPAs. Among the reasonable grounds for requiring a vessel to proceed to or stay at a particular location, the CMA includes the proximity of animals whose well-being could be endangered by the ship and for which vessel compliance is required (CMA, 1998, s 58(2)–(3)). Port authorities may use this power to fulfil their duties under conservation legislation, such as SARA. Where the conservation measures extend over a large area, a cooperative approach involving port authorities, other federal authorities, and stakeholders is called for.

The St. Lawrence Seaway has its own management system shared between counterpart authorities in Canada and the United States.[7] The St. Lawrence Seaway Authority is responsible for the Canadian section of the Seaway. Its regulation is the responsibility of the Governor in Council, and the Authority, as designated by the Minister of Transport, is responsible for taking measures to ensure control of traffic (CMA, 1998, ss 88–89).

5.5 Indirect Area-Based Regulation of Shipping

This section discusses indirect regulation of shipping within MPAs, national marine conservation areas, marine wildlife areas, marine bird sanctuaries, and fisheries habitat sanctuaries. The principal purpose of the protected area regulations is marine conservation, but they may have incidental effects on shipping. The following legislation and related regulations are reviewed: the *Oceans Act*, the *Canada National Marine Conservation Areas Act* (CNMCAA), *Canada Wildlife Act* (CWA), *Migratory Birds Convention Act* (MBCA), SARA, and *Fisheries Act*. The federal 2023 Marine Protected Areas (MPA) Protection Standard is also discussed for its relevance to shipping (Government of Canada, 2023c).

[7] The Seaway is defined as “the deep waterway between the port of Montreal and the Great Lakes that is constructed and maintained pursuant to the Agreement between Canada and the United States providing for the development of navigation and power in the Great Lakes-St. Lawrence Basin, dated March 19, 1941, including the locks, canals and facilities between the port of Montreal and Lake Erie and generally known as the St. Lawrence Seaway” (CMA, 1998, s 2).

5.5.1 Marine Protected Areas

The *Oceans Act* defines MPA as "an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada" for the conservation and protection of (a) commercial and noncommercial fishery resources, including marine mammals, and their habitats; (b) endangered or threatened marine species, and their habitats; (c) unique habitats; (d) marine areas of high biodiversity or biological productivity; (e) any other marine resource or habitat as is necessary to fulfil the mandate of the Minister; and (f) marine areas for the purpose of maintaining ecological integrity (Oceans Act, 1996, s 35(1)). Regulations exist for each designated MPA that include a general prohibition on any activity that "disturbs, damages, destroys or removes" any living marine organism or its habitat from the MPA (ibid, s 35(2)(b)). Each MPA designation is accompanied by dedicated regulations. Some MPA regulations include prohibitions on depositing, discharging, or dumping any substance and provide exceptions for permitted activities within MPAs for the purpose of public safety, national defense, national security, law enforcement, and scientific research (GMPAR, 2004, s 11(c)).

Restrictions on navigation in Canadian waters are generally limited to internal waters or the territorial sea, while the freedom of navigation in the EEZ is typically unrestricted. This freedom is illustrated in the Gully MPA regulations, which state that "the activities of a ship that is exercising international navigational rights in the Gully Marine Protected Area and is not contravening the *Canada Shipping Act* or any requirements of the International Maritime Organization" are exempt from submitting a plan of activities in the MPA (GMPAR, s 11(c)). Therefore, vessels in the Gully MPA are still bound by the CSA 2001 and the IMO-adopted rules and standards. The St. Anns Bank MPA regulations also state that navigation may be carried out in the MPA located off Cape Breton, Nova Scotia, and no anchoring prohibitions exist (SABMPAR, 2017, s 6).

A voluntary industry code of practice for the Gully MPA led by Ovintiv, Inc. (formerly EnCana), a hydrocarbon exploration and production company, restricts its vessels from transiting the Gully MPA (Ovintiv, 2020). This voluntary code is consistent with earlier codes adopted by Exxon Mobil and EnCana that committed their vessels to avoid the Gully MPA (Exxon Mobil, 2018; Encana, 2011: Appendix 1).

Some MPA regulations specifically include vessel operation restrictions. For example, the Musquash Estuary MPA in the Bay of Fundy limits vessel speeds in Zones 2A or 2B to no more than 5 knots or to no more than 8 knots in Zone 3 (MEMPAR, 2006, s 4(c)). These speed restrictions are set to minimize impacts on lobster, herring, and recreational fishing and manual dulse harvesting in Zones 2A, 2B, and 3. The Laurentian Channel MPA between Newfoundland and Nova Scotia restricts anchoring in Zones 1A and 1B while otherwise permitting navigation (LCMPAR, 2019, s 5(a)). Anchoring restrictions relate to the MPA conservation objectives to protect corals, particularly significant concentrations of sea pens, from harm due to human activities in the Laurentian Channel.

The Banc-des-Américains/American Bank MPA off the Gaspé Peninsula in the Gulf of St. Lawrence prohibits anchoring in Zone 1, the core protection zone and most sensitive area, as the conservation objectives for the MPA include conserving and protecting benthic habitats. No sewage or graywater discharge is permitted for vessels of 400 gross tonnage or more or certified to carry 15 persons or more, but navigation is unrestricted in the MPA (ABMPAR, 2019, s 6(a)–(b)). The Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs MPA off British Columbia prohibits anchoring in its three core protection zones containing sponge reefs but otherwise permits navigation in accordance with the CSA 2001 (HSMPAR, 2017, s 7(b)(ii)). Finally, the shallow coastal Basin Head MPA in Prince Edward Island permits motorized vessels in Zone 2 solely for transiting to and from boat launches (BHMPAR, 2005, s 4(b)).

5.5.2 National Marine Conservation Areas

The CNMCAA enables the designation of national marine conservation areas (NMCAs) for the purpose of protecting and conserving representative marine areas for the benefit, education, and enjoyment of the people of Canada and the world (CNMCAA, 2002, s 4(1)). NMCA reserves are established where an area or a portion of an area proposed for an NMCA is subject to a claim with respect to aboriginal rights that has been accepted for negotiation by the Government of Canada (ibid, s 4(2)). There are five NMCAs, namely, the Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site in British Columbia, the Fathom Five National Marine Park in Georgian Bay, the Lake Superior National Marine Conservation Area, the Saguenay-St. Lawrence Marine Park in the St. Lawrence River Estuary, and the Tallurutiup Imanga National Marine Conservation Area in Nunavut.

The CNMCAA states that provisions of a management plan or an interim management plan respecting marine navigation and marine safety are subject to an administrative agreement between the Ministers of Parks Canada, Transport Canada, and DFO (CNMCAA, 2002, s 4(1)). Furthermore, regulations that restrict or prohibit marine navigation or activities related to marine safety, to the extent that such regulations can be made on the recommendation of the Minister of Transport under the CSA 2001 or AWPPA, may only be made on the recommendation of the Ministers of Parks Canada and Transport Canada (ibid, s 16(3)). TC therefore retains its authority over marine navigation in NMCAs, and the Minister of Parks Canada and the DFO Minister must jointly collaborate with the Minister of Transport to develop and implement management measures related to shipping in NMCAs. No provisions in the CNMCAA currently address shipping or shipping impacts within NMCAs, other than prohibiting the disposal of substances in NMCA waters, which would include vessel discharges (ibid, s 14(1)). The marine activities in the *Saguenay-St. Lawrence Marine Park Regulations* have prohibitions related to vessel speed and avoidance distance requirements around cetaceans in the Park and require cruise ships to have a permit to operate in the Park (SSLMPR, 2002, ss 3(1), 15, 19).

5.5.3 Marine Wildlife Areas

"Protected marine areas" may be established under the CWA to protect wildlife in any area of the sea, including internal waters, the territorial sea, or the EEZ (CWA, 1985, s 4.1(1)). The Scott Islands Marine National Wildlife Area northwest of Vancouver Island is the only protected marine area established under the CWA. The *Scott Islands Protected Marine Area Regulations* prohibit activities that disturb, damage, or destroy wildlife or its habitat and prohibit the dumping or discharge of any waste material or substance likely to harm wildlife or degrade wildlife habitat in the protected marine area (SIPMAR, 2018, s 2(1)). However, these prohibitions do not apply to vessels operating under the CSA 2001 or to naval vessels belonging to or under the command of the Royal Canadian Navy. The regulations also prohibit anchoring a vessel of more than 400 gross tons within one nautical mile of Triangle, Sartine or Beresford Islands, and prohibit vessels transiting within 300 meters of these islands (ibid).

5.5.4 Migratory Bird Sanctuaries

The MBCA implements an international convention for the protection of migratory birds in Canada and the United States, in Canada and in its EEZ (MBCA, 1994; Migratory Birds Convention, 1916). The MBCA prohibits vessels from depositing substances harmful to migratory birds and prohibits a substance from being deposited in waters or an area frequented by migratory birds or in a place from which the substance may enter such waters or such an area (MBCA, 1994, s 5.1(1)). The only exemption from this prohibition is if the deposit is authorized under the CSA 2001 or authorized for scientific purposes. Of the 259 migratory bird sanctuaries in Canada, a significant number have marine components. For example, 54 bird sanctuaries in Canada are defined as having a marine biome, including many areas at increased risk adjacent to commercial vessel traffic routes with 10+ vessels per day per square kilometer.[8]

[8] Bird sanctuaries close to busy shipping routes in Canadian waters include Machias Seal Island, NB, Grand Manan, NB, Gros-Mécatina, PQ, Baie de Brador, PQ, Sainte-Marie Islands, PQ, Watshishou, PQ, Île aux Basques, PQ, Bonaventure Island and Percé Rock, PQ, Rochers aux Oiseaux (Bird Rock) off Îles-de-la-Madeleine, PQ, Victoria Harbour, BC, and the George C. Reifel sanctuary near Richmond, BC (Canadian Protected and Conserved Areas Database, 2023); Veinot et al., 2023).

5.5.5 Species at Risk Critical Habitats

SARA includes a blanket prohibition that no person shall kill, harm, harass, capture, or take an individual of a wildlife species that is listed as an extirpated species, an endangered species, or a threatened species (SARA, 2002, s 32). The Act also provides for the designation of critical habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species (ibid, ss 2(1), 56 *et seq.*).

There are no regulatory measures under SARA specifically targeting shipping to protect marine species at risk. The only vessel operations in Canadian waters impacted by critical habitat relate to the IMO-designated area to be avoided (ATBA) concerning the Roseway Basin Critical Habitat off southwestern Nova Scotia for NARWs. Vessels of 300 gross tonnage and more must avoid the Roseway Basin ATBA from June 1 to December 31 annually to protect seasonally resident NARWs in the designated SARA critical habitat that comprises the ATBA (Government of Canada, 2008; IMO, 2007).

5.5.6 Fisheries Conservation Areas

The *Fisheries Act* provisions related to fish and fish habitat protection and pollution prevention prohibit the deposit of deleterious substances of any type in water frequented by fish or in any place where the deleterious substance may enter the water (Fisheries Act, 1985, s 36(3)). The Act provides an exception with respect to any deposit of a deleterious substance that, within the meaning of Parts 8 or 9 of the CSA 2001, constitutes a discharge of a pollutant caused by or otherwise attributable to a vessel. Sections 257 and 258 of the CSA 2001 on jurisdiction in case of offenses and over vessels lying off coasts apply to offences under the *Fisheries Act* in the same manner and to the same extent as they apply to offences under the CSA 2001. Fishery closures for the purposes of fisheries management and conservation per se have no bearing on commercial shipping, including closed areas under the *Pacific Fishery Regulations*, *Atlantic Fishery Regulations*, and the *Maritime Provinces Fishery Regulations* of the *Fisheries Act* for purposes of fisheries conservation, habitat protection, or gear conflict mitigation. Again, fisheries closures such as marine refuges/OECMs established pursuant to the *Fisheries Act* via variation orders and/or conditions of license also have no impact on commercial navigation rights.

5.5.7 MPA Protection Standard 2023

The Marine Protected Areas (MPA) Protection Standard of February 8, 2023, is intended to provide consistency and clarity on prohibited activities in federal MPAs, including *Oceans Act* MPAs, NMCAs, and marine components of national parks, marine national wildlife areas, and marine portions of national wildlife areas and migratory bird sanctuaries (Government of Canada, 2023c). The MPA Protection Standard applies through legal mechanisms to MPAs established by federal departments and agencies after April 25, 2019. The MPA Protection Standard was first developed in 2019 with an initial focus on prohibiting oil and gas exploration and exploitation, mining, dumping, and bottom trawling in all new MPAs. The prohibition on dumping has been expanded in the 2023 Protection Standard to include disposal at sea of waste and other matter, dumping of fill, deposit of deleterious drugs and pesticides, and enhanced restrictions on vessel discharges. Future changes to the MPA Protection Standard are expected to address offshore wind development in MPAs.

TC is leading a process to develop regulatory amendment proposals to enhance restrictions, including limitations or prohibitions, in existing and new MPAs within the 12 M territorial sea with respect to vessel discharges of oily engine bilge, sewage (blackwater), graywater, food waste, and scrubber washwater. TC is required to conduct industry stakeholder consultations for any regulatory amendments. Any necessary regulations to implement the Protection Standard could require amendments to the VPDCR and would apply to new MPAs, subject to technical and operational exceptions to ensure navigational safety.

For MPAs in the EEZ, TC will seek voluntary measures for the five substances noted above, including garbage, food wastes, and noxious liquid substances. Any increased restrictions on vessel discharges in the territorial sea may apply to existing MPAs, and voluntary restrictions may be pursued in existing MPAs in the EEZ, where possible. Since a TC-led regulatory process is required for changes to regulations in the territorial sea, they are not expected to enter into force in the near future. Within the EEZ, Canada puts into practice accepted rules and standards adopted by IMO; however, voluntary measures in the EEZ could be proposed to IMO for future adoption in international rules and standards. Furthermore, the MPA Protection Standard states that it does not apply to ballast water exchanges and releases because these are necessary for safe navigation of a vessel. However, ballast water management practices in Canada are undergoing changes that will come into effect as early as September 2024 (BWR, 2021).

Given the scope of application of the Protection Standard to federal MPAs, marine refuges and OECMs are excluded from potential voluntary or regulatory measures related to shipping. This is a potential weakness of marine refuges and OECMs to protect marine biodiversity from shipping impacts. As noted above, nine OECMs in Canada overlap with TC's Alternate Ballast Water Exchange Areas. This gap could be addressed by marine refuges and OECMs being included in the MPA Protection Standard or as separate measures to address shipping impacts under a proposed OECM Protection Standard.

5.6 Discussion

5.6.1 Purposes and Functions

Canada employs a varied range of direct and indirect ABM tools in the regulation of shipping to pursue policy goals and management functions and ensure regulatory clarity, consistency, predictability, equity, and effectiveness. The explicit or implicit policy purposes in the *Oceans Act*, CSA 2001, and several marine environmental statutes are ocean management, maritime safety, environmental protection, marine security, and public health. The functions may be grouped as (a) regional provision of services and allocation of resources for the governance and support of shipping (e.g., search and rescue), (b) designation of the geographical limits of various types of shipping in support of ocean uses (e.g., through licensing and corridors), and (c) prevention or mitigation of negative interactions between ocean uses or other adverse impacts (e.g., routeing measures).

The utilization of ABMs to organize maritime functions at the regional level may be described as *organizational* and is necessarily reflective of Canada's complex geography, including extremely long coastlines and numerous human settlements on three oceans and extensive inland waterways (mainly the St. Lawrence Seaway). Each of the four major areas of navigable waters has its own characteristics that require adaptation of the ABMs to the needs of the region. For example, all Arctic waters are subject to a mandatory SRS, unlike in the case of Atlantic and Pacific waters, in the interests of safety and protection of the unique environment.

The designation of geographical limits of ship-based ocean uses through ABMs may be described as *allocational*, as it serves to confer rights of ocean space and resource uses, thus legitimizing them and maintaining public order at sea. Such uses include all resource activities (e.g., offshore hydrocarbons, fishing) and spatial uses (e.g., aquaculture, offshore renewables, cables, pipelines). The rights conferred may concern simply a right of use (usufructuary) or preferential or even exclusive use of allocated space, as in the case of safety zones designated around offshore installations and structures, navigation in which is restricted to service vessels. As Canada gradually moves toward the allocation of ocean space to offshore windfarms, it remains to be seen whether navigation in these spaces will be limited to service vessels or other uses, such as fishing and/or aquaculture, will be permitted.

Canada's employment of ABMs by regulation or executive order serves to address use and user interaction at sea and emergencies and may be described as *operational*. For example, the instructions usually given to vessels in need of assistance to head to a place of refuge to stabilize a problem on board is a case in point. ABM to enhance safety as part of the rules of the road employs routeing systems to facilitate safe navigation and the safety of other ships and activities at sea, for example, to avoid collisions, allisions, and anchors dragging submarine cables. Routeing measures for safety are mostly permanently in place, as is the case of VTS in the vicinity of and in Canada's major ports and the St. Lawrence Seaway. However, routeing measures may also be informed by the precautionary approach and be seasonal or temporary or on an emergency basis to address specified concerns, as in the case of the protection of marine mammals and other species through areas to be avoided and speed limits in designated areas. The use of routeing measures in this manner demonstrates the value of their flexibility and nimble use. As Canada continues the process of designation of low-impact shipping corridors in Arctic waters, it will have to consider a suite of permanent, seasonal, and ad hoc routeing measures, perhaps recommended or even mandatory, as in the case of the NORDREG SRS.

5.6.2 Implementation of International Commitments

Canada has employed ABMs as tools to facilitate the performance of commitments to international conventions and other agreements. For example, it designated different types of protected areas in the marine environment to meet international targets under the UN 2030 Agenda for Sustainable Development, the Strategic Plan for Biodiversity and Aichi Targets, and the Fifth International Marine Protected Areas Congress, 2023 (UNSDGS, 2015, goal 14.1; CBD, 2011; IMPACS, 2023). It also applied restrictions and conditions for the mobility of shipping within national jurisdiction in accordance with IMO international convention standards (e.g., BWM exchange areas and routeing under SOLAS).

While international commitments are respected, Canada also designated ABMs in domestic navigable waters to address exclusively national or regional concerns. The designation of Arctic waters for heightened construction, design, equipment, crewing, operations, and reporting standards is perhaps the most extensive in terms of geographical area and diversity of applicable standards. It is pertinent to note that the standards for shipping in Canadian Arctic waters now mostly embrace IMO Polar Code standards, although there are also Canadian modifications (Chircop et al., 2018). However, the mandatory SRS is separate and a departure from ship reporting under SOLAS (SOLAS, 1974, Chap V reg 11). This can be explained by the imperative of having knowledge of and ability to assist traffic in Canadian Arctic waters, which is generally remote and where the infrastructure to support shipping remains largely underdeveloped. There are also Canadian modifications in ABM use in the implementation of the COLREGs, most especially with respect to navigation on the St. Lawrence Seaway (Collision Regulations, 2008, scheme 1).

5.6.3 Allocation of Ocean Space

Ocean space within Canada's jurisdiction is usually subject to multiple uses. The rules of the road ensure that vessels are navigated safely when in proximity to one another and with clear rules for stand-on and give-way vessels. In certain areas where traffic converges, vessel traffic separation schemes are designed to separate opposite directions of traffic in areas where shipping tends to converge, such as within ports and harbors and in their approaches.

At times, ocean space is allocated exclusively to the exclusion of other uses to enhance safety or for the protection of sensitive parts of the marine environment. Areas to be avoided, which may be permanent or temporary, are useful measures in this regard. In other instances, longer-term exclusive assignment of space to a particular ocean use is necessary, especially for ocean uses that are stationary, have a large spatial footprint, and are regulated in accordance with designated license areas. For example, the designation of safety zones around installations and structures in the offshore oil and gas industry exclude fishing and commercial and other shipping (other than service vessels) due to the potential gear snags and collisions with rigs and oil and gas flow lines in the water column. Similarly, offshore wind turbines, which are subject to license areas and safety zones, exclude other ocean uses due to interconnecting, unburied submarine cables and anchor lines. In this context, the outcomes of risk assessment decision-support tools are key drivers of decision-making around two or more ocean uses being deemed compatible *or* incompatible in the same ocean space, both temporally and spatially.

Coastal and ocean uses with large spatial and functional footprints tend to be subject to public consultation processes to generate views and data on ways to mitigate conflicts and formulate compromises. The consultation processes are either through permanent structures, such as CMAC, its regional sections, and its many related Standing Committees or through ad hoc consultations such as those concerning proposed updates to the *Vessel Operation Restriction Regulations* in response to requests from local authorities to enhance safety, environmental protection, and the public interest (Government of Canada, 2010; Government of Canada, 2022b).

5.6.4 Considerations for Integration

The *Oceans Act* requires the DFO Minister to "lead and facilitate the development and implementation of plans for the integrated management of all activities or measures" in waters within Canadian jurisdiction (Oceans Act, 1996, s 31). This duty carries procedural requirements, in particular to work collaboratively with other federal ministers, boards and agencies, provincial and territorial governments, affected Indigenous organizations and land claims agreements, and coastal communities and other persons (ibid). It is worth emphasizing that while the Minister's duty concerning integrated planning and management concerns "all activities," this is qualified by a corollary duty to "develop and implement policies and programs *with respect to matters assigned by law to the Minister*" (emphasis added) (ibid, s 32(a)). Hence, the planning of ABMs with respect to "all activities" is significantly limited to the Minister's sectoral concerns in the department's own legislation, although the Minister also has a duty to coordinate with other federal ministers, boards, and agencies and even establish joint mechanisms (ibid, ss 32(b)–(c), 33). As seen earlier, the TC and ECCC Ministers enjoy ABM designation powers under their respective statutory remits.

Against this backdrop, it should not be surprising that ABM practices discussed in this chapter demonstrate approaches that appear fragmented and distinctly sectoral rather than based on integrated, comprehensive multi-use zoning. Separate federal legislation for ABM designation appears to give rise to siloed departmental mandate-driven management approaches. Hence, ABM practices concerning shipping in Canada have emerged not out of a grand coordinated scheme but rather because of the exercise of individual mandates to problems as they arise.

One may also question whether an integrated approach to ABMs in shipping is always necessary or desirable. On the one hand, one could argue that at least there should be integration of ABM tools within or that affect the shipping sector to ensure efficiency, consistency, and coherence. On the other hand, it is equally arguable that while commercial shipping is a distinct sector, shipping generally is not one sector because ships are platforms for other sectors. Hence, the needs of individual sectors ought to be reflected in the ABM tools within a primary sector. It may also be argued further that while MSP is a desirable framework to facilitate coordination of the planning and management of ocean uses, the exercise of individual ABM designation authority enables departments and agencies to address problems that arise in a nimble, measured, and efficient manner. Speed restrictions in emergency situations are cases in point.

Perhaps a key point to underscore is that there should be consultation and coordination in the administration of ABM tools of common concern to federal authorities. This is certainly a legislated expectation of the DFO Minister and is equally to be expected of other ministers and their departments and agencies where mandates overlap. Federal departments have memoranda of understanding to address areas of common concern, and some departments have such understandings with their counterparts in the United States (Transport Canada and DFO, 1996; Transport Canada and CNLOPB, 2022; Transport Canada and CER, 2022; Transport Canada and USCG, 2002). For example, the vessel traffic services provided by a port authority should be consistent with national standards and practices established under the CSA 2001 (CMA, 1998, s 56(3); VTSZR, 1989).

5.7 Conclusion

MSP is increasingly seen as a mainstream approach to managing ocean space to prevent or mitigate potential conflicts and promote complementary marine uses. Newer ocean uses, such as large-scale aquaculture and offshore renewables, will likely intrude into spaces that have long been the realm of traditional navigational, resource, and recreational uses. At the level of ocean management needed to prevent or mitigate conflicts, MSP can be expected to grow in strategic importance. However, even with an MSP strategy in place, the use of tactical ABM tools, most significantly those that have long been in sectoral use in commercial shipping, such as routeing measures, will be necessary. ABM tools in shipping address the ship as the platform for most ocean uses.

The Canadian experience appears to demonstrate that while MSP at the strategic level is not in general use, the use of shipping ABM tools has been widespread and useful. They constitute problem-oriented approaches, applied with variable scale and scope, involving permanent and temporary measures, frequently sectoral in scope and led by a federally mandated body. At times they are informed by IMO international standards, but they have also been fashioned to address urgent domestic issues in a nimble manner. While they are usually sectoral, they appear to produce positive safety and environmental outcomes.

If MSP should be the answer to integrated management, implying comprehensive multi-level and multi-use zoning schemes in Canada's ocean space, law reform is likely needed. Amendment of the *Oceans Act* and other federal sectoral-based legislation would be required to develop and implement comprehensive spatial zoning plans for MSP and to require effective cooperation of all the departments and agencies concerned. Legal reform on this scale may not be a realistic proposition in the contemporary context, given the political divides and social priorities that currently exist in Canada.

However, in the absence of law reform to enable MSP, could Canada continue to manage its ocean spaces by using shipping ABM tools on a problem-by-problem basis? Experience suggests that this might well be the reality that coastal and ocean management must contend with. In turn, this implies that it is imperative that coastal and ocean managers on the one hand and maritime administrators on the other collaborate more closely. To facilitate collaboration and consistency in decision-making, it would be useful for MSP Operational Guidelines and Planning Standards to be developed and adopted inter-departmentally at the federal level or even intergovernmentally.

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Chapter 6
Canadian Arctic Shipping Governance: Incorporating Indigenous Knowledge in Area-Based Management Frameworks and Tools

Claudio Aporta, Leah Beveridge, and Weishan Wang

Abstract The need for Indigenous rights to be recognized and for reconciliation to occur is becoming increasingly engrained in the fabric of Canada. From the perspective of Indigenous peoples in Canada, reconciliation is seen as a process of decolonization. With the launch of the Oceans Protection Plan in 2016, the narrative of Indigenous engagement was brought directly to the topic of shipping governance. But the question remains: how to achieve reconciliation in concrete and tangible ways through policies and governance procedures? Importantly, reconciliation is not a discrete state or a destination, but a continuous process.

In Canada, area-based approaches are becoming more common in the regulation of marine affairs, including shipping. The increasing prevalence of area-based, ecosystem-based approaches is resulting in the development and application of decision support systems (DSSs) that are designed to process, visualize, integrate, and communicate information. While the significance of such DSS cannot be overestimated, a less discussed fact is that the knowledge of coastal communities is remarkably difficult to represent unless it is adapted to the language and requirements of these tools and systems. In practice, this results in decreasing the value of observational, "local" knowledge while increasing the significance of quantifiable "scientific" observations or measurements. This chapter proposes that the ways of treating local knowledge in area-based management can facilitate or hinder processes of reconciliation in the context of ocean governance.

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6.1 Introduction

Area-based management (ABM) approaches, including marine spatial planning, are prominent in the context of Canada's ocean policy and legal frameworks, namely, the *Oceans Act* (1996), Oceans Strategy (DFO, 2002), and Oceans Protection Plan (Canada, n.d.), which have consistently proposed integrated and ecosystem-based approaches, clearly requiring the engagement of local communities and Indigenous peoples. Canada's Oceans Strategy states that integrated planning processes need to "gather input from scientific and traditional knowledge, vigorous public debate, monitoring, assessment and reporting" (p. 5). More specifically, the Strategy calls for the following:

- New technologies and understanding of traditional ecological knowledge that become part of the approach
- New sets of information and new types of relationships that will promote wealth generation and assist in managing conflicts
- Efficiencies through an increased knowledge base, establishing effective networks and reducing regulatory delays (p. 5)

More recently, Canada introduced the *United Nations Declaration on the Rights of Indigenous Peoples Act* (UNDRIP Act, 2021), which affirms Canada's commitment to implement the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP, 2007). The *UNDRIP Act* requires that the laws of Canada are amended, as necessary, to ensure they are in line with UNDRIP and directs the Government to implement an action plan to achieve the Declaration's objectives (GoC, 2023), all in consultation and cooperation with Indigenous peoples. In practical terms, this may require federal departments and agencies to develop new strategies for engagement, from improving consultation mechanisms to involving Indigenous communities in the design and implementation of governance models, including on maritime issues.

Integrated marine planning today is intrinsically connected to and dependent on decision support tools and systems that process information. Computational and remote sensing tools, such as geographic information systems (GIS), Marxan, automatic identifications systems (AIS), logbooks, biological sampling, catch sampling, etc., are heavily reliant on quantitative data and datasets, and they are seamlessly integrated into DSS.

The reliance on information tools is increasing, and it is beginning to be recognized that the growing dependence on these tools in management may be to the detriment of observational, experiential, and traditional knowledge systems, such as those of Indigenous peoples (Tesar et al., 2019). Multiple stakeholders, activities, and goals, among others, are involved in ABM, which includes marine protected areas (MPAs) and marine spatial planning (MSP). With the prevalence of computer-based decision support tools (DSTs), local stakeholders are forced to adapt their understanding and knowledge of the environment to fit the demands (and limitations) of the tools. Furthermore, the systems are complex, and management and planning tools are often only fully understandable, accessible, and therefore helpful, to individuals and organizations that have the technical capacity to use them, which often excludes local knowledge holders.

DSTs are not only invaluable but essential today, as marine planning involves lengthy public consultations, processing large amounts of information, generating heat maps, providing feedback to the system, etc. In shipping, specifically, such DST can provide up-to-date information to mariners, and they can be used to enforce or to guide in compliance with regulations. In Arctic shipping, these tools can offer real-time information about sea ice and determine—in a flexible way—areas to be avoided or areas where the speed of a vessel should be reduced. The trade-off of these tools and systems is that Indigenous knowledge held by communities is often left out or incorporated in ways that strip the knowledge from its original meaning and context. Marine atlases, for instance, include Indigenous knowledge as data layers, most often as geographic/spatial data points, lines, or polygons, while narratives and context of Indigenous knowledge are more difficult to include. This challenge is experienced, for instance, in the under construction Canadian Marine Planning Atlas (https://www.dfo-mpo.gc.ca/oceans/planning-planification/atlas/about-au-sujet-eng.html), where data layers such as boundaries of MPAs and bathymetry can be easily incorporated, whereas local knowledge would require alternative approaches to documenting and visualizing information. ABM is a significant framework to approach environmental governance in a holistic way, and as such it could be an appropriate model to be applied to governance problems involving Indigenous peoples, including Arctic shipping. ABM is also the governance approach underlying this book, and it is implicit in the Government of Canada's overarching Northern Low-Impact Shipping Corridors initiative.

The issues discussed in this chapter are far from being exclusively technical (how to incorporate observational knowledge in tools that were mostly conceived to deal with quantitative or discrete information), as DST and DSS provide frameworks of practice, set up standards, and trigger actions. If Indigenous knowledge is not properly accounted for and, perhaps more importantly, if Indigenous peoples have no role in informing such tools and systems, their engagement in the process will be mostly anecdotal or peripheral, as what Arnstein's still relevant conceptual model of citizen participation called "tokenism" (citizens' involvement is sought only *to show* that they are being involved) implies (Arnstein, 1969). While federal and provincial governments frequently embark on public consultation processes, these might not be appropriate in the case of Indigenous peoples and indeed might not truly reflect the federal government's fiduciary duties and duty to consult.

In the context of working with Indigenous peoples, it is important to note the "consultation and cooperation" spectrum outlined in the newly released United Nations Declaration on the Rights of Indigenous Peoples Action Plan 2023–2028 (GoC, 2023). It is also essential to distinguish between consultation and the legal duty to consult. The duty to consult in Canada is derived from the Honour of the Crown and has been defined by the Supreme Court of Canada (*Delgamuukw v. BC*, 1997; *Haida Nation v. BC (Minister of Forests)*, 2004). It, too, lies on a spectrum: at the low-end, where the "potential for infringement [is] minor," there is a duty to, at minimum, "give notice, disclose information, and discuss any issues raised in response" (*Haida v. BC*, para 43), and at the high-end, where "the right and potential infringement is of high significance to the Aboriginal peoples, and the risk of non-compensable damage is high … deep consultation, aimed at finding a satisfactory interim solution, may be required" (*Haida v. BC*, para 44) or the duty to accommodate may be revealed (*Haida v. BC*, para 47). Regardless of where along the spectrum a particular case lies, some form of consultation *is required* once the duty to consult has been found to exist, and the process "must be in good faith and with the intention of substantially addressing the concerns of the aboriginal peoples whose lands are at issue" (*Delgamuukw v. BC*, para 168).

Terms are important, and engagement of Indigenous peoples in Canada is framed beyond mere consultation to involve higher levels of participation. *Cooperation*, for instance, means "that Indigenous peoples have the opportunity, including through their representative organizations, to participate in and to positively influence federal decision-making processes with adequate time and supported by adequate resources" (GoC, 2023: 22). *Co-development* takes participation one step further, "and involves Indigenous peoples and the Government of Canada working together in good faith through a substantive, collaborative, and consensus-based process to develop effective solutions and advance UN Declaration implementation in a timely way" (ibid).

Arnstein proposed that true participatory approaches necessarily comprise citizen empowerment, which should lead to real redistribution of power. In this context, MSP has been recognized as an effective means to implement ecosystem-based management, but, at the same time, it could potentially reinforce preexisting conditions of power imbalance to the detriment of the more vulnerable actors (Flannery et al., 2020). In other words, there seems to be a shared understanding that MSP facilitates participation, but whether such participation results in empowerment of local actors is an entirely different issue. Most literature and guiding principles on MSP refer to the engagement of stakeholders, whereas in the context of Arctic shipping, local coastal communities are composed of "rightsholders" (people with inherent rights). Each of the four Inuit land claims that encompass the entirety of Canada's Arctic coastline extend to the boundary of the territorial sea (12 nautical miles offshore), except in the Inuvialuit Settlement Region, where the western boundary reaches to longitude 141° and north to 80° N (beyond the exclusive economic zone).

Arctic shipping is a unique and interesting governance problem upon which to develop our argument, as regulations must be clear for shipping companies, instructions must be precise for mariners (yet flexible to adapt to environmental conditions), and up-to-date information, including charts, bathymetry, and sea ice conditions, is key to ensuring the safety of navigation and the efficiency of trade. While this is true for all shipping, the uniqueness in Arctic shipping lies in the standards for ship design, construction, crewing and operations, as well as the unique vulnerabilities of the region and, in Canadian waters, the fundamental rights of Indigenous peoples.

As shipping activities increase in the Arctic, so does the reliance on data for decision-making. At the same time, the vulnerability and adaptive capacity of Inuit coastal communities become central issues if their rights as Indigenous peoples are truly recognized, as shipping potentially could be a threat to cultural traditions, historical links to the marine environment, legal obligations to Indigenous peoples, economic and social well-being, and food security. Shipping is also considered as an opportunity for development and well-being, as long as governance and control mechanisms are in place.

Regarding its relationship with Indigenous peoples, Canada as a country has committed to a journey of reconciliation, which includes the acknowledgment of Indigenous rights both nationally (CA, 1982; UNDRIP Act, 2021) and internationally (UNDRIP, 2007). It goes without saying that Arctic shipping is also a multi-scale problem, with local, national, regional, and international dimensions (AMSA, 2009).

In terms of ocean policy and legal frameworks, the Oceans Protection Plan has set up clear (if broad) goals regarding engagement, capacity-building, and partnership-building with Indigenous peoples (Canada, n.d.). Such goals are being pursued through significant investment, initiatives, and programs that are meant to engage Indigenous peoples.

While reconciliation is often referenced as a destination (e.g., "action was taken towards *achieving* reconciliation"), it is also an ongoing process that goes far beyond the limits of a particular law or policy. As the Truth and Reconciliation Commission of Canada defines it, reconciliation is "an ongoing process of establishing and maintaining respectful relationships" (TRC, 2015, p. 11). The roots of the conflict between Indigenous peoples and Canada are ineludibly historical in nature (mostly manifested through trauma, cultural loss, territorial loss, and massive loss of lives), and they transcend specific policies, laws, and regulations. Reconciliation is also closely related to decolonization, which involves the deconstruction of colonial institutions, processes, and relations to enable new interpersonal and institutional relationships and processes to be built upon a foundation that recognizes the rights of Indigenous peoples.

For federal regulators, policy-makers, and law enforcers, this broader context may be unknown, blurred, ignored, or forgotten. The tensions stemming from historical wrongdoings by colonizing states and the resulting intergenerational and ongoing traumas, hardships, and discrimination faced by Indigenous peoples across colonized spaces throughout the world are in the background of any engagement of Indigenous peoples in ocean governance, including in (Arctic) shipping in Canada. The process of reconciliation—of interacting from a space that recognizes the wrongdoing of the past and the rights of Indigenous peoples—must therefore address these tensions through models of governance that involve respectful, equitable, and inclusive partnerships (Beveridge, 2023). There are many facets of and mechanisms for decolonization, such as the repatriation of land, institutional change, and healing, but this chapter will focus on understanding power imbalances between Indigenous and non-Indigenous actors within the governance of shipping and, more specifically, within the context of decision-making tools and systems.

The use of Indigenous knowledge in decision support tools and systems is far beyond the limits of a technical discussion. On the contrary, the technical issue of properly engaging with the knowledge of Indigenous peoples unfolds within broader contexts that either facilitate or hinder reconciliation and decolonizing processes. This chapter addresses the following research question: how can area-based planning facilitate (or hinder) processes of reconciliation with Indigenous peoples? There are three fundamental dimensions to answering this question: a) political (regarding the will, actions, investments, and commitments to engage with Indigenous peoples), b) ontological (concerning the assumptions, principles, and openness of governance frameworks), and c) methodological (concerning how to engage with Indigenous knowledge holders through decision support tools and systems). While these three dimensions are discussed here, they should be treated as intrinsically connected, and specific emphasis is given to the last two as they relate more specifically to the use of knowledge in decision support tools.

Understanding how to meaningfully work with Indigenous peoples through a multidimensional lens involves acting upon the acknowledgment that there is more than one way to conceptualize the marine environment (ontological awareness) and having the methodological open-mindedness to recognize that Indigenous peoples must inform and impact the design and operation of governance frameworks and tools. ABM, if properly conceived, can in fact be a path through which processes of reconciliation and decolonization can be facilitated by creating spaces for people to work together. ABM, however, is not necessarily a ticket to just and equitable governance, as its application without critical awareness can also normalize and even increase inequality.

This chapter is structured as follows: the next section offers a brief context of Canadian Arctic shipping, followed by a section that looks closely at ontological assumptions in marine spatial planning. The following section analyzes three Arctic shipping initiatives, of different scope, that include Indigenous knowledge and Indigenous engagement as part of their mandates: the Northern Low-Impact Shipping Corridors, the Enhanced Maritime Situational Awareness (EMSA) initiative, and the Proactive Vessel Management (PVM) initiative. The discussion section analyzes how the three initiatives deal with the three dimensions identified in this chapter, and the conclusion offers ideas on futures direction for research.

6.2 Canadian Arctic Shipping Governance and Inuit: A Brief Context

The significant increase in Arctic shipping in Canada is primarily attributable to the ongoing effects of climate change and the consequent reduction of sea ice coverage (AMSA, 2009; Chen et al., 2021; Pizzolato et al., 2014, 2016). From 1990 to 2019, the number of voyages and distances traveled by ships tripled (Auditor General of Canada, 2022; PAME, 2021). Previously inaccessible areas and resources are becoming increasingly accessible by ships, creating economic opportunities that may potentially result in benefits to communities.

However, the increase in Arctic maritime activities also raises concerns about potential environmental risks, disruptions, and the increased likelihood of encounters between shipping vessels and activities of Indigenous peoples (AMSA, 2009; Olsen et al., 2019). Geopolitically, tensions arising from Russia's invasion of Ukraine have significantly amplified the strategic significance of the Arctic region (Koivurova et al., 2022; Waloven et al., 2023). In this context, Canada's federal agencies have been found to have a long way to go in bridging the persistent gaps in the monitoring and surveillance of Arctic waters (Auditor General of Canada, 2022).

Because of the increasing economic and geopolitical importance of the Arctic, creating and adopting effective measures that ensure the safety and responsibility of shipping operations in Canadian Arctic waterways has become of critical importance. This involves implementing rigorous maritime regulations, policies, protocols, and monitoring systems to mitigate risks and promote sustainable shipping practices, as well as mechanisms of engagement with Indigenous peoples.

A detailed description of the Canadian governance approach in Arctic waters has been done elsewhere (Wang, 2023), including in this book (see Chap. 9, this volume). In the context of this chapter, it suffices to say that Canada has been developing a particular approach to governing Arctic shipping activities that aligns with broader ocean policy frameworks, ultimately promoting integrated, area-based management, as well as the engagement of coastal communities in the process of governance. Such foundations were clearly laid out in the Oceans Protection Plan (OPP), which establishes directions for the implementation of comprehensive measures to further enhance the safety in and achieve greater protection of Arctic waters (Canada, n.d.).

Significant investments are being made in safety equipment and marine infrastructure (TC, 2023). These investments aim to provide the necessary resources and infrastructure to respond effectively to emergencies and mitigate risks associated with shipping activities. Additionally, Canada has prioritized the improvement of charting and the establishment of safe shipping routes through the Northern Low-Impact Shipping Corridors initiative, which seeks to enhance navigational safety and minimize impacts of shipping on wildlife and culturally and ecologically sensitive areas (DFO, 2022a). Several programs are designed to track marine pollution and facilitate prompt response to all marine emergencies (TC, 2023). Canada also has intensified its efforts to establish meaningful partnerships with Arctic Indigenous peoples in shipping governance aiming at increasing their local marine safety capacity and integrating Indigenous perspectives and knowledge to improve marine safety, environmental monitoring, and protection (TC, 2023).

To implement the next phase of the OPP (TC, 2022a), Canada has specifically allocated substantial funding to bolster Canadian Coast Guard (CCG) and Canadian Hydrographic Service's initiatives to enhance safe and security in Arctic waters (DFO, 2022b). Furthermore, the Canadian government has reached a conclusive agreement with Irving Shipbuilding to commence the construction of an additional pair of Arctic and offshore patrol ships, which are designated for deployment within the CCG (Maritime Executive, 2023).

The governance of Arctic shipping involves intergovernmental governance bodies, local and Indigenous communities, and a complex governance framework that entails international and domestic conventions, maritime laws, policies, and industry standards (AMSA, 2009; VanderZwaag et al., 2008). By introducing the *Arctic Shipping Safety and Pollution Prevention Regulations* (ASSPPR, 2017), Canada sought to incorporate the International Code for Ships Operating in Polar Waters (Polar Code, 2014/15) into domestic legislation, which meant that overall safety and pollution safety standards were raised and that Canadian regulation was synched to international regulation (Chircop, 2018).

However, historically, the governance of Arctic shipping has been situated at the international and national levels, with only recent (and still limited) engagement of Indigenous peoples, especially Inuit, who have a long-standing history of use of Arctic waters, coastal environments, and marine resources (Carmona et al., 2023) As Arctic shipping continues to increase, both positive and negative environmental, economic, and social impacts from shipping are magnified, and the issue of Inuit involvement in governance and decision-making processes becomes more critical. This engagement is crucial for Inuit communities, as shipping activities affect their daily lives in several ways, including impacts on the seasonal patterns of marine and land animals that are vital for their livelihoods and on the sea ice that is intricately intertwined with the land environment and the mobility routes Inuit have been using for millennia (Aporta, 2009).

Rethinking governance to ensure that Indigenous rights, interests, and perspectives are taken into account has become paramount, not only from the communities' perspectives but also in light of international and national obligations contracted by Canada in the last few decades. UNDRIP was adopted by the United Nations General Assembly in 2007 to systematically outline and elaborate Indigenous rights in governance, decision-making, and economic, cultural, and social development (UNDRIP, 2007). Though nonbinding, UNDRIP was negotiated as a means of articulating rights already present in the international human rights framework that Indigenous peoples have been denied and which have been supported through the actions of states and reactions of the international community to their violation (Anaya, 2010; ILA, 2016). The International Law Association reviewed this topic and in a 2012 resolution identified those articles of the UNDRIP that correspond to existing customary and conventional international law (ILA, 2012; Rodriguez-Piñero, 2009)[1] and noted that those that do not necessarily correspond to existing customary or conventional international law still represent an international standard because the Declaration was negotiated within the framework of the Charter of the United Nations between states and Indigenous peoples for the purpose of "[improving] existing standards for the safeguarding of Indigenous peoples' human

[1] These include the right to self-determination; to autonomy and self-government; to cultural identity; to traditional lands, territories, and resources; to establish educational institutions (including with respect to language) and media; and to reparation and redress.

rights" and "reflects the highest possible level of consensus" (ILA, 2012, para 3; see also ILA, 2016).

UNDRIP Article 18 states that Indigenous peoples have the right to participate in decision-making on matters that may affect them/their rights, including subsistence lifestyles and cultural connection. It could be argued that in a context of increased shipping, voyage planning may affect Inuit rights, which could translate to Inuit having the right to inform voyage planning to ensure their rights are respected. There is general voyage planning made onshore by a company ahead of a transit, and there are dynamic adjustments that a mariner must make on the bridge based on what is in front of them. The influence of Inuit in voyage planning on board is limited to wildlife monitors who are already assisting with the dynamic on-the-bridge decision-making to ensure marine wildlife is protected in certain areas (e.g., Tarium Niryutait MPA/Anguniaqvia Niqiqyuam MPA). The scope of this engagement, therefore, is limited to wildlife monitoring in some specific areas.

In recent years, there has been some recognition of the importance of Indigenous rights in the interpretation and implementation of the *United Nations Convention on the Law of the Sea* (UNCLOS, 1982; Chircop, 2018) and other international conventions (e.g., in SOLAS, 1974 and MARPOL, 1973/78), particularly through the Arctic Council in the context of maritime search and rescue, marine oil pollution preparedness and response, as well as Arctic scientific cooperation (Kirchner & Cristani, 2023). In 2021, the Inuit Circumpolar Council (ICC) obtained a 2-year provisional consultative status at the International Maritime Organization (IMO) (ICC, 2021a). This status granted ICC the opportunity to actively participate in discussions, provide expertise, and voice the concerns and perspectives of Inuit communities in matters relating to Arctic shipping activities, such as black carbon emissions (ICC, 2021b), fisheries (ICC, 2023a), and underwater noise pollution reduction (ICC, 2022, 2023b). Obtaining this status was considered by Inuit and other Indigenous peoples as a positive step toward the recognition of their rights and perspectives in maritime governance (ICC, 2021a, 2023c), but the "provisional" nature of the position may have limited consequences in the long term.

Increased efforts on and recognition of Inuit rights in Arctic shipping governance have prompted a critical examination of Canada's existing governance mechanisms and encouraged the development of an integrated governance framework that includes Indigenous knowledge and safeguards Indigenous rights. While the political will to enhance the engagement of and fulfil the obligations with Indigenous peoples has increased significantly in recent years, particularly through OPP initiatives, ontological tensions are rarely explicitly discussed, and the implications and limitations of using certain decision-making tools and systems in governance are also seldom reflected upon. The following two sections will look at the ontological and methodological dimensions of shipping governance, first through a review of assumptions underpinning marine spatial planning and second through the analysis of initiatives that show progress in engagement but also the challenges in their effective application.

6.3 Ontological Assumptions of Governance Approaches

Governance approaches (from governance frameworks to management tools) are based on principles, although their ontological underpinnings (ontological assumptions) are not often articulated. Ontologies are not easy to articulate because they are difficult to perceive, especially when regarding our own assumptions. Ontologies are underlying beliefs about the nature of reality that shape how we perceive and approach a particular subject (Brown, 2015). These ontological assumptions can collectively shape the conceptual framework and guiding principles of marine management, influencing how stakeholders perceive, analyze, and address the challenges of sustainable marine governance.

Systematically identifying ontological assumptions of governance approaches and tools is mostly in the realm of philosophy of science and science and technology studies (Seguin & Vinck, 2023). For the sake of our argument, it suffices to say that ontologies are in fact fundamental in influencing how we interact with the world and that tensions will emerge when different ontologies are in conflict, or when they are not recognized, or when one is implicitly or explicitly favored over another (Nader, 1996; Green, 2006). For instance, single-sector management tools, such as establishing fishing quotas in isolation, may be based on the assumption that certain regulations (e.g., establishing limits to fishing) will have a positive environmental effect (e.g., conservation or recovery of a certain species). The ontological underpinning of such assumptions may be that it is possible to control behavior through regulation and that a species could be "treated" as separate from the ecosystem. On the other hand, integrated management approaches, such as the ones favored in Canada's overarching legislation (i.e., *Oceans Act* (1996), Oceans Strategy), are based on assumptions that activities in the ocean must be understood as interrelated and that the ocean and people are part of an ecosystem (ecosystem-based approach). The ontological assumptions of ecosystem-based approaches are clearly more in line with Inuit approaches.

Inuit ontologies tend to conceptualize humans as part of the environment, as well as challenging other dichotomies that are quite common in non-Indigenous worldviews, such as that of ocean and land, humans and animals, physical and spiritual, etc. (Barras, 2019). This holism is much broader than in integrated management approaches, as it may include all aspects of life (beyond what is normally considered in defining a governance problem). This level of connection among things and with the world affects rules of interactions among humans and within the environment (Rasing, 2017), and it may conflict with concepts of the world (including management and regulations) embedded in prevailing (Western) marine governance frameworks. Different ontologies are not necessarily incompatible, and models have been proposed to improve dialogs between worldviews in marine management and research (e.g., Smith et al., 2023), but multi-ontological scenarios are complex and embedded in broader power relationships that implicitly or explicitly favor one ontological approach over others. In the cross-cultural and postcolonial context of Arctic shipping governance, ABM models may align with Inuit ontological views, in terms of proposing integrated, ecosystem-based approaches, but differences will remain, as Inuit have unique understandings of how to conceptualize problems, risks, decision-making, seasonality, and boundaries.

A crucial point is that ontological tensions between non-Indigenous and Indigenous governance approaches are not often (if ever) discussed and that, in the context of asymmetric power relations, initiatives whose ontological tensions remain hidden risk not being effective in the reconciliation process. Collaborations, therefore, may fail unless such differences are discussed and Indigenous views are considered in all stages of the governance process through culturally aware partnerships.

6.3.1 MSP as a Decolonizing Tool?

Marine spatial planning is interesting as it has been conceived as an area-based management approach involving collaboration and engagement. The principles embedded in MSP (integrated management, area-based, data integration, stakeholder engagement) are, on paper, generally in line with Indigenous/Inuit approaches to environmental governance. As defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO), MSP is "a public process of analyzing and allocating spatial and temporal distribution of human activities in marine areas" and an open and practical way to protect the marine environment, achieve social objectives, and develop sustainable ocean economy (Ehler & Douvere, 2009; IOC-UNESCO/European Commission, 2022; UNESCO, 2023). MSP is known for its capability to facilitate integration, which involves collaboration with multiple stakeholders, use of different sources of information, intersectoral or interdepartmental cooperation, and transboundary management (Flannery et al., 2016; IOC-UNESCO/European Commission, 2022).

MSP seeks to adopt a comprehensive and inclusive approach through continuously engaging stakeholders throughout almost every planning stage (Ehler & Douvere, 2009). It also aims to integrate scientific knowledge, spatial data, and local knowledge into geographic information systems and decision support tools to understand the ecological, social, and economic implications of different scenarios and options (Agardy, 2010). Comprehensive MSP has been widely adopted by more than 100 countries as a framework that has the capability to deal with conflicts in using marine spaces and wicked problems in a comprehensive and coordinated manner through an integrated framework (Ehler & Douvere, 2009; IOC-UNESCO/European Commission, 2022).

The governance of shipping activities involves multiple jurisdictions and sectors, various stakeholders, and, in the Canadian Arctic, rightsholders, making it a good candidate for the application of MSP as a governance approach. In fact, Canada has adopted area-based measures and comprehensive planning frameworks to reduce shipping risks and mitigate impacts from shipping activities that align with the principles of MSP. There have been discussions about the potential to adopt MSP as an explicit framework to facilitate the governance of shipping activities within national jurisdiction, especially in terms of facilitating interdepartmental collaboration, science-based decision-making, and engagement of Indigenous peoples (Wang, 2023; Wright et al., 2021).

While the concept and practices of MSP have gained popularity as a comprehensive planning framework for managing marine resources and regulating human activities, some of Canada's past and existing MSP practices have been found to be less effective or functional for governing shipping activities and delivering expected engagement outcomes. For instance, Canada's Eastern Scotian Shelf Integrated Management (ESSIM) initiative and the Marine Plan Partnership for the North Pacific Coast (MaPP) are found lacking in collaboration with federal maritime authorities (Diggon et al., 2022; McCuaig & Herbert, 2013; Rutherford et al., 2005; Wang et al., 2022; Wang, 2023). On the other hand, MaPP is considered groundbreaking in establishing co-governance models involving Indigenous peoples.

The idea that MSP can balance multiple interests and achieve diverse objectives is wrongly taken for granted. In fact, there is relatively little research that has critically examined the extent to which MSP objectives are achieved in the context of power un/balance and redistribution of power (Flannery et al., 2016) and even less research on how Indigenous peoples may be engaged in a marine plan as *rightsholders* (Diggon et al., 2021; Ban & Frid, 2018). Furthermore, there are certain challenges when it comes to using appropriate participatory approaches with a wide range of stakeholders (and rightsholders) with diverse interests, knowledge, and levels of influence in MSP. For instance, power dynamics and limited representation of marginalized or less influential groups can influence the extent to which stakeholders are effectively engaged. For example, the ESSIM initiative encountered challenges in fully engaging the fishing industry and First Nations (McCuaig & Herbert, 2013; Wang, 2023). The fishing industry, in this case, thought that integrated ocean management could adversely affect their fishing activities, showing that, in the context of MSP, these processes have to contend with special interest groups that are ready to use political lobbying to shape the planning process.

Furthermore, one of the main principles of MSP, referring to the integration of different types of knowledge and information, often may be used to overlook the need to (a) understand the ontological frameworks and the nature of different knowledge systems and (b) devise knowledge coproduction mechanisms that can consider not only scientific data but also local knowledge. In a cross-cultural and postcolonial context, true "integration" of knowledge is not straightforward (and perhaps not even desirable), considering that Indigenous peoples' unique worldviews, values, and knowledge do not cleanly "fit" within existing scientific MSP frameworks. In this context, the empowerment of Indigenous communities to influence the design of DSS and DST that are instrumental in knowledge sharing is critical. In other words, a significant issue for Indigenous peoples participating in marine governance processes may be their lack of political leverage, as compared with the fishing, energy, and transport industries, as well as the perception that local/Indigenous knowledge is less authoritative as compared to information and knowledge produced through scientific methods.

MSP's goals include coordinating decision-making, integrating policies, engaging stakeholders, fostering collaboration, and ensuring the integration of environmental considerations. However, for MSP (or other ABM approaches) to become instrumental in the reconciliation process, it would need to more appropriately and effectively address socioeconomic inequities in the use of ocean space. Therefore, MSP can, in principle but not necessarily, align with Indigenous peoples' holistic approaches to environmental governance.

The most relevant caveat regarding the use of MSP as a participatory approach inherently capable of decolonizing ocean governance comes from a point elaborated by Ellis and Flannery (in Flannery et al., 2016), who highlighted the dangers of using MSP in an uncritical way, one which ignores "often unarticulated, assumptions and values" (ibid: 5) frequently underlaying MSP initiatives. Ellis and Flannery's call to critically assess MSP to identify assumptions and *winners and losers* in the governance process is a critical point. This is also important in the assessments of MSP (and ABM in general), which tend to "exhibit a dominance of research on positivist traditions in natural resource management, technical assessment processes or descriptive case studies" (ibid.). Ellis and Flannery are correct in calling for a more critical assessment of MSP, which will address cultural, social, and distributive consequences of the implementation of the initiatives, as well as the impact of MSP in the most vulnerable (local) actors. In general, our argument reflects the view of Flannery et al. (2020) that social science perspectives (and certainly Indigenous perspectives) are needed in MSP studies and design, as the prevailing approaches are rooted in the fields of natural science and environmental management.

A further relevant question is whether an uncritical application of MSP or ABM could, unintentionally, rationalize, perpetuate, legitimize, and even increase inequity among local resource users, particularly in the context of Arctic shipping. On the other hand, an equally important question can be asked regarding whether a properly (and critically) designed MSP/ABM framework, which explicitly addresses power unbalance and Indigenous ontologies and rights (i.e., a decolonized MSP/ABM framework), may align with and facilitate processes of reconciliation in the Canadian context. This may be possible through policies and practices designed to address historical and systemic disadvantages and to increase Indigenous representation and capacity-building, as well as considering the political, ontological, and methodological challenges of implementing policies and plans. This issue is discussed in more detail in the next section, but the critical point to make here is that ontological issues have not been explicitly addressed in the context of Arctic shipping.

6.4 DSS/DST: A Conceptual Discussion and Examples of Engagement in the Canadian Arctic

In the Canadian Arctic, the application of MSP (or other comprehensive ABM approaches) to facilitate more inclusive shipping governance engaging Inuit communities is a promising opportunity, but a critical lens is needed. Ignoring ontological differences in the understanding of and interactions with marine environments, resources, and activities may result in governance models that could trivialize, simplify, and even marginalize the views of Inuit communities. It is critical to recognize that Inuit relationships with and knowledge of the marine environment are historically rooted, multidimensional, and hard to capture by conventional information and visualization tools that are common in spatial planning. Furthermore, while Western environmental governance practices, in all their variety, have historically tended to reflect a conceptual separation of the environment from humans, Indigenous peoples' approaches (in all their variety) tend to consider humans as part of the environment (Ingold, 2000), whereas the concept of managing an external entity (e.g., a resource, a bounded space, nature) is often foreign to their own ontological approaches.

For instance, in the Inuit context, the assessments of harvesting over periods of time resulted in what elders defined as "the land becoming heated," which required specific human intervention (socially defined avoidance of a certain area) until the land "cooled down." Julia Amarualik, an elder in Igloolik that Aporta interviewed in 2001, gave an example of such approach:

> [The camp] Avvajja, was abandoned because "our elder Ittusarjjuat, just before he passed on, had made it known that this place had heated up from all the use; he wanted this place abandoned to give it a chance to cool down; it might be only for a year. That means no one was to stay there during that period; if they so wish they could come back and live there again." (Aporta, 2003)

Such "normative" practices were not necessarily described as management approaches by Inuit, but rather as ways of dwelling (Ingold, 2000) in a world that is shared between humans and nonhumans. In practice, the emphasis was not on protecting the resource (e.g., walrus), but on maintaining a balanced relationship with the land. Under this ontological perspective, therefore, the walrus well-being was entangled with social well-being of the community and even more generally with the world's well-being. This holistic understanding of the environment with people *in it* is still prevailing in contemporary Inuit communities, and it critically affects communities' responses to governance and policy efforts that may focus on one activity or one dimension of the environment. It should be noted that Indigenous ways of "environmental governance" were overwhelmingly ignored and unacknowledged in the process of colonization in the Americas (including Canada), as part of a political strategy that chose to characterize native inhabitants as not having any agency over their territories (Bell & Asch, 1997). Remnants of these assumptions are still present today in the background of policies and research approaches that tend to ignore Indigenous views in favor of Western scientific frameworks.

In this light, the contemporary concept of DSS and DST are intrinsically dominated by Western conceptions of knowledge (as scientifically validated), although paradigms of environmental governance have evolved toward more holistic and integrated concepts, in part as a response to the crises generated by industrial overexploitation of marine resources (Johnsen et al., 2009). As mentioned above, MSP was developed as a response to such complex problems, and there is evidence that it is an effective approach for the management of marine areas that include multiple users and uses (World Ocean Council, 2016). However, an unintended consequence of data integration is that the significant knowledge and ontological approaches of local actors are ignored or not valued enough in a process that increasingly relies mostly on "hard data," quantitative analyses, and peer-reviewed science-based evidence. While it is hard, if not impossible, to argue against the value of MSP and other area-based frameworks, the problem remains that actors that are already marginalized may be further disempowered by the use of DSS and DST that do not account for different ways in which local communities experience their own environments and how they communicate their knowledge. This ontological tension is particularly true when involving Indigenous communities.

An increasing problem regarding the reliance on complex decision support tools (e.g., Marxan) is that their mastery and use are often beyond the technical capacity of most people (let alone marginalized communities). The question, therefore, of how to appropriately document, visualize, and utilize communities' knowledges across cross-cultural systems is not only relevant to truly achieve the goals of MSP but also as a step toward reconciliation when decisions or governance problems include local Indigenous communities.

6.4.1 DSS and DST in Canadian Arctic Shipping

This section provides examples of how Indigenous knowledge and perspectives are considered and incorporated into the design of frameworks, systems, and tools in the governance of Arctic shipping within a general framework of reconciliation with Indigenous peoples. The three initiatives analyzed are of different scope (a governance framework, a decision support tool, and a decision support system), but they are intertwined, and all of them are situated within the context of Canada's Arctic shipping policies. While they do not explicitly reflect ontological awareness, they do represent efforts to include Indigenous peoples in their design.

The distinction between DST and DSS is important here. DST are typically software applications or methods that aid in the decision-making process, providing data, analytics, visualization options, etc. They do not necessarily make decisions but provide insights to assist in decision-making. DSSs, on the other hand, involve more complex and integrated solutions that incorporate various DSTs and aim to support the decision-making process at various stages, levels, and scales. They usually have advanced features for data integration, processing, and reporting, providing a comprehensive platform for decision support. A DSS is a more extensive platform that integrates multiple tools, data sources, and, in practice, expert systems to support decision-making in a more holistic manner.

In the context of governing marine shipping activities in the Canadian Arctic, DSS and DST are pivotal. They encompass onboard and onshore systems, supporting diverse types of decisions, including route planning, risk assessment, emergency response, and identification of sensitive areas. Their application seeks to generate the conditions for secure, efficient, and ecologically responsible shipping practices in the demanding Arctic environment. A range of systems has been developed to provide mariners with relevant and timely information about vessels' positions, sea ice conditions, weather, and other datasets to support safe navigation in Arctic waters and decision-making.

6.4.1.1 Geographic Information Systems

Applications containing various forms of geographic information systems have been widely used to document, visualize, and use Indigenous knowledge in Canada since the land use studies of the 1970s (Freeman, 1976; Aporta, 2016). GIS is relevant for the integration of Indigenous knowledge in ABM because of its ability to spatialize "uses" and knowledge, in ways that make them potentially compatible with spatial planning.

GIS and various GIS software applications, such as ArcGIS and PostGIS, play a significant role as decision support tools for effective governance of marine shipping operations in the Canadian Arctic. GIS enables the integration of spatial data, encompassing maps, charts, and satellite imagery, with attribute data, including vessel characteristics, ice coverage, bathymetry, weather patterns, collision-prone areas, and regulatory demarcations. This integration facilitates comprehensive analysis and informed decision-making processes related to marine shipping activities.

GIS has numerous applications in shipping, and it is of course a critical tool in any MSP and area-based initiative. For instance, Étienne et al. (2013) developed a methodology to forecast marine traffic density in the Canadian Arctic through mapping traffic patterns in GIS software with data from the CCG. ArcGIS software was employed by Smith and Stephenson (2013) to identify the fastest available trans-Arctic routes for different types of vessels. Furthermore, Mueller et al. (2013) extensively used GIS software to analyze ice shelves data and conduct spatial analysis, thereby gaining deeper insights into ice-generated risks faced by vessels navigating through the Canadian Arctic.

Importantly, GIS has the capability to generate various outputs, including interactive maps, which can potentially allow users (from government to a range of stakeholders) to develop spatial analysis and get involved in the management of marine shipping activities. Specifically, the utilization of public participatory GIS (PPGIS) can facilitate community engagement, and it can potentially enable collaborative coproduction of knowledge through collaboration of Indigenous communities and science (Aporta et al., 2020; Lamers et al., 2018). However, documenting and visualizing Indigenous knowledge in GIS does not necessarily involve fostering participation in decision-making processes.

The utilization of ArcGIS software within the Arctic Corridors and Northern Voices (ACNV) project to document Inuit perspectives on Canada's Northern Low-Impact Shipping Corridors initiative (described below) is certainly a remarkable case study. The ACNV project adopted a community-based research approach to gather data through Inuit participatory mapping and focus group discussions (Dawson et al., 2020). Subsequently, the collected datasets were subjected to analysis within the ArcGIS software, enabling the digitization and visualization of qualitative information, as well as the creation of maps highlighting areas to be avoided by ships as identified by Inuit community members (Dawson et al., 2020). The outputs generated by the ACNV project, stemming from GIS applications, are examples of valuable information sources for understanding Inuit perspectives, but they are just one dataset among many others, feeding into further decision-making processes for optimizing the placement/location of the corridors.

This, of course, is the differentiation between the DST and DSS—while a DST such as GIS may be a useful tool for *visualizing* Inuit knowledge, it does not guarantee an effect on the decisions made through broader governance processes. Given that the corridors have not been adjusted since they were first released (Chénier et al., 2017; Dawson & Song, 2023), it remains to be seen whether and how this knowledge will be integrated or applied effectively in decision-making, as well as how Inuit communities themselves will be able to manage and control future uses of their data in the context of broader decision support systems. It is also clear that rendering knowledge in a GIS type of framework can usually capture only one or two dimensions (spatial and sometimes seasonal) of a type of knowledge that is multidimensional by nature (Aporta et al., 2020).

6.4.1.2 Northern Low-Impact Shipping Corridors

Our exploration of Indigenous engagement in the context of Arctic shipping starts with a framework of governance, whose principles may set the tone for the development and application of decision support tools and systems. The Northern Low-Impact Shipping Corridors (Corridors) initiative is jointly led by Transport Canada, the Canadian Coast Guard, and the Canadian Hydrographic Service. The primary aim of the Corridors initiative is twofold: (1) identify corridors that will shape future regulatory decisions and guide infrastructure investments to encourage traffic through routes that enhance maritime safe navigation practices that prioritize both the well-being of people and environmental considerations and (2) to collaboratively develop a governance framework for determining and managing the corridors moving forward (Dawson et al., 2019; Dawson & Song, 2023; DFO, 2022a).

The policy foundation for the Corridors initiative is in alignment with Canada's Oceans Protection Plan.[2] The objectives of the Corridors initiative align with the OPP's objectives of enhancing Canada's marine safety and protecting the marine environment. Additionally, policy studies, such as the one conducted by The Pew Charitable Trusts, provided insights by proposing policy actions and establishing guiding principles specifically tailored for the development of Arctic corridors (PCT, 2016). The Corridors governance framework is meant to complement existing regulatory frameworks in Arctic waters by engaging with Indigenous rightsholders, particularly Inuit, and providing navigation guidance to vessel operators.

Central to the Corridors' governance framework is an area-based planning model, notably comprising multiple levels of corridors in its preliminary design based on historical ship movement data (Chénier et al., 2017) and consultation with mariners (Dawson et al., 2017). From an implementation perspective, the Corridors initiative adopts a nonmandatory approach, advocating for voluntary compliance to mitigate risks, enhance marine safety, and improve government services (Dawson & Song, 2023). This voluntary governance framework fits the unique maritime navigational conditions and infrastructure development challenges in the Arctic. Chapter 9 in this volume explores how such a voluntary framework has the potential to effectively achieve the goals of Arctic governance (the authors propose to look at the successful implementation of the Voluntary Protection Zone (VPZ) for shipping located at the west coast of Haida Gwaii as a model of co-governance).

Area-based planning for the Corridors will involve the utilization of several decision support tools/systems. The preliminary designed corridors were created, classified, and visualized by using historical shipping data and visualizations tools. They were data-driven designs based on scientific studies and statistics, and they did not consider Inuit experiences, knowledge, and their views on what areas were culturally, socially, and environmentally sensitive (Dawson et al., 2020). As mentioned above, the Arctic Corridors and Northern Voices project's goal is to account for Inuit knowledge and views in a way that can inform the Corridors. The communities' knowledge was documented through spatial analysis tools, including participatory mapping, GIS, and community-based research that allowed for active Inuit engagement to gather local perspectives and knowledge about culturally significant marine areas. The documentation and interpretation of Inuit knowledge resulted in a series of reports, measures, and recommendations that could be taken to optimize area-based planning and management of the corridors (Dawson et al., 2020).

The ACNV project reveals the extensive local and environmental knowledge of Inuit that could contribute to the management of Arctic shipping. The federal government recognized the importance of considering the views and opinions of a wide range of stakeholders and rightsholders in creating the governance framework for the corridors. Thus, it launched an extensive public consultation program in 2022 to engage with Inuit and First Nations organization and governments, territorial and

[2] The Corridors predate the OPP, but the alignment in goals and principles is important, as the next two case studies discussed here are part of the OPP and show a general direction toward acknowledging Indigenous participation.

provincial governments, shipping industry practitioners, nongovernmental organizations, academia, and others (DFO, 2022a). However, as noted by Beveridge, the sheer existence of engagement does not necessarily equate to a feeling of being meaningfully engaged (Beveridge, 2024).

Now that the Corridors initiative is underway as the OPP enters its second phase of development, the emphasis of its next phase is to develop the governance framework and to identify priority areas (TC, 2022a). The challenges of true engagement with Inuit are multifaceted and include designing frameworks, tools, and systems that properly account for communities' knowledge and views. Explicitly or implicitly, this has been recognized in the efforts by the federal government to design decision support tools and systems following a collaborative approach, including the EMSA and the PVM initiatives.

6.4.1.3 EMSA (as a DST)

The EMSA initiative was launched in 2017 with the aim of providing Indigenous peoples and coastal communities improved access to local data on marine traffic and information on the local marine environment (TC, 2020). It was piloted with 13 Indigenous communities across Canada, who came together to collectively decide on the industry partner that would develop the EMSA system "to provide near real-time vessel activity and other marine environmental information in local waters through a user-friendly web platform" and to improve communities' situational awareness on the water (TC, 2022b). EMSA functions as a DST in facilitating not only data collection and integration but also providing opportunities for local and collaborative planning, spatial analysis, and decision-making (TC, 2021).

EMSA is a multifaceted tool that includes various functions pivotal to informed decision-making. One of its primary functions involves the integration of diverse datasets of historical and near real-time marine vessel tracking data (e.g., AIS data, historical vessel data) and marine environment information (e.g., hydrographic data and biophysical data about weather, ice, wind, wildlife, pollution, and sensitive areas) (TC, 2022b). With these datasets, EMSA users have the capability to perform comprehensive spatial analyses, considering both data- and area-based factors. This enables the generation of near real-time scenario analyses for the local marine navigation environment, contributing significantly to the enhancement of safety on the water. The user interface within EMSA is designed as a friendly web-based platform with data layers and spatial analysis tools, providing data access to Indigenous organizations and local communities (GoC, 2021). Overall, EMSA has been developed as an integrated tool with the intent of helping users to improve decision-making in local waters by collecting data, conducting data analysis, and developing emergency management plans (Beecherbay, 2023).

EMSA's potential value goes beyond informing the location of vessels. In 2019, an exercise was held by the Tuktoyaktuk Hunters and Trappers Committee—one of the pilot project partners—to demonstrate how EMSA was contributing to community safety. The scenario was that a community member went hunting but did not return that evening. On the first day of the exercise, participants tried to find the missing community member, but after 7.5 hours they gave up. The second day, they redid the exercise, this time using EMSA to help them locate the missing community member; they were found after only 1 hour and 7 minutes as the location of the missing hunter was quickly identified using EMSA tools (TC, 2019).

EMSA aims to integrate Indigenous knowledge and local knowledge to foster a user-friendly environment where Indigenous community members may be able to make informed decisions that uphold their interests and values. As a practical tool, EMSA can also be applied through other DSSs (such as the PVM, see below) for a wider range of applications, but it remains to be seen how (and if) Indigenous knowledge will be integrated and used. In the case of the Tuktoyaktuk pilot, EMSA already, to some degree, includes Indigenous knowledge by showing where people are taking their boats or snowmobiles and where they are harvesting. This information is only available to the community in order to protect the privacy of their members and to avoid advertising harvesting locations.

As of September 2023, TC is funding 13 pilot projects, 3 of which are in the Canadian Arctic (TC, 2022b): with the Tuktoyaktuk Hunters and Trappers Committee in the Inuvialuit Settlement Region, in Nunavut with the Ekaluktutiak Hunters and Trappers Organization, and with the Nunatsiavut Government in Nunatsiavut (TC, 2022b). The EMSA framework is anticipated to undergo evolution and development, presenting prospects for the inclusion of expanded data sources and even the integration of artificial intelligence tools to further enhance its core functionalities (Larkin & Hall, 2022). The design of EMSA to date has been driven by the interests of participating Indigenous communities and consensus-based decision-making. Therefore, it is anticipated that the future of EMSA will continue to be shaped by these communities and respond to the interests of those it intends to serve. EMSA is an example of how a shipping-related DST can be developed in a context of partnership, and as such it has been positively received by communities.

6.4.1.4 Proactive Vessel Management

Also under the OPP, the PVM initiative is an example of a forum that aims to improve engagement and collaboration with Indigenous peoples. It is meant to safeguard coasts and local waterways while addressing marine safety concerns associated with commercial shipping. PVM's objectives include enhancing both marine safety and environmental protection and fostering collaboration with diverse stakeholders and rightsholders, including Indigenous partners; coastal communities; industry; commercial vessel operators; federal departments; provincial, territorial, and municipal governments; and nongovernmental organizations. The key deliverable of the PVM is a national framework, a draft of which was collaboratively developed with partners and stakeholders, to provide comprehensive guidance and directives for implementation across Canada (TC, 2019). The national framework was to help guide individual collaborations (e.g., with specific communities). Each PVM table—through agreed upon procedures—decided their own priorities, the information required, tools for analyzing information, and solutions. PVM is not strictly a decision support system, but it provides guidelines for the collaborative development of a decision support system based on data inputs and situational awareness.

Besides being proposed as a national framework, to date the focus has been on regional pilots. For example, in the Inuvialuit Settlement Region, the desire is for the PVM framework to include a checklist of "dos and don'ts" based on local needs and the abilities of small vessel operators, including guidelines of applying necessary techniques (e.g., AIS devices) (Inuvialuit Regional Corporation, 2020). There is also interest in having it incorporate a set of guidelines tailored to local requirements and the capacities of small vessel operators, potentially providing ship operators a checklist of recommended practices. For instance, it might outline the proper application of essential techniques, such as AIS devices (Inuvialuit Regional Corporation, 2020).

Another feature of PVM is its voluntary or collaborative nature, which contemplates only nonmandatory measures designed to complement existing marine safety and environmental regulations. So far, regulatory or mandatory measures are firmly outside the scope of discussion at a PVM table.

In order to achieve these objectives, PVM has placed emphasis on preserving the integrity of the marine environment by minimizing conflicts among local waterway users, identifying ecologically and culturally sensitive areas (this specifically refers to the PVM pilot project on the west coast, namely, the VPZ off Haida Gwaii). In the Arctic, a *Notice to Mariners* was developed in Cambridge Bay in 2019 (CCG, 2022; TC, 2023). Several techniques and tools (e.g., GIS, Marxan, and other spatial planning and analysis tools) have been applied within PVM pilot projects with the aim of improving communication efficiency on waterways, introducing measures for speed control and routing, and establishing designated local areas to be avoided. Such marine spatial analysis tools, however, are not particularly designed for processing qualitative information, let alone Indigenous knowledge in the form of narratives. But the development of local management measures/guidelines is supposed to be informed by local (Inuit) knowledge and inputs, and information coming through the system is in turn supposed to help increase awareness of shipping traffic for community members.

In order to emphasize its "proactive" attribute, PVM emphasizes collaboration and co-development of policies with Indigenous peoples and communities. This process has led to the recognition of the PVM's feasibility and effectiveness by the North Pacific coast First Nation communities engaged in the initial pilot project, acknowledging its potential for further progress (Island Trust, 2019). Meanwhile, these engagements have also sparked new inquiries and pathways for future Indigenous involvement in shipping governance (Clear Seas, 2021).

6.5 Discussion: A Decolonizing Approach for Area-Based Planning

The main argument here is that for ABM approaches to align with the process of reconciliation, the three dimensions of the problem (i.e., political will, methodological appropriateness, ontological awareness) need to be considered together. ABM, in this sense, potentially can create a space for working collaboratively with Indigenous peoples in a reconciliation process, which inherently must involve decolonization (Beveridge, 2024). As such, the ontological biases of the governance process (including frameworks, systems, and tools) must be examined.

Based on recent political narratives (e.g., statements, commitments), there have been significant advancements in political will in Canada, from overarching marine policies (e.g., *Oceans Act*), national initiatives (e.g., the Oceans Protection Plan), international and national commitments to the rights of Indigenous peoples (e.g., Canada's commitments regarding UNDRIP), and concrete initiatives in the context of Arctic marine shipping (e.g., Corridors initiative). These advancements have trickled down to specific government actions, institutional efforts to adapt to new frameworks of engagement, and the establishment of concrete initiatives and programs.

The second and third dimensions of the problem (methodological appropriateness and ontological awareness) are fundamentally intertwined and more difficult to address. As shown in Table 6.1, methodological awareness involves finding alternative ways of documenting, visualizing, and using Indigenous knowledge, as well as

Table 6.1 Interconnected obstacles for the true engagement of the Inuit in MSP

Ontological	Political	Methodological
Ontological obstacles might derive from the different perceptions of the marine environment. Western views tend to be Cartesian and reductionist, separating humanity from nature, whereas indigenous ontologies usually perceive humans as a part of nature with interconnections and reciprocal relationships. These fundamental differences can cause misunderstandings and miscommunications in MSP. Ontological obstacles may derive from asymmetric power relations in a postcolonial context, where historic wrongdoings by colonizing states may not be considered in processes of engagement	Political obstacles may involve a lack of will to engage Indigenous peoples, including Inuit, in a fair and meaningful way in decision-making processes. Existing power dynamics, governance structures, and historical injustices can also be barriers	The overreliance on scientifically derived data and underrepresentation of Indigenous knowledge in the methodologies employed in ABM is also an issue. If the DSS and the methodologies used in marine planning do not effectively capture, represent, value, and deploy local/Indigenous knowledge, then this may impede the meaningful involvement of Inuit people. Addressing these obstacles requires acknowledging different knowledge systems, creating political will and procedures that facilitate genuine engagement, and being open to innovate the methodologies used in marine governance

figuring out novel ways of knowledge sharing between Indigenous peoples, other stakeholders, and governmental institutions.

A methodological approach must be designed to address cross-cultural differences, and it must respect the context and nature of local (Indigenous) knowledge. One particular challenge in this regard is that while information sharing is crucial for ABM, Indigenous knowledge is subject to guidelines that may include protection of such knowledge (as defined by the duty to consult—see Chap. 2, this volume). Codesigning mechanisms are needed not only to document and visualize Indigenous data but also to respect Indigenous approaches to reality and knowledge.

Setting standards for methodological appropriateness in governance requires addressing an even more challenging dimension of the problem, namely, becoming aware not only of *others'* ontologies but also of *our* own ontological principles and biases. As discussed above in the context of MSP, ontological approaches and biases are embedded in governance approaches, including in ABM.

The three initiatives discussed above are, potentially, steps in the right direction, but their effectiveness and their place in the reconciliation process remain to be seen, which is normal providing that they are still at the planning or pilot stages. The governance framework of the Corridors initiative can potentially be a space for Indigenous engagement, and it is hoped that the ACNV project will have an impact on effective corridors design and governance approaches.

The decision to look at Indigenous engagement through a discussion of decision support tools and systems stems from the fact that these systems and tools reflect (in their design) certain ontological and methodological decisions, approaches, and, potentially, biases regarding the understanding and the value given to Indigenous knowledge. It is easy to propose ideas regarding incorporating Indigenous knowledge and views in general governance frameworks, but it is certainly more challenging to operationalize these ideas in decision-making systems and tools. If the general ontological assumption of tools and systems involves respect for Indigenous approaches, such tools and systems can in principle create conditions for reconciliation. On the other hand, if ontological biases are not addressed (for instance, the idea that Indigenous knowledge is less reliable), the systems and tools likely will not be effective in the reconciliation process.

EMSA and PVM are examples of operationalization of Indigenous engagement in shipping governance, and they show promising features that can potentially guide the development of other tools and systems in the context of marine governance in general. EMSA is a DST that has been designed and is implemented in the form of pilots through partnerships with Indigenous communities and organizations, and PVM is an example of co-development of guiding principles that may result in decision support systems that are tuned to local realities, environments, and actors. They are both examples of engaging with Indigenous peoples at early stages of decision-making, including in the technical design of a tool, and are geared toward responding to local needs and interests within the governance of Arctic shipping. Paired with early and continuous engagement and collaboration, these initiatives have demonstrated respect for the concerns of participating communities and offered spaces for positive relationship-building.

Some major challenges remain. For instance, how the knowledge documented by the ACNV project will be operationalized and integrated into broader systems of decision-making, including in the layout and governance of the Corridors initiative. Furthermore, the multidimensionality and narrative-driven approach of Inuit knowledge seems difficult to integrate with the quantitative nature of most of the tools and systems used in the governance of shipping.

Incorporating Inuit knowledge and interests in DST and in platforms used to support operational decision-making for shipping is an essential first step toward respecting Inuit rights. However, the information is only one part of the equation. Assumptions regarding how to document and use Inuit knowledge, and more general assumptions about how governance problems are conceptualized (for instance, how risks are defined and assessed), are deeper than methodological choices, and they go beyond good intentions in utilizing participatory approaches for governance. If most of the relevant decision-makers, authorities, regulators, and planners align with "Western" ontologies, and little room is given to others' approaches, it is likely that those being engaged will perceive their level of engagement to be at the very bottom of the participatory ladder, resulting in little change in power distribution (a central element of the reconciliation process) and little impact in the well-being of Arctic communities. On the contrary, such legitimately important initiatives and goals could end up generating frustration in all parts due to lack of results. Building capacity so that Inuit communities and organizations can participate in the design and utilization of the DSS and DST for decision-making in shipping is paramount.

Finally, little advancements will be made in creating more effective and participatory governance without long-term political will to continue to implement and support governance mechanisms that will be both effective for shipping management and just in the processes of empowering Indigenous communities whose livelihoods are directly and indirectly impacted by shipping and, as such, who have rights to participate in decision-making.

Ontologically, the main challenge is accepting that if there are multiple ways to conceptualize the marine environment, there may also be multiple ways of governing activities that take place in this environment. Crucially, this introduces cultural values to the governance realm, which is typically not part of discussions, particularly in the context of shipping. Conceptualizations of risk, for example, can vary widely between cultures, rather than representing objective realities outside of interpretation. Of course, the presence of floating ice will be an objective danger to a ship, but risks associated with the ship transit in a particularly sensitive marine area need ontological framing and negotiations in cross-cultural settings to be truly participatory (for a discussion of risk conceptualizations, see Chap. 2, this volume).

The ontological dilemma extends much further than the regulation of an activity (e.g., shipping), and hence implementing comprehensive ABM approaches is a step in the right direction. From the perspectives of Indigenous communities, however, the holistic nature of problems extends beyond the realm of ABM to encompass all dimensions of life, including the historical tensions of colonial processes. This explains, for example, how topics such as residential schools and marginalization may be brought up by community members in all sorts of fora, including in the engagement process that takes place in shipping governance. A decolonizing approach in shipping governance would not ignore the specific needs of shipping regulations and management, but it will also create conditions for fair engagement where the knowledge and history of Indigenous communities are recognized in their own right.

Meaningful Indigenous engagement must move beyond the incorporation of scientific and technical information, and/or Indigenous knowledge presented as such, to ensure that Indigenous peoples themselves inform and impact the design and operation of frameworks and tools so that their knowledge and ontology influences decision-making and planning. All this requires political will from government to create and implement procedures to meaningfully engage Indigenous peoples in these ways.

As described, these three elements—the ontological, methodological, and political—are intricately intertwined. The idea of an inclusive governance framework for the Corridors initiative and the development of EMSA and PVM are steps in the right direction, but broader ontological issues should be explicitly considered in future developments. Ultimately, the initiatives must unfold in the context of a systematic and politically robust approach to empower local communities through capacity-building and a clear recognition of the value of Indigenous knowledge and views.

6.6 Conclusion

There have been significant advances in policies and initiatives focused on increasing the engagement of Indigenous peoples in Canada, including the documentation of Indigenous knowledge and voices for area-based management. However, it remains true that there is a large gap between policies, planning, and implementation. The final decision-making in the context of shipping remains solely with the mariner, shipping company, and federal government, none of which have historically had mechanisms to incorporate, reflect, or include Indigenous ontologies or peoples. Examples of Indigenous engagement in shipping governance are few, but significant, including the three examples described above. DSS and DST have critical roles in the implementation of ABM initiatives, but the underpinning methodological and ontological biases inherent in those systems and tools, and how they affect Indigenous engagement, are rarely (if ever) discussed. Therefore, efforts to truly facilitate Indigenous engagement often fall short of their original expectations, generating frustration both in government and Indigenous communities.

The Northern Low-Impact Shipping Corridors initiative is a crucial opportunity to implement ABM tools and approaches that include Inuit in the context of a process of reconciliation in an area of Canada that is almost exclusively inhabited by Indigenous peoples. ABM approaches can indeed improve participation in marine governance, and specifically in Arctic shipping, as long as ontologies are made explicit, methodologies are properly designed, and Inuit are involved in all stages of the process.

One of the main problems to achieve true engagement and empowerment of Indigenous communities is the fact that Inuit ontologies and the inherent biases of tools, systems, and frameworks of prevailing governance models are often ignored. In order to pursue reconciliation, the three dimensions (ontological, methodological, and political) should be approached as intrinsically connected.

Understanding this problem through a multidimensional lens involves open-mindedness to recognize that Indigenous peoples must inform and influence the design of frameworks and tools within the context of ABM, so that the decision support tools and systems are not only reliant on scientific and technical information but also on Indigenous knowledge and insights.

A prerequisite of the application of ABM is the gathering and use of evidence from different sources for decision-making, but in practical terms, decision support systems and tools rely mostly on quantitative or quantifiable information that excludes or decontextualizes local knowledge. Therefore, in most cases, decision support systems and tools are better suited to be used by corporations, governments, institutions, and scientists. Local communities often require assistance and, in some cases, translation to participate. Community engagement is often reduced to data collection and harmonization (at its best) and empty consultation (at its worst). In the process of transforming Inuit knowledge into evidence for decision-making, the "journey" of local knowledge usually includes reduction, simplification, and decontextualization.

To revert this power unbalance, governance models need to start by identifying and recognizing the ontologies embedded in prevailing governance and management frameworks, as well as the ontologies of local actors and main users of the marine space. A pragmatic (but conceptually informed) approach is needed to define specifically tailored best practices that can include a combination of approaches, techniques, and knowledge. A combination of ontological awareness, methodological fine-tuning, and political will is needed. The result could be a step forward in the general journey of reconciliation.

The main limitation of this analysis is that the descriptions of the EMSA and PVM initiatives were based on reports and available literature, which are not detailed. An in-depth look into these initiatives (including the design and implementation stages) could shed light into several significant issues, including how Inuit ontologies were considered, how and if they are resulting in capacity-building for Inuit communities and organizations, what mechanisms are in place for long-term maintenance and improvement of tools and systems, and what future plans are in place for effective incorporation of Inuit knowledge. In the meantime, both EMSA and PVM seem to offer a space for partnership development in the context of Arctic shipping governance. Whether this leads to advancements in the path of reconciliation is only for Inuit and other participating Indigenous peoples to say.

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Part II
Vessel Traffic Management

Chapter 7
Risk Analysis for Vessel Accident Prevention in Marine Areas: An Accident-Theoretic Perspective on Spatial Aspects of Risk

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Abstract Area-based marine management approaches aim to mitigate the risks and impacts of shipping on human safety at sea and on ecosystems in marine and coastal environments. Through various regulatory initiatives and policy practices, risk assessment has been established as an important element to support decision-making for area-based marine management. This chapter focuses on the use of risk assessment for supporting decisions to manage navigational risks through risk control measures such as the design of vessel traffic separation schemes, the selection and positioning of aids to navigation, and the definition of operational requirements from a vessel traffic management perspective. To facilitate further developments in this domain, this chapter provides a brief overview of risk analysis techniques currently promoted at the international level, and selected approaches proposed in the academic literature are outlined. A discussion is provided on these selected techniques, through the lens of accident causation theories, focusing on how aspects related to the marine space are conceptualized in these techniques. Finally, directions for future research and development are outlined.

Keywords Risk management · Risk analysis · Accident prevention · Waterway risk analysis · Accident theories · Accident pyramid · Linear accident causation · Systems-theoretic accident model · Risk indicators · IALA Risk Management Toolbox · Navigational traffic conflict technique · IALA Waterway Risk Assessment Program · Systems-theoretic process analysis · Ports and waterways safety assessment

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7.1 Introduction

Risk assessment is increasingly embedded in the maritime regulatory context and in the shipping industry to support proactive decision-making to mitigate a variety of risks. For example, at the International Maritime Organization (IMO), the formal safety assessment (FSA) process was adopted in 2002 to support rule-making processes (IMO, 2002) and has been applied to assess the safety level of various ship types and suggest risk control measures based on risk-cost-benefit considerations (e.g., IMO, 2007, 2008). Goal-based ship design standards have also been introduced at the international level (Hoppe, 2005), for which risk-based approaches have been proposed to support the ship design process through structured and systematic analyses. Various methods and tools have been developed to support risk-based design (Papanikolaou, 2009), industry guidelines have been issued to support approval processes (KR, 2015), and risk-based ship design is an active area of academic research (Kujala et al., 2019). Risk assessment is also used in operational practices in the maritime industries. A prominent example of this is the industry practice of using risk assessment techniques and processes to satisfy requirements of the International Safety Management (ISM) Code to "establish safeguards against all identified risks" (IMO, 1993, para 1.2.2.2). Extensive industry guidance has been issued on how to use risk assessment to satisfy this requirement (INSB Class, 2010; IRS, 2018). Other contexts for which risk assessment techniques have been developed and guidance has been issued include maritime pollution preparedness and response (PPR) (Laine et al., 2021; Parviainen et al., 2021) and search and rescue (SAR) (Akbari et al., 2018).

Particularly relevant for area-based management of navigational shipping risk is the provision in the *International Convention for the Safety of Life at Sea* (SOLAS) that contracting governments should "undertake to arrange for the establishment of VTS [Vessel Traffic Services] and AtoN [Aids to Navigation] Services where the volume of traffic and the degree of risk justifies such services" (SOLAS, 1974). This has led the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), in collaboration with national authorities, industry, and academic experts, to develop a toolbox for waterway risk management, to assess this "degree of risk", and to consider measures to reduce these risks. Associated with this toolbox is guidance on how AtoN authorities can implement risk management within their activities and apply the techniques in the toolbox (IALA, 2022a). Training is also provided to support capacity-building through the IALA World-Wide Academy. The primary stated purpose of waterway risk assessment in this context is to assess navigational risks in maritime areas, to enable risk-based decisions to prevent accidents from occurring. Tools from the IALA Risk Management Toolbox have been used, for instance, to make recommendations to enhance waterway maintenance, install additional AtoNs, and improve operational reporting practices and information exchange (USCG, 2021; Nash Maritime, 2021).

The development of waterway risk identification and analysis techniques and related issues such as proposing risk acceptability criteria (Wang et al., 2022) and metrics to support cost-effectiveness analyses (Ventikos and Sotiropoulos, 2014), as well as proposing stakeholder processes to manage navigational risks in particular sea areas (Haapasaari et al., 2015), are active areas of academic work. Comprehensive literature reviews about maritime waterway risk models have been published by Li et al. (2012), Goerlandt and Montewka (2015), Lim et al. (2018), and Kulkarni et al. (2020).

In the wider academic risk and safety literature, there has been considerable attention to understand accident causation in socio-technical systems. This has led to the formulation of a number of so-called accident causation theories (Qureshi, 2007), which consist of a set of principles and mechanisms through which a socio-technical system transitions from a normal state of operation to a state beyond the normal operation conditions, in which a failure with unwanted safety implications has occurred. Some authors have discussed or analysed the relationship between waterway risk models and accident causation theories (e.g., Hänninen, 2014; Du et al., 2020).

However, no particular focus was given to how spatial aspects of risk are considered in waterway risk models or in the accident causation theories on which they build. In this chapter, this relationship will be explored through a selection of waterway risk analysis models. The conceptualization of the marine space is considered through four aspects: physical, environmental, infrastructural, and organizational, following knowledge obtained from ship accident investigations (Schröder-Hinrichs et al., 2011; Mullai and Paulsson, 2011; Puisa et al., 2018). The physical aspect concerns the layout of the waterway, addressing aspects such as the water depth, channel or fairway width, or the air draught for fairways with bridge spans. The environmental aspects address issues such as currents, waves, wind, and visibility conditions. The infrastructure aspect focuses on man-made structures or technological devices present in the waterway or sea area to facilitate navigation, for instance, aids to navigation (buoys, lights, etc.) and communication technologies to provide information to the different actors in ensuring navigation safety, for instance, Very High Frequency radio, automatic identification systems (AIS) transmission, etc. The organizational aspect focuses on the role and performance of individuals and teams working in the different organizations responsible for ensuring safe navigation, including the vessel's master and ship personnel, pilots, and vessel traffic services (VTS) operators.

A better understanding of how different waterway risk models relate spatial aspects of risk to the occurrence of accidents can help academics better understand conceptual differences between approaches and reflect on open questions and uncertainties, through which further advancements in developing approaches to support area-based accident prevention can be made. The analysis and discussion can also help practitioners and decision-makers better appreciate the complexity of accident causation and consider some limitations of the existing approaches to waterway risk analysis.

To contextualize the work and to serve as an introduction to readers less familiar with the subject matter, Sect. 7.2 first gives a brief overview of the waterway risk models included in the IALA toolbox, contextualizing this in IALA's suggested approach to risk management. Thereafter, Sect. 7.3 describes selected waterway risk models in some more detail. This includes a discussion on how these reflect the tenets of a particular accident causation theory and how spatial aspects of risk are reflected in the models. Section 7.4 provides a discussion on the findings, indicates directions for future academic research, and highlights some implications for practitioners and decision-makers.

7.2 International Recommended Practice for Waterway Accident Risk Management

7.2.1 IALA Risk Management Process

The overarching guidance document introducing the IALA Risk Assessment Toolbox is the IALA 1018 Guideline for Risk Management (IALA, 2022a). This builds on the IMO FSA process and the ISO 31000:2018 risk management standard (ISO, 2018), linking common practice for regulatory decision-making in the maritime shipping industry, with established risk management concepts and processes across industries. Figure 7.1 illustrates how these two processes are integrated. It shows how the IALA guideline adopts FSA's analytical steps of hazard identification, risk assessment, risk control options, cost-benefit assessment, and decision-making recommendations, while using the ISO standard's management processes

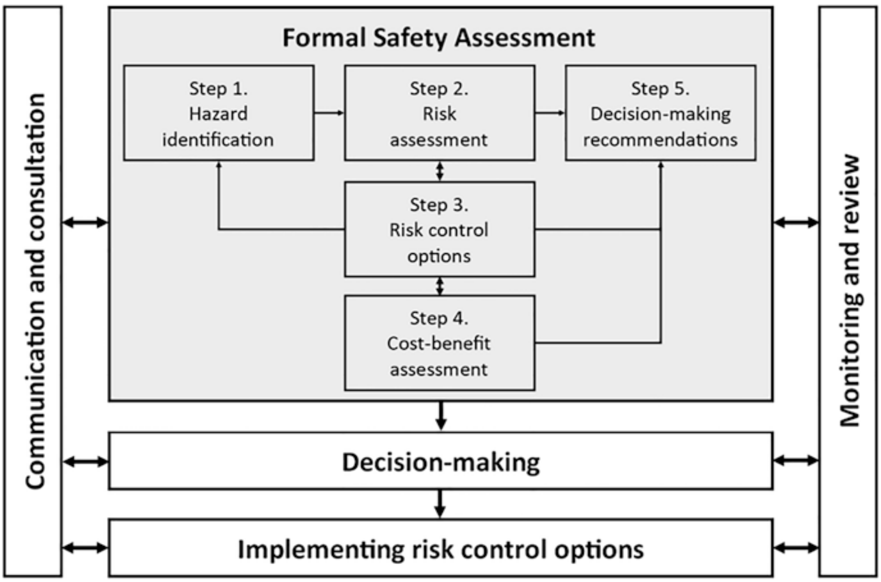

Fig. 7.1 Overview of the IALA risk management process, based on IALA (2022a)

of communication and consultation, monitoring and review, decision-making, and implementation of risk control options.

The FSA part of the guideline, indicated in light grey in Fig. 7.1, focuses on producing information on waterway risks, identifying possible measures to implement to reduce their risks, and assessing whether these measures are cost-effective to reduce the waterway risks. In the G1018, three different strategies are proposed on how to practically implement these FSA-based processes. Strategy 1 focuses on small-scale assessments (e.g., marking a shipwreck) and includes only steps 1, 2, 3, and 5 of the FSA process. Strategy 2 addresses medium-scale assessments (e.g., new AtoN installations) and additionally contains step 4. Strategy 3 concerns large-scale assessments (e.g., planning a new offshore wind farm). This includes all steps of the FSA process, as well as an iteration aimed to assess and mitigate new hazards which could be introduced into the system, for example, stemming from the implementation of new routing measures. Thus, the selection of which strategy to follow depends on the scope and context of the problem for which a risk assessment is performed.

The other parts of the guideline are based on the ISO 31000:2018 standard and are indicated in white in Fig. 7.1. The parallel process of communication and consultation includes deliberation on the selected strategy (Strategy 1–3), the selection of the risk assessment tools, engaging in discussions with stakeholders as to what should be included in the scope of the analysis, and the collection of data, information, and expert judgments to support the analyses. Monitoring and review is a parallel process that involves periodically tracking and observing the risk management activities, evaluating the actual performance of the organization's risk management processes, and assessing where and how continuous improvement actions are needed to improve how the risk management process is implemented in the organization. Decision-making should be risk-informed, so that the risk assessment results, the identified risk control options, and (if applicable in the selected strategy) the cost-benefit analyses are considered alongside with other concerns and considerations, such as legal constraints, stakeholder views, and the availability of resources. This decision-making should consider whether risks are at an acceptable level. If not, risk controls should be implemented to reduce the risk levels to be as low as reasonably practicable. Finally, when implementing the new risk control measures, the roles and responsibilities of different stakeholders should be agreed upon and appropriately embedded in organizational practices.

7.2.2 IALA Risk Assessment Toolbox

The IALA Risk Assessment Toolbox contains selected methods and techniques to support waterway risk assessments of AtoN authorities. This section briefly addresses these tools, outlining their main features and highlighting applicability for executing the different steps of the FSA-based risk assessment process described in Sect. 7.2.1.

The current toolbox contains six freely available methods. Table 7.1 briefly describes these, references the IALA Guidance document, and gives insights in the degree of required resources and skills and the type of output provided. To illustrate, the table shows that using the One Page Risk Assessment (OPRA) tool requires only low resources and skills, whereas in the IALA Waterway Risk Assessment Program (IWRAP) tool, the criteria are medium for both these aspects. This underscores why the IALA World-Wide Academy has developed training courses to support administrations in applying the IWRAP tool. Similarly, a navigation simulator (SIMULATOR) tool can provide quantitative outputs, whereas most other tools result in qualitative outputs, for example, the Ports and Waterways Safety Assessment (PAWSA), Simplified IALA Risk Assessment (SIRA) method, and IALA Risk Management Summary (IRMAS).

Table 7.1 IALA Risk Assessment Toolbox: overview and key features, based on IALA (2022a)

Tool ID	Description	Resources needed	Skills required	Can provide quantitative output	Reference
IRMAS	A standardized approach to document the risk assessment process, which also provides for a repository of operational risk assessments undertaken for small-scale applications	Low	Low	No	G-1018
OPRA	A simple tool for operational small-scale assessments of navigation risk, e.g., those associated with temporary marking of a wreck, the small change of an aid to navigation characteristic, or the establishment of a virtual aid to navigation	Low	Low	No	G-1018
PAWSA	A qualitative tool for assessing risk in a defined waterway area by means of a structured workshop. This is undertaken by carrying out a knowledge-based assessment of the risks in that waterway, strongly relying on the experience of maritime experts and other stakeholders	High	Medium	No	G-1124 G-1018
IWRAP	A modelling tool aimed to provide authorities a standardized quantitative method for estimating the probability of collision and grounding accidents in a given waterway or sea area. The tool requires access to AIS data	Medium	Medium	Yes	G-1123 G-1018

(continued)

Table 7.1 (continued)

Tool ID	Description	Resources needed	Skills required	Can provide quantitative output	Reference
SIRA	A simple inductive tool to structure an expert panel risk assessment. The basis of the tool is the risk matrix in which the probabilities and consequences of the most relevant accident scenarios are rated and supporting justification filled	Low	Low	No	G-1138 G-1018
SIMULATOR	Navigational simulation may provide both quantitative and qualitative data and can be applied in two different ways: fast-time simulation and real-time simulation. The tool can be valuable, e.g., to better understand the effects of risk control options being considered	High	High	Yes	G-1058 G-1018

Table 7.2 IALA Risk Assessment Toolbox: applicability for different FSA steps, based on IALA (2022a)

ID	Name	HI	RA	RCO	CBA	DMR
IRMAS	IALA Risk Management Summary	▪	▪	▪	□	▪
OPRA	One Page Risk Assessment	▪	▪	▪	□	▪
PAWSA	Ports and Waterways Safety Assessment	■	■	■	□	□
IWRAP	IALA Waterway Risk Assessment Program	▪	▪	▪	□	□
SIRA	Simplified IALA Risk Assessment method	■	■	■	□	■
SIMULATOR	Navigation simulation	■	■	■	□	□

HI hazard identification, *RA* risk assessment, *RCO* risk control options, *CBA* cost-benefit assessment, *DMR* decision-making recommendations, ■ strongly applicable, ▪ applicable, □ not applicable

Table 7.2 illustrates the applicability of the IALA risk assessment tools for performing the steps of the FSA-based process shown in Fig. 7.1. As shown in the table, these tools are applicable especially for hazard identification (Step 1), risk assessment (Step 2), and estimating the effects of risk control options (Step 3) related to ports, waterways, and sea areas. These steps can be conducted, for example, by using the PAWSA or IWRAP tools. It is also seen that only SIRA, IRMAS, and OPRA tools are applicable to directly provide decision-making recommendations (Step 5), while none of the IALA tools can be used for cost-benefit assessment (Step 4). For that purpose, however, the original IMO FSA Guidelines can be utilized, and work is ongoing at IALA to provide further guidance on cost-benefit assessment.

Overall, the current IALA Risk Assessment Toolbox provides a fairly comprehensive set of different risk assessment tools, which has been used extensively to produce risk-related information to support subsequently the decision-making process. Finally, the IALA Risk Management Guideline also provides references to other risk assessment tools, if additional information is required.

7.3 An Accident-Theoretic View on Spatial Aspects of Risk in Waterway Risk Analysis Techniques

7.3.1 A Brief Outline of Some Common Accident Theories

In the risk and safety literature, a significant question concerns how accidents happen. This is a difficult problem as a large body of empirical and multidisciplinary research has shown that a wide variety of physical, environmental, technological, psychological, and social factors and mechanisms contribute to the occurrence of accidents in socio-technical systems. Over the history of safety science, several attempts have been made to summarize these mechanisms in various levels of abstraction, leading to the existence of a number of so-called accident causation theories. Some of these are very briefly outlined below to support the subsequent discussion. It is important to note that several variations exist of each theory, with often nuanced but potentially significant differences in how exactly accidents are conceived to occur. For the present purposes, a high-level simplified description is considered sufficient to distinguish these theories and the waterway risk analysis methods based on these in the subsequent sections.

One of the oldest conceptions of accident causation is the accident pyramid, which is illustrated in Fig. 7.2a. This relational theory builds on the observation that different events with a gradation in severity levels occur in a system and uses observation to infer that these events are indicative of how susceptible a system is to experience accidents. A typical distinction between different events includes near-misses, minor accidents, and major accidents. The central mechanism in this accident causation theory is thus relational, that is, the notion that there is a more or less stable relationship between the number of near-misses, minor accidents, and major accidents occurring in a system. The model depicts a larger number of near-misses at the base, fewer minor accidents above, and the fewest severe accidents at the pyramid's peak. This relational model suggests that for every severe accident, there are numerous near-misses and minor incidents. It is considered that understanding and addressing the near-misses at the base of the pyramid can effectively prevent more severe incidents and major accidents (Meyer and Reniers, 2016).

A second theory is the linear accident causation model, of which one of the most well-known and widely used versions is illustrated in Fig. 7.2b. The

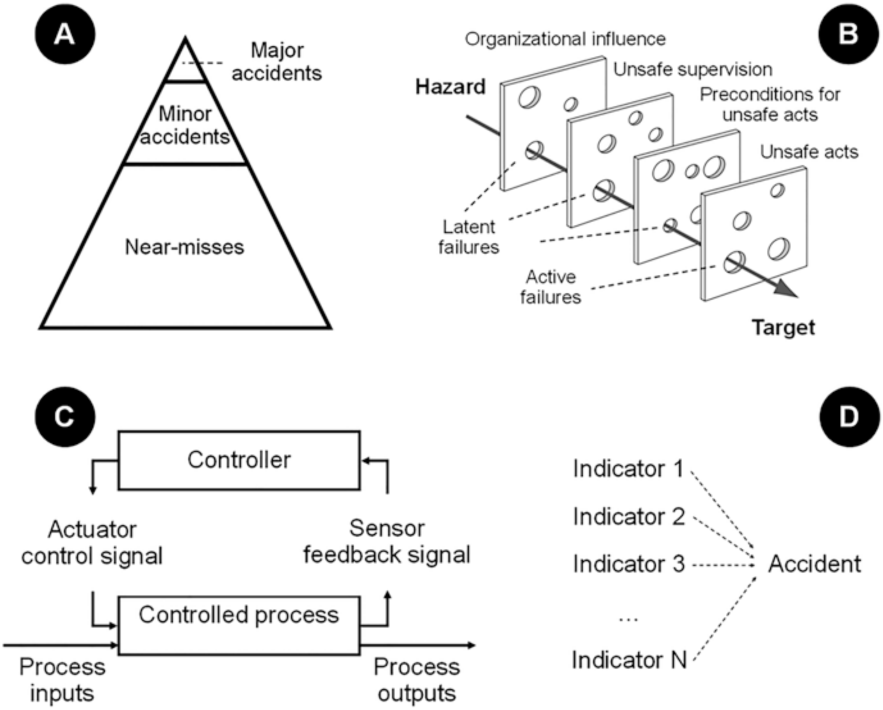

Fig. 7.2 Simplified graphical representation of some prominent accident theories, based on Meyer and Reniers (2016), Reason (1997), Leveson (2016), and Rae (2018)

central idea is that when a hazard (typically a physical phenomenon) can reach a target (e.g., a person, or a vulnerable environment), this leads to losses (e.g., injury or death, financial costs, environmental damage). Several layers of defence protect the target from being impacted by the hazard, so that this model (often referred to colloquially as the "Swiss Cheese" model) is more commonly referred to as the complex linear model, defence-in-depth model of accident causation, or the epidemiological model in the academic literature (Reason, 1997). Each layer in the model symbolizes a defensive barrier against accidents. When holes, which represent errors or failures in these layers (hence the "Swiss Cheese" analogy), align, a linear progression of events takes place, resulting in the occurrence of an accident. The linear character of this accident theory arises from the sequential alignment of these failures in the defensive barriers, considering how, when one layer fails, it leads to the exposure of the subsequent layer's weakness, eventually creating a clear path for an accident. This linear view suggests that accidents result from a step-by-step series of failures in these defences. The theory considers accidents in a multi-faceted manner, emphasizing that it is the alignment of multiple failures rather than a single linear cause that allows accidents to manifest. In socio-technical contexts, typically considered failures include unsafe acts by a person (i.e., "human errors"), preconditions for unsafe acts (i.e., physical contextual conditions making it more or less likely for the "human errors" to occur), unsafe supervision (i.e., social conditions in the relationship between the person committing the unsafe act and managerial supervision), and organizational influences (i.e., factors stemming from the broader organizational context in which the work occurs, e.g., related to safety culture or safety training).

A third theory, which has gained significant support in academic and industry contexts in the last decade, is a systems-theoretic accident model based on control system theory. The Systems-Theoretic Accident Model and Processes (STAMP) is a comprehensive accident causation theory that shifts focus away from individual errors to a systemic view of accidents, which are considered to arise from complex interactions between multiple actors within a system. As illustrated in Fig. 7.2c, it takes a multi-layered hierarchy of controllers and controlled processes, along with command signals and feedback loops, as a basis of understanding the system's functionality, which dynamically aims to maintain a safe state. The interplay between actors and their interactions in the system and the environment in which the system operates are considered key factors in accident causation. Causal factors stem from the mismatch between the system's design and its operational demands, as well as from the dynamic unexpected adaptations in the system and its operative context. The resultant unexpected interactions, as well as the flawed control and feedback processes, are considered the primary mechanisms from which accidents emerge (Leveson, 2016).

The final accident causation theory considered here concerns risk indicators and is illustrated in Fig. 7.2d. These refer to measurable factors that act as warning signs within a system or environment, highlighting system components, functions, or characteristics which are considered to have a causal relationship to the possible occurrence of an accident. By monitoring and analysing these indicators, vulnerabilities or weak points within a system are proactively identified, enabling preemptive measures aimed at mitigating risks and preventing accidents. This accident causation theory does not necessitate combining these indicators as standing in specific relation to one another, and there is no necessary reference to an underlying linear representation of events or systemic interactions. In this sense, risk indicators do not explicitly depict the causal mechanisms through which an accident progresses (unlike the linear or systems-theoretic accident theories) but rely on a more implicit inference about the connection between the status of indicators and accident occurrence (Rae, 2018).

7.3.2 Techniques Based on Relational Accident Theories: Conceptualization of Space

In the IALA guideline G1018, there are currently no risk models or techniques included which build on the relational view on accidents as represented in the accident pyramid. Nevertheless, several risk models have been developed in the academic literature that build on a hierarchy of traffic conflicts to estimate the accident risk in a maritime traffic area, particularly for collision accidents.

A prime example of such a risk model is the navigational conflict technique proposed by Debnath (2009). The basic idea of this approach is that the severity of non-collision ship traffic encounters can be ranked and that this information can be used to derive the probability of a collision. The procedure to achieve this is schematically shown in Fig. 7.3. First, a vessel conflict operator is constructed using an

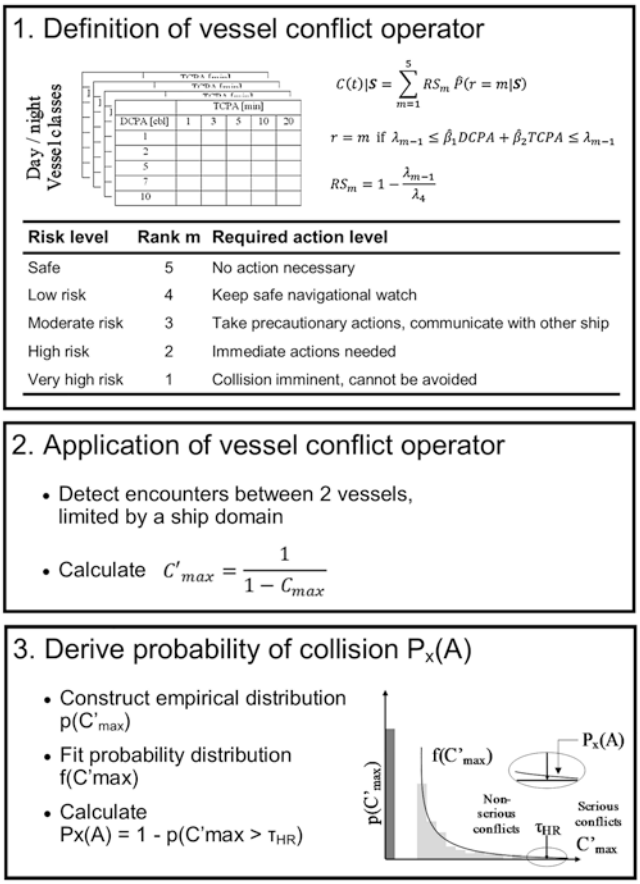

Fig. 7.3 Overview of the navigational conflict technique to assess collision risk in waterways, based on Debnath (2009)

ordered probit regression model of expert judgments on the risk level in vessel interactions. This risk level of ship-ship encounters uses well-known navigational proximity indicators DCPA (Distance to Closest Point of Approach) and TCPA (Time to Closest Point of Approach), making distinctions between day and night conditions and different vessel sizes. Vessel encounters are interpreted in five risk levels as indicated in Fig. 7.3, and a mathematical operator C(t)|S is defined. Second, this operator is applied in vessel traffic data for encounters involving a vessel conflict, and a measure C'_{max} is calculated. Finally, the collision probability $P_X(A)$ is mathematically derived from the fitted distribution $f(C'_{max})$ to the empirical distribution $p(C'_{max})$. The threshold value τ_{HR} corresponds to the distinction between serious and non-series conflicts, that is, based on the risk score RS_m corresponding to the "high risk" level. Thus, the accident probability $P_X(A)$ is derived from a monotonically decreasing function, which is conceptually similar to an accident pyramid in that this function represents vessel conflicts of increasing severity, with the area of the function above the defined threshold associated with the estimated accident risk.

In this approach, the characteristics of the marine space are conceptualized as not having an influence on the accident risk level. The relative spatial relationship between two encountering vessels is accounted for in the vessel conflict operator as a perceived risk level by expert navigators. However, this relationship is independent from physical, environmental, infrastructural, or organizational characteristics of the marine space in which the vessel encounter occurs.

7.3.3 Techniques Based on Linear Accident Theories

In the IALA guideline G1018, a clear example of a model based on the linear accident theory is the IALA Waterway Risk Assessment Program (see IALA, 2022b). Furthermore, many risk models based on a linear view of accident causation have been proposed in the academic literature (see, e.g., Du et al. (2020) for a review). To serve as a basis for discussion, IWRAP is briefly explained below, focusing on collision accidents and making links to the closely related pertinent academic literature as appropriate.

This method aims to estimate the frequency of collision accidents in a waterway, as follows:

$$f = N_G P_C \tag{7.1}$$

The calculation is based on a simplified sequence of events: the ship-ship encounter and the collision. Hence, the model represents a simple linear causality: first, two ships encounter each other, and second, if they fail to execute successful evasive actions, they collide. In IWRAP, the number of ship-ship encounters N_G is determined through a calculation based on probabilistic information of traffic flow characteristics (obtained through analysis of ship traffic data from the AIS). As an example, the formulation for crossing encounters is given below:

$$N_G^{CR} = \sum_i \sum_j \frac{Q_i^{(1)} Q_j^{(2)}}{V_i^{(1)} V_j^{(2)}} D_{ij} V_{ij} \frac{1}{\sin\theta} \tag{7.2}$$

with V_{ij} the relative speed between the vessels and D_{ij} the apparent collision diameter, defined as follows:

$$D_{ij} = \frac{L_i^{(1)} V_j^{(2)} + L_j^{(2)} V_i^{(1)}}{V_{ij}} \sin\theta + B_j^{(2)} \sqrt{1 - \left(\sin\theta \frac{V_i^{(1)}}{V_{ij}} \right)^2} + B_i^{(1)} \sqrt{1 - \left(\sin\theta \frac{V_j^{(2)}}{V_{ij}} \right)^2} \tag{7.3}$$

$Q_i^{(1)}$ and $Q_j^{(2)}$ are the flow rates of vessels of subclasses i and j. L and B represent ship length and width, V the ship speed, and θ the angle between the waterways. The cross-waterway traffic distributions $f_i^{(1)}(z_i)$ and $f_j^{(2)}(z_j)$ integrate to unity for crossing encounters, but for overtaking and meeting encounters, the shape of these distributions affects the number of calculated encounters. The procedure to detect the number of encounters assumes that neither ship takes an evasive action prior to collision (Fig. 7.4).

A widely used approach to determine the probability of an accident given an encounter, recommended in IALA's IWRAP approach, is deriving this from accident statistics (Kujala et al., 2009), which leads to a recommended generic value for P_C of 1.2×10^{-4}. Another approach to determine this probability, which has the advantage of allowing an analysis of the effects of risk control options as part of the causal chain, is using Bayesian network (BN) models (see, e.g., Friis-Hansen and Simonsen, 2002; Valdez Banda et al., 2016). A BN is a causal diagram that represents probabilistic relationships between variables and thus captures information how factors and events influence each other. It is a structured way to model dependencies, offering insights into the probability of an outcome based on the interconnected influence of various contributing factors. An important characteristic of BNs is that while complex causal dependencies can be represented, all links are linear,

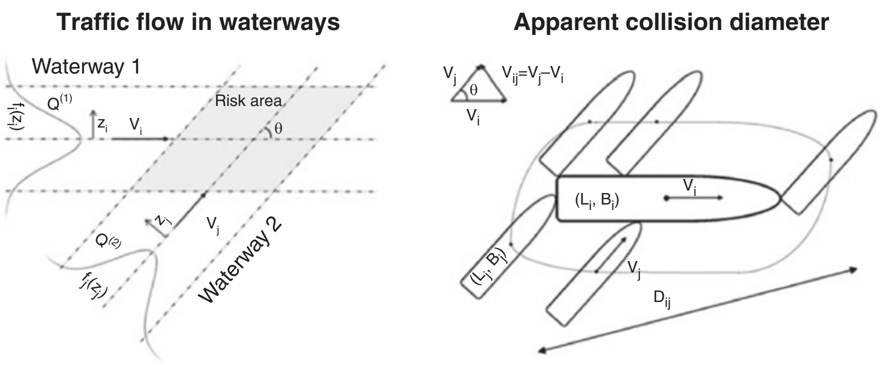

Fig. 7.4 Overview of the logic underlying the IALA IWRAP tool, based on Pedersen (2010)

and no feedback loops between factors or events can be accounted for (Hänninen, 2014). Hence, referring to Eq. (7.1), when complex linear dependencies are modelled to estimate the probability of an accident given an encounter P_C using a BN, this approach relies on linear causal pathways influencing the occurrence of an accident by focusing on a sequence of events. This event sequence contains causally dependent events, as well as contextual causal factors influencing the probability of occurrence of the events in the sequence.

In this approach, a relative spatial relationship between two traffic flows of encountering vessels is accounted for in the way the number of ship-ship encounters N_G is determined. The characteristics of the marine space can furthermore influence the accident risk level if such spatial characteristics are represented in the causal network represented by the BN. For example, the model by Friis-Hansen and Simonsen (2002) includes spatially dependent environmental, infrastructural, and organizational factors such as visibility, weather conditions, traffic intensity, and the presence of a VTS. Other models to estimate the accident occurrence for grounding accidents (Mazaheri et al., 2016) and for accidents of vessels engaged in ice-going operations (Fu et al., 2023) similarly include event sequences and various spatially dependent physical, environmental, infrastructural, and/or organizational characteristics of the marine space in which the vessel encounter occurs, which are accounted for as causal factors influencing the occurrence of the events in the sequence leading to an accident.

7.3.4 Techniques Based on Systems-Theoretic Accident Models

In the IALA guideline G1018, there currently is no waterway risk assessment method based on systems-theoretic accident theories. Similarly, in the academic literature, there has until recently been little focus on developing navigational risk assessment methods based on these theories (Du et al., 2020; Kulkarni et al., 2020). To serve as a basis for discussion, a recently proposed risk analysis methodology for innovative remote pilotage operation in coastal areas, proposed by Basnet et al. (2023), is briefly outlined.

This method relies on the Systems-Theoretic Process Analysis (STPA) and BNs to identify and prioritize causal factors associated with hazards and accidents. The STPA technique is a hazard analysis method based on the STAMP systems-theoretic accident model (see Sect. 7.3.1). In addition to component failures, the technique focuses on understanding hazards occurring due to unsafe interactions of non-failing components. The STPA technique consists of the following steps: (i) defining the purpose of the analysis, that is, defining losses which are unacceptable to the stakeholders; identifying hazards at the system level, which can lead to the identified losses; and specifying the safety constraints to be satisfied to prevent the hazards; (ii) developing a model of the safety control structure (SCS), which is a hierarchical model showing the control actions and feedback loops between system components; (iii) identifying the unsafe control actions (UCAs) by inspecting the

SCS using a set of guidewords; and (iv) identifying loss scenarios, that is, the causal factors that can lead to each UCA. In the method by Basnet et al. (2023), the information obtained through the STPA analysis is converted into a BN model, which then allows quantifying the influences of the causal factors to the losses.

Figure 7.5 shows the SCS for the case study of a remote pilotage operation in a coastal area, with further details concerning examples of control and feedback signals between the controllers and controlled processes given in Table 7.3.

Applying the subsequent steps of the STPA technique to the SCS leads to an identification of the unsafe control actions and the causal factors. These are then causally connected to the system-level hazards, accidents and incidents, and losses using a BN model. The hierarchical structure of this STPA-based BN for the remote pilotage risk assessment in coastal areas is then developed, as illustrated in Fig. 7.6 and Table 7.4, and quantification of the nodes in the BN is performed based on incident and accident data and expert judgment. This allows an analysis of the most important causal factors in preventing the occurrence of system-level hazards, accidents, and losses.

This approach is based on a systems-theoretic view on accident causation, which focuses, as can be seen in Fig. 7.5, on the controllers, controlled processes, and the control and feedback signals between these. These are connected in a non-linear manner, with unsafe control actions, which lead to system-level hazards, being associated with the control and feedback processes as the basis for analysis. In turn, the causal factors are associated with these unsafe control actions, providing reasons why these can occur. In the provided example case study on remote pilotage in coastal areas, it is noteworthy that all causal factors are associated with deficiencies of the controllers or controlled processes (e.g., “fatigue”, “thruster unit failure”) or with the control or feedback signals between these (e.g., “lack of procedures or checklists”, “network failure”). Hence, this method focuses extensively on how

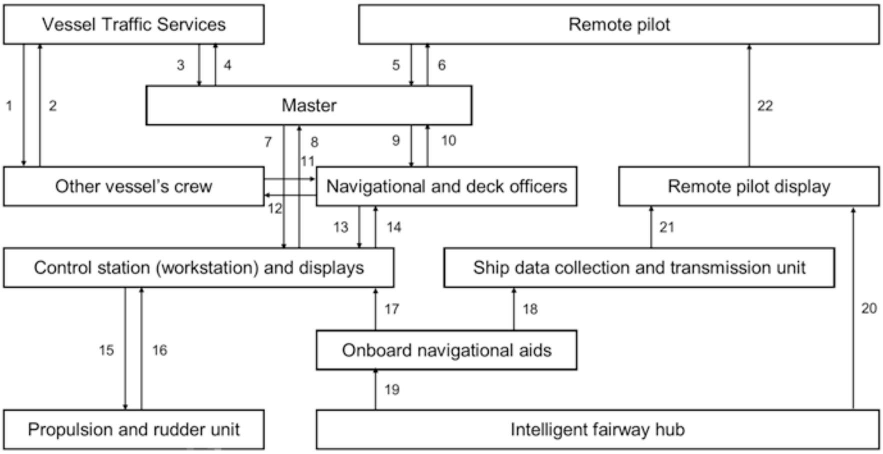

Fig. 7.5 Safety control structure of remote pilotage operations in a coastal area, based on Basnet et al. (2023)

Table 7.3 Control and feedback signals in the safety control structure of remote pilotage operations in a coastal area, based on Basnet et al. (2023)

ID	Examples of control or feedback signals
1	Permit vessel entry, traffic updates and navigation suggestions, monitor fairway traffic
2	Vessel arrival information, manoeuvring information
3	Permit vessel entry, traffic updates and navigation suggestions, monitor fairway traffic
4	Vessel arrival information, manoeuvring information
5	Pilotage plan, master-pilot exchange document, navigation suggestions, traffic updates
6	Pilot card, wheelhouse poster, master-pilot exchange document, updates on crossing situation
7	Assign control
8	Monitor ship dynamics
9	Navigation commands
10	Intended route plan and settings, crossing updates, daily reports, log entries
11	Crossing information
12	Crossing information
13	Navigational instructions
14	Rudder angle and pitch, ship speed, ship systems status
15	Propulsion parameters settings (power, pitch, rudder angle, etc.)
16	Current pitch, power, engine, thruster and rudder angle settings
17	Ship position, speed, heading, under keel clearance, water depth, traffic information, DCPA and TCPA
18	Ship position, speed, heading, under keel clearance, water depth, traffic information, DCPA and TCPA
19	GPS correction, real-time VTS radar images
20	Real-time wind and current speed and direction, wave height and direction, fairway visuals
21	Ship position, speed, heading, under keel clearance, water depth, traffic information, DCPA and TCPA
22	Ship position, speed, heading, traffic information, real-time wind and current speed and direction

infrastructural and organizational aspects of the marine space relate to the waterway risk. However, none of these causal factors are, in the given case study, related to spatially dependent physical or environmental characteristics of the marine space in which the vessels operate.

7.3.5 Techniques Based on Risk Indicators as Accident Theory

In the IALA guideline G1018, the Ports and Waterways Safety Assessment tool is a clear example of a risk assessment technique based on risk indicators. The PAWSA technique sets the basis for a systematic and highly collaborative process, engaging a diverse group of maritime experts, including vessel operators, regulators, pilots,

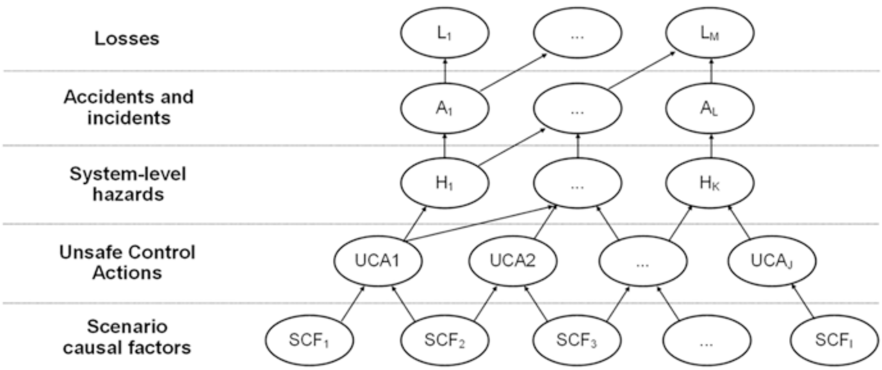

Fig. 7.6 Schematic representation of the hierarchical structure of the STPA-based BN for remote pilotage operations in a coastal area, based on Basnet et al. (2023)

Table 7.4 Examples of losses, accidents and incidents, system-level hazards, unsafe control actions, and scenario causal factors for remote pilotage operations in a coastal area, based on Basnet et al. (2023)

Losses		Accidents and incidents	
L_1	Loss of life	A_1	Collision and contact
L_2	Loss of ship	A_2	Grounding
L_3	Loss of customer satisfaction	A_3	Pilotage delay without accident
System-level hazards			
H_1	Ship violates minimum separation standards or under keel clearance in route		
H_2	Disruption or loss of ship manoeuvrability		
H_3	Lack of prerequisites for conducting remote pilotage operations		
Unsafe control actions			
UCA_1	Pilotage plan and master-pilot exchange document are not sent from the remote pilot to the master before pilotage		
UCA_2	Wrong, incomplete, or unclear pilotage plan and/or master-pilot exchange document is sent from the remote pilot to the master		
UCA_3	Navigation suggestions are not sent from the remote pilot to the master when required during pilotage in shallow or congested water		
UCA_4	Wrong or unclear navigational instructions are sent from the master to the deck officers during congested or shallow water pilotage		
UCA_5	Turn on/off command is not sent from the control station to the main propulsion unit or side thrusters when requested by the deck officers during remote pilotage		
Scenario causal factors			
SCF_1	Lack of skills	SCF_5	Network failure
SCF_2	Fatigue	SCF_6	Displays failure
SCF_3	Lack of procedures or checklists	SCF_7	Thruster unit failure
SCF_4	Issues with traffic data	SCF_8	Control station failure

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

Fig. 7.7 Ports and Waterways Safety Assessment (PAWSA) waterway risk model, based on IALA (2022c)

port authorities, and other relevant stakeholders, to collectively identify, analyse, and evaluate risk factors within the specific waterway (IALA, 2022c).

PAWSA is undertaken in a structured, 2-day workshop where risks and potential mitigation measures are assessed based on inputs from local experts. During these workshops, waterway users and stakeholders discuss and estimate risks levels for 24 different risk factors, organized into 6 risk categories, which are represented in the waterway risk model shown in Fig. 7.7. The participants provide numerical values on a 1–9 scale to quantify their knowledge-based assessments of the status of each waterway risk indicator. Prior to the workshop, a facilitator team gathers, analyses, and prepares a summary of pertinent information to facilitate discussions. This can include, for instance, data on maritime traffic, cargoes, and maritime casualties; official nautical charts and publications; meteorological, hydrographic, and oceanographic records; and (if relevant) proposed or planned projects in or near the waterway in focus.

The experts' numerical ratings are weighted based on a rating of each expert team's expertise, for which a weighting exercise is undertaken first. Subsequently, the baseline risk levels for each of the risk indicators are assessed, that is, the risks in the waterway are assessed without considering the existing mitigation measures. Thereafter, the effectiveness of the existing risk mitigation measures is assessed for each risk indicator. This results in the present level of risk, that is, accounting for the existing risk mitigation. The purpose of this is to evaluate the effectiveness of existing mitigation strategies in reducing the risk level for each factor in the model and to determine whether the risk mitigation strategies already in place adequately balance the resulting risk level. For those risk indicators which are found to be not adequately mitigated or balanced, additional mitigation measures are identified, and it is estimated how effective those new strategies would be to reduce the risk to acceptable levels.

This approach is clearly based on risk indicators, which are used as a basis for an expert-based deliberation on the effectiveness of risk mitigation measures and on the need for additional ones. From Fig. 7.7 it is seen that several indicators concern spatial aspects of the waterway, especially in the categories "Navigational conditions" and "Waterway conditions". Environmentally dependent indicators include wind conditions, water movement, and visibility restrictions. Physical characteristics include the dimensions, configuration, and bottom type of the waterway and the presence of obstructions in the waterway. Infrastructural and organizational aspects relevant to the marine space are also included in the indicators, where, for example, the configuration of the waterway can include technological support for navigation, and the vessel and traffic conditions allow experts to focus on the performance of vessel operators and other waterway users. In practical applications of the PAWSA approach, such as in (USCG, 2021, 2023), experts reflect on these indicators and make observations and recommendations tailored to the local conditions, for instance, commenting on defective aids to navigation or sharp bends in port fairways (related to the "Configuration" indicator) or on the effects of background lighting on visibility due to the presence of commercial infrastructure near the waterway.

7.4 Discussion

The analysis of the waterway risk analysis methods promoted at the international level shows that these are based on a diverse set of accident causation theories. Currently, only methods based on complex linear accident and indicator-based theories are included in the guidance on waterway risk analysis by IALA. In the academic literature, methods have additionally been proposed which are based on relational (accident pyramid) and control systems perspectives. These different theoretical lenses through which accident risks are analysed consider the physical, environmental, infrastructural, and organizational aspects of the marine space in different ways.

In the presented method based on the relational accident theory (Sect. 7.3.2), no aspects of the marine space were considered in assessing the risk of ship collision. In the method based on the complex linear accident theory (Sect. 7.3.3), selected aspects of the environmental, infrastructural, and organizational context are considered in assessing the occurrence of a collision accident. In this method, these spatial aspects are conceived to have a direct causal relationship to the occurrence of an accident. In the control systems-based risk assessment method (Sect. 7.3.4), there is a very strong focus on infrastructural and organizational aspects of the marine space, whereas the presented case study does not include causal factors related to physical or environmental aspects of the marine space. In this theory, the causal factors are related to unsafe control actions, which are associated with feedback loops between the different actors in the safety control structure. Even though these causal factors are linked through linear causal relationships in the Bayesian network represented in Fig. 7.6, the underlying mechanisms of accident causation represented through the analysis focus on the non-linear interactions between actors. Finally, in the presented indicator-based methodology (Sect. 7.3.5), all considered aspects of the marine space are represented, that is, physical, environmental, infrastructural, and organizational aspects can be addressed by the experts in the workshops. In practical applications of this method, the local knowledge of domain experts will direct the focus on particular issues relevant to the case.

The fact that different waterway risk assessment methods are based on different mechanisms to understand accident causation and the observation that different methods include different causal factors to assess the occurrence of an accident raises questions about how reliable and valid these approaches are. In other words, if different methods rely on different factors to make statements about the risk level in a waterway or sea area, which method gives the "correct" result? Or more generally, which method can be relied on to provide useful information to reduce the risk level? In this regard, it is perhaps surprising that, even though relatively many methods have been proposed in the academic literature, there has only been limited focus on the reliability and validity of waterway risk assessment methods (Du et al., 2020). Research where the results of different applications of quantitative methods have been compared for selected case studies has furthermore indicated that different methods can lead to significantly different results (see, e.g., Goerlandt and Kujala, 2014; Rawson and Brito, 2022). This observation does not imply that waterway risk assessments have no use, but it should warn decision-makers not to rely exclusively on one quantification-oriented method and to seek information on risks in wider qualitative processes. This is consistent with views in the wider literature on quantitative risk analysis that such analyses are best thought of as systematic arguments (Apostolakis, 2004) and as a basis for discussion and shared understanding by different stakeholders, not as an accurate representation of an underlying true risk (Aven and Heide, 2009; Rosqvist, 2010).

More generally, the complexity of accident causation and the different theoretical lenses through which accidents in socio-technical systems can be understood have proven a rich ground for academic debate. In particular, the relational accident pyramid and the linear accident theory have received significant criticism. These are challenged, for instance, for their adherence to the "common cause hypothesis", according to which different types of events (near misses, minor accidents, and major accidents) have the same underlying causes, whereas evidence suggests that this hypothesis does not hold in complex systems. Another critique on the relational theory is that evidence suggests that the ratio between the events in different categories is not stable, so that making a mathematical abstraction to derive an estimate of major accidents based on observed near-misses is questionable (Dekker, 2019). The linear theory has been criticized for its simplistic view that complex systems can be divided in separate components and that the occurrence of events can be reduced to a simple failure of such individual components, which does not account for component interaction failures and the conflicting goals of actors in the system (Leveson, 2016). Similarly, while indicators can be a fruitful way to gain insight in the status of systems and serve well as a basis for discussions between stakeholders, the value of such indicator-based methodologies relies on the indicators being representative of the factors which are, in fact, indicative of the occurrence of accidents. Therefore, relying on well-grounded empirical and/or theoretical approaches to decide what indicators to include in the method is important (Rae, 2018).

Currently, there appears to be an academic trend towards understanding accidents based on systems-theoretic views on accidents (Dekker, 2019; Kulkarni et al., 2020). This can be explained because these theories better account for mechanisms which have been observed in accidents, such as the presence of conflicting goals, systems failures due to erroneous interactions between system components, and the multi-level hierarchies of safety controls to dynamically maintain a system in a state of safety. As described in Sects. 7.2 and 7.3, the international guidelines for waterway risk assessment, however, do not currently include methods based on systems theory.

Therefore, it may be a fruitful area of future work to develop and test systems-theoretic waterway risk assessment methods which meet the requirements of different stakeholders, for instance, in terms of the required skill level and the required resources for executing analyses. Other questions which would benefit from future research include how decision-makers use the results of waterway risk assessments to guide their decision-making, for example, whether they use results of different analyses and under which conditions. It is also an open question how decision-makers and stakeholders understand accident causation and how this understanding affects their preference for a specific assessment method or the credibility they assign to its results. As mentioned above, increased research on the reliability and validity of specific waterway risk assessment methods would also be beneficial to better understand the limits and value of the methods in particular case studies. The effectiveness of using different methods as a basis for decision-making would also benefit from future study, especially when they rely on different accident causation theories and when they stress different aspects of the marine space (physical, environmental, infrastructural, and organizational) as causal factors. Also considering the status of the international guideline on waterway risk assessment, particularly Table 7.2, future work on developing guidelines for cost-benefit analysis and risk acceptance would also be useful to support decision-making processes. Whereas some methods allow consideration of risk control options, developing guidelines for selecting risk control options for a particular context and to assess their effectiveness would also be beneficial. Finally, referring to other chapters in this book that address the issue of traditional knowledge and indigenous knowledge systems (see Chap. 6, this volume), a fruitful area of future scholarship relates to how such knowledge can be constructively aligned with the results of risk assessments based on Western scientific views on accident causation.

7.5 Conclusion

This chapter has provided an overview of risk assessment methods for preventing accidents in waterway areas. The international recommended practice for waterway accident risk management is described, including the overall process and a high-level description of the tools included in the IALA Risk Assessment Toolbox. Thereafter, a brief description of some common accident theories is presented, and selected examples of waterway risk assessment methods are outlined to illustrate how these accident theories are reflected in practical risk assessment models and techniques.

The conceptualization of space in terms of physical, environmental, infrastructural, and organizational characteristics relevant to accidents in marine areas is investigated for a selected set of examples for the relational, complex linear, systems-theoretic, and indicator-based accident causation theories. Models based on different theories do not put equal focus on these spatial characteristics, and the related causal factors have a different relation to the accident causation mechanisms in the different theories. In the presented vessel traffic conflict technique, which is based on the relational theory (accident pyramid), no features of the marine space are accounted for in estimating the occurrence of accidents. In the IWRAP model, which is based on the complex linear theory of accident causation, selected environmental, infrastructural, and organizational factors are included in the model. These spatial characteristics are conceived as having a direct causal relationship to the occurrence of a sequence of events, which ultimately results in a navigational accident. In the presented case study on risk assessment for remote pilotage operations, which is based on a control-systems theoretic view on accidents, there is a very strong and elaborate focus on infrastructural and organizational aspects of the marine space. The focus of this analysis is on the unsafe controls in the non-linear interactions between actors in multiple hierarchical levels. In this view, the occurrence of these unsafe control actions is perceived to be influenced by infrastructural and organizational aspects of ship operations in a given marine space. However, in the presented case study on remote pilotage operations, no causal factors related to physical or environmental aspects of the marine space are considered. Finally, in the indicator-based method, no specific causal mechanism is defined through which accidents are considered to manifest. The indicators in the PAWSA method allow experts of various stakeholder groups relevant to the given waterway to identify challenging conditions in the area in a collaborative workshop setting. In this method, all characteristics of the marine space (physical, environmental, infrastructural, and organizational) can be addressed through discussions on the 24 risk indicators included in the PAWSA waterway risk model.

The presented findings have several implications. First, users of the results of waterway risk assessments should understand and consider the limitations of risk assessments. These should primarily be understood as systematic arguments about hazards and risks in waterways, and additional information beyond the risk quantifications should be sought to support decision-making, including the evidence base on which the risk assessments build. Second, considering that waterway risk assessments rely on different accident causation theories and include different causal factors related to the marine space, questions about the reliability and validity of waterway risk assessment methods would benefit from increased academic work. Similarly, increased focus on the selection, use, and credibility of waterway risk assessments in practical contexts would be a fruitful research direction. Finally, future work can be directed towards developing new approaches based on systems-theoretic views on accident causation; developing and documenting guidance on cost-benefit analysis, risk acceptance, and selection of risk control options for waterway risk management; and proposing approaches and processes to constructively align the results of waterway risk assessment based on Western scientific views on accident causation with traditional knowledge and indigenous knowledge systems.

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Chapter 8
Vessel Traffic Management in the Era of Maritime Autonomous Surface Ships and Digitalization: Experiences in European Waters

Anish Arvind Hebbar, Jens-Uwe Schröder-Hinrichs, and Serdar Yildiz

Abstract The safety of navigation in approaches to harbours and along coasts has been a concern since the beginning of maritime trade approximately 2000 years ago. The ways and means for facilitating the safety and efficiency of maritime navigation have undergone a remarkable transformation from lighthouses, first established in 300–280 BC in Alexandria, Egypt, combined with the use of flag signals by ships to announce their arrival when approaching a harbour, through the use of radars for electronic monitoring combined with radio communications by ships, to the use of satellite-based automatic identification systems combined with automated digital information exchange between maritime autonomous surface ships and geographically distant shore control centres.

This chapter examines vessel traffic management from an interwoven, regulatory, and technological perspective. It attempts to trace the evolution of international and European Union regulatory and organizational frameworks in response to the emerging needs of navigational safety and efficiency. In this context, essential technical jargon as key to an understanding of the topic of vessel traffic management is unpacked. Relevant work of the International Maritime Organization, International Association of Marine Aids to Navigation and Lighthouse Authorities, European Commission, and European Maritime Safety Agency (EMSA) is discussed. The transformative role of the European Maritime Single Window environment stands out while traversing the contribution of technological advancements in the maritime domain leading to the development of vessel traffic management system architecture and capabilities. Digitalization and automation in maritime infrastructure are explored for their influence and significance of contribution to navigational safety. The ensuing discussion highlights the role of maritime single windows and the EMSA's SafeSeaNet as key pillars for enhanced situational awareness in European

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waters together with the cutting-edge approach of sea traffic management. The chapter concludes with a fascinating outlook on the vessel traffic management system of the future in the emerging context of the fourth industrial revolution driven by artificial intelligence, machine learning, and maritime autonomous surface ships.

Keywords Vessel traffic management · Sea traffic management · SafeSeaNet · European Maritime Single Window environment · Vessel traffic services · Next-generation vessel traffic management

8.1 Introduction

The safety of navigation, including in port waters and along coasts, has been a concern since the advent of maritime trade dating back at least 2000 years. One of the first well-documented examples of a lighthouse, the Pharos of Alexandria in Egypt, was built in 300–280 BC (Stevenson, 2013: 5). Indeed, lighthouses, shore-side beacons, and buoys continue to serve as passive safety guides for entry into a port, strait, or channel, ships approaching a port traditionally announced their arrival through the use of flag signals. However, flag signalling by itself proved to be inefficient and insufficient for dealing with increasingly dense traffic and adverse weather conditions. Therefore, with the invention of radio, the use of flag signals was promptly replaced with radio communications in the early 1900s. Subsequently, radio detection and ranging during the Second World War and its proliferation in civilian industries witnessed the establishment in 1948 of the world's first harbour-control radar at Victoria Pier, Douglas, Isle of Man (Hughes, 2019), followed by the port of Liverpool, United Kingdom, in 1949. In the 1950s, ports in Europe, and elsewhere, were equipped with shore-side radars and a radio for communicating with vessels, bringing quick gains in efficiency. The Netherlands, for example, proceeded with setting up a radar at the approaches to the port of Amsterdam in 1952 and, by 1956, had established a system of radar stations for oversight of shipping traffic in the entire Rotterdam port area.

Although the ability to keep track of shipping traffic by radar coupled with the ability to transmit navigational messages to ships by radio constituted the first formal vessel traffic systems, these early radar surveillance systems and other aids to navigation lacked the capability to interact and respond to traffic situations. The inadequacies in surveillance and management of maritime traffic were highlighted in the wake of continuing major shipping disasters in Europe attributed to mammoth tankers, from the *Torrey Canyon* and *Amoco Cadiz* to *Erika* and *Prestige* (Djønne, 2023). The development of modern-day vessel traffic management and information systems embracing advancements in radar technology from automatic radar plotting aids to integrated electronic chart displays and information systems and new equipment, such as automatic identification systems for interacting with, advising, and assisting ships, was imperative to ensure the safety and efficiency of navigation.

This chapter examines vessel traffic management from a regulatory and technological perspective. The evolution of regulatory and organizational frameworks for navigational safety and efficiency is charted. Relevant work of the International Maritime Organization (IMO), International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), European Commission (EC), and European Maritime Safety Agency (EMSA) is elaborately discussed. The transformative role of the European Maritime Single Window environment (EMSWe) is examined. The contribution of digitalization and automation to navigational safety is explored. EMSA's SafeSeaNet is highlighted as a key pillar for enhanced situational awareness in European waters together with the cutting-edge approach of sea traffic management. The chapter concludes with an outlook on the vessel traffic management system of the future in the emerging context of the fourth industrial revolution driven by artificial intelligence, machine learning, and maritime autonomous surface ships.

8.2 International Regulatory Framework for Vessel Traffic Management

In matters maritime, IMO, established under the *Convention on the International Maritime Organization* in 1948, provides, among other things, "machinery for co-operation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade, and to encourage the general adoption of the highest practicable standards in matters concerning maritime safety and efficiency of navigation" (IMO Convention, 1948). However, it was not until 1968 that IMO formally considered that port advisory services could make a valuable contribution to safety in harbour approaches and adopted an Assembly resolution recommending to governments that they consider setting up such services in ports and their approaches, particularly in ports and terminals handling oil and noxious or hazardous cargoes (IMO, 1968).

As vessel traffic services began to be implemented in a number of areas around the world, at the operational level, there was a risk of differing procedures likely resulting in confusion for masters of vessels. From a legal perspective, there was the need to ensure that such advisory services did not prejudice the right of innocent passage in territorial waters and were offered on a voluntary basis in waters outside the territorial seas. Guidelines for vessel traffic services (VTS) were, therefore, adopted at the 14th Assembly session of IMO (1986) aimed at harmonization of operational procedures for improving safety and efficiency of maritime traffic. The Guidelines suggested areas where VTS would be particularly appropriate, namely, in the approaches and access channels of a port and in areas having high traffic density, movement of noxious or dangerous cargoes, navigational difficulties, narrow channels, or environmental sensitivity. The Guidelines clarified that navigational decision-making remained the ship master's prerogative. The importance of pilotage in a VTS and reporting procedures for ships passing through an area where a VTS operates were also highlighted. The Guidelines recognized that vessel traffic services may offer different functional interaction levels, namely, as an "information service" by broadcasting or exchanging traffic conditions and safety matters; as a "navigational assistance service" normally at the request of the vessel or of own accord, in difficult navigational or meteorological circumstances; as a "traffic organization service" preventing development of dangerous situations through forward planning of vessel movements; and support of allied activities such as pilotage, search and rescue, and pollution prevention and control. Furthermore, the Guidelines expected that a VTS authority should promulgate appropriately, including through chartlets, local traffic movement rules and regulations, services offered, and area of application.

An update to the guidelines for vessel traffic services (IMO, 1997a) provided greater clarity on tasks that may be performed by a VTS in accordance with the service rendered. In the updated guidelines, the traffic management functions of vessel traffic services were delineated between the primary function and the enforcement function. The primary function was further distinguished as the strategical function of allocation of space by forward planning that can be performed by a traffic organization service and tactical function of assisting manoeuvres to avoid collision or navigational decision-making on board that related to an information service and/or navigational assistance service. The concept of a "traffic image" was introduced in the updated guidelines in the context of the capability of a vessel traffic service to interact with traffic and respond to developing traffic situations and included compiling data on the fairway situation, traffic situation, and vessels. Distinction was also made between a port or harbour VTS and coastal VTS. More importantly, violations of VTS regulatory requirements were to be addressed in accordance with established policy that is consistent with national law.[1] When rendering services, instructions issued by an authorized VTS are expected to be result-oriented, such as to not encroach on the master's responsibility for safe navigation or disturb the traditional relationship between the master and pilot. As such, in any message directed to a vessel by a VTS, it should be made clear whether the message contains information, advice, warning, or an instruction.

Further revised guidelines for vessel traffic services (IMO, 2022a) identified navigational information that can assist onboard decision-making, provide ship

[1] For example, according to the Finnish Maritime Administration *Vessel Traffic Service Act* (623/2005), Section 29—Penal provisions, "A person who deliberately or through carelessness violates orders issued by the VTS authority under section 17(1), provisions of section 21 or orders confirmed in the decision to establish a VTS referred to in section 8 or neglects the notification duty laid down in section 22 or section 23 must be sentenced to a fine for a vessel traffic service violation unless a more severe punishment is laid down elsewhere in law". (https://vayla.fi/documents/25230764/35592998/EN_2005_NR11.pdf/. Accessed 22 February 2024)

traffic information for monitoring and management, and recognize developing unsafe situations that may require a mitigation response to improve the safety and efficiency of navigation in a VTS area and the protection of the marine environment. The imperative to harmonize data exchange, information sharing, and VTS operations with ship reporting systems, ships' routeing measures, and allied services is reemphasized.

Incidentally, although guidelines for vessel traffic services were first adopted by IMO in 1968 and thereafter updated in 1986, 1997, and 2022, VTS were not specifically referred to in IMO's key pillar for maritime safety, the *International Convention for the Safety of Life at Sea, 1974* (SOLAS, 1974), until June 1997, when a new regulation to Chapter V (Safety of Navigation) was adopted by the Maritime Safety Committee (IMO, 1997b) setting out when VTS can be implemented. The new regulation, Regulation 8-2, entered into force, under "tacit acceptance" on 1 July 1999. Shortly thereafter, as part of the substantial revisions to the fifth version of SOLAS, 1974, the existing text of Chapter V was replaced, and a new, revised SOLAS Chapter V on "Safety of Navigation" was adopted in December 2000 and entered into force on 1 July 2002 (IMO, 2000). According to the new SOLAS Chapter V, "Vessel traffic services (VTS) contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment … from possible adverse effects of maritime traffic". However, in keeping with the provisions of the law of the sea, the use of VTS may only be made mandatory in sea areas within the territorial seas of a coastal state. Chapter V, Regulation 12 identifies specific obligations of Contracting Governments:

- to arrange for the establishment of VTS where, in the Contracting Governments opinion, the volume of traffic or the degree of risk justifies such services;
- to follow the guidelines developed by the Organization in planning and implementing VTS, wherever possible; and
- to endeavour to secure the participation in, and compliance with, the provisions of vessel traffic services by ships entitled to fly their flag.

The regulatory framework under SOLAS is complemented by the role and contribution of the IALA in pursuit of its mission to ensure the provision of effective and harmonized marine aids to navigation systems and services worldwide. IALA is essentially an international, technical association, and since its establishment nearly 100 years ago, it has developed several important concepts and systems contributing to the safety of navigation, such as the IALA maritime buoyage system, differential Global Positioning System, automatic identification system (AIS), Very High Frequency (VHF) data exchange system, and vessel traffic services. Guidance on providing marine aids to navigation services and vessel traffic services accounts for more than 250 standards, recommendations, and guidelines published by IALA. The work of IALA relating to VTS is mainly organized through its VTS Committee into five IALA standards, as enumerated in Table 8.1.

It must be highlighted that whereas IALA began in 1957 as a consultative, technical, not-for-profit international organization, its work assumes added significance

Table 8.1 IALA standards for VTS and scope (IALA, n. d.)

Standard	Title	Scope
S1040	Vessel traffic services	VTS implementation VTS operations VTS communications VTS auditing and assessing VTS data and information management VTS technologies VTS additional services
S1050	Training and certification	Training and assessment Accreditation, competency, certification, and revalidation
S1060	Digital communication technologies	Harmonized maritime connectivity
S1070	Information services	Data models and data encoding
S1010	Marine aids to navigation planning and service requirements	Obligations and regulatory compliance Risk management Quality management

since the process has been set in motion for its transition to an intergovernmental organization with the adoption, in February 2020, of the *Convention on the International Organization for Marine Aids to Navigation* (IALA, 2021).

IALA apparently takes a system perspective[2] of vessel traffic services. According to the IALA Guideline on functional and performance requirements for VTS systems (IALA, 2022),[3] a VTS system comprises VTS software, hardware, communications, and sensors but excludes personnel and procedures. A defined set of operational requirements[4] is imperative for the establishment of a VTS system. The functional and performance requirements for a VTS system are derived from the operational requirements. Regarding the potential equipment and sensors for a VTS system, generic guidance is found in the IALA G1111 Guideline Series. The system approach adopted by IALA is key to understanding the contemporary developments in vessel traffic management (IALA, 2022).

[2] The systems approach recognizes that the components that make up a system such as vessel traffic services are inter-related and inter-dependent and require consideration as a unitary whole for system effectiveness.

[3] Guideline G1111 is associated with IALA Recommendation R0128 VTS Systems and Equipment, a normative provision of IALA Standard S1040 Vessel Traffic Services (VTS).

[4] According to IALA (2022, 7), operational requirements imperative for the establishment of a VTS system would include but are not limited to the following:

- Delineating the VTS area and, if appropriate, VTS sub-areas or sectors
- Types and sizes of ships required or expected to participate in the VTS navigational hazards and traffic patterns
- Human/machine interface and human factors, including health and safety issues
- Tasks to be performed by VTS operators and/or supervisors
- Operational procedures, including communication, staffing level, and operating hours of the VTS
- Information sharing and co-operation with external stakeholders
- Legal framework

8.3 Vessel Traffic Management System in the European Union

The earliest regulatory initiative relating to VTS in European waters appears to have been taken in 1993 when Council Directive 93/75/EC (EC, 1993b),[5] Article 5, paragraph 5, obliged vessels entering or leaving a port located in a Member State to make use of local vessel traffic services *where they exist*. A reporting system requiring a specified set of information was introduced for all vessels bound for or leaving a community port and carrying dangerous or polluting goods in bulk or packaged form. The Directive was a follow-up of a common policy objective on safe seas adopted earlier in 1993 (EC, 1993a) for the introduction of a mandatory information system to give EU Member States rapid access to all important information relating to the movements of ships carrying dangerous or polluting materials and to the precise nature of their cargo.

However, a series of major maritime oil spills in rapid succession, resulting in significant deleterious effects on the marine environment, essentially triggered the accelerated implementation of vessel traffic information and management systems in Europe (EC, 1993b). Of particular relevance was the *Erika* oil spill in 1999, a 25-year-old single-hull tanker which severely polluted 400 kilometres of the French coastline and resulted in an exceptionally high damage to fisheries and tourism, making the Erika a major environmental disaster which aroused much public concern about the safety of maritime transport (EC, 2001). Even before Europe could recover from the impacts of the *Erika* oil spill, the *Prestige* carrying some 77,000 tonnes of fuel oil broke up off Spain in 2002, causing major ecological and socio-economic disaster in the coastal areas of Spain, France, and Portugal and the European Parliament adopting a resolution (EC, 2002a) calling for stronger measures that can enter into force more rapidly, besides stating that the Prestige disaster once again underlined the need for effective action at international and European Union level in order to significantly improve maritime safety.

An almost immediate regulatory response to the *Prestige* incident was the significant reinforcement, extension, and amendment of the provisions of Directive 93/75/EC (EC, 1993b) to enhance the safety and efficiency of maritime traffic and better prevent and detect pollution by ships through the establishment of the Community Vessel Traffic Monitoring and Information system (VTMIS system) together with the European Union Maritime Information and Exchange system (SafeSeaNet). The repealing Directive 2002/59/EC (EC, 2002b)[6] followed up on the

[5] Repealed by Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002 establishing a community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC

[6] Annex III to Directive 2002/59/EC is replaced by text in Annex to Commission Directive 2014/100/EU of 28 October 2014 amending Directive 2002/59/EC of the European Parliament and of the Council establishing a community vessel traffic monitoring and information system. OJ L 308 (29 October 2014), p. 2

initiative requiring set up a ship reporting and monitoring system by obliging a mandatory notification 24 hours prior to entry into the ports of Member States and a concurrent obligation on Member States for monitoring ships entering waters in their area of responsibility, including any mandatory ships' routeing systems. The information and reporting system was to be supported by the mandatory use of AIS and long-range identification and tracking (LRIT) systems by ships, with AIS fixed-base stations in EU Member States and a LRIT European Cooperative Data Centre in charge of processing long-range identification and tracking information. The 2002 Directive further required necessary equipment and infrastructure for ship reporting systems, ships' routeing systems, and vessel traffic services to be established by the end of 2007. Furthermore, in a step change, exchanges of data between Member States regarding dangerous and polluting goods carried on board ships would henceforth take place electronically.

SafeSeaNet (EMSA, n.d.) has transformed the efficiency and effectiveness of vessel traffic management in the European Union. It enables the receipt, storage, retrieval, and exchange of information for the purpose of maritime safety, port and maritime security, and marine environmental protection in addition to ensuring the efficiency of maritime traffic and maritime transport. It facilitates the exchange of information in an electronic format across a network of national SafeSeaNet systems in Member States, with the Central SafeSeaNet system established in the European Maritime Safety Agency[7] serving as a nodal point, all of which are linked together by the Union Maritime Information and Exchange network. The system is configured for the automatic transmission of data received at Member States. The central SafeSeaNet facilitates the distribution of electronic messages and exchange or sharing of data covering nearly 480 different elements (see Table 8.1 and 8.2 for a broad overview) in accordance with the VTMIS Directive (EC, 2009b), with other relevant Union legislation serving as performance enablers, inter alia, Directive 2000/59/EC on port reception facilities (EC, 2000); Directive 2005/35/EC on ship-source pollution (EC, 2005); Directive 2009/16/EC on port state control (EC, 2009a); and Directive 2010/65/EU on reporting formalities for ships arriving in and/or departing from ports and LRIT information concerning third country vessels (EC, 2010). Overall, the SafeSeaNet system supports the realization of a barrier-free, European maritime transport space (EC, n.d.).

Among the enablers of the VTMIS, Directive 2010/65/EU on reporting formalities for ships elaborated on the data subject to electronic transmission and introduced the concept of a "single window environment" effective no later than 1 June 2015, linking SafeSeaNet, e-Customs, and other electronic systems, such that all information is reported once and made available to various competent authorities and the Member States. A comprehensive Ship Pre-Arrival Security Information Form was implemented for all ships prior to entry into an EU port. Further, where reporting formalities are required and to the extent necessary for the good functioning of the single window, the electronic systems must be interoperable, accessible, and compatible with the SafeSeaNet system and, where applicable, with the

[7] The Agency (EMSA) is established by a Regulation of the European Commission (EC, 2002c).

Table 8.2 List of reporting obligations for ships in European Union ports and waters as per Regulation (EU) 2019/1239 (EC, 2019)

A. Reporting formalities resulting from legal acts of the European Union	B. Convention on Facilitation of International Maritime Traffic (FAL, 1965) forms and formalities resulting from international legal instruments
Notification for ships arriving in and departing from ports Border checks on persons Notification of dangerous or polluting goods carried on board Notification of waste and residues Notification of security information Information on persons on board Customs formalities Safe loading and unloading of bulk carriers Port state control Maritime transport statistics	FAL form 1: General declaration FAL form 2: Cargo declaration FAL form 3: Ship's stores declaration FAL form 4: Crew's effects declaration FAL form 5: Crew list FAL form 6: Passenger list FAL form 7: Dangerous goods Maritime declaration of health

computer systems stipulated for a paperless environment for customs and trade in the European Union (EC, 2010).

Further, to enhance the identification and monitoring of ships through reporting formalities, EU Member States are obliged by the VTMIS Directive (EC, 2002a), Article 23, to work together with the Commission to put in place, where necessary, mandatory reporting systems (MRS), mandatory maritime traffic services, and appropriate ship's routeing systems, with a view to submitting them to IMO for approval. They are also required to collaborate, within the regional or international bodies concerned, on developing LRIT systems.

Subsequently, as experience was gained and technical advancements progressed, SafeSeaNet evolved into a more integrated information system and a platform facilitating the convergence and interoperability of maritime systems and applications, including space-based technologies combining information from other EU monitoring and tracking systems (CleanSeaNet, the EU LRIT Data Centre, and THETIS) and also from external systems (e.g. satellite AIS). These developments, effective November 2015, played a central role in the development of the voluntary Common Information and Sharing Environment (CISE)[8] for the European maritime domain, through a collaborative process in the Union (EC, 2014).

[8] The CISE network spans across seven relevant sectors and user communities relating to border control and "maritime surveillance" including transport, environmental protection, control of fisheries and borders, general law enforcement, customs, and defence. CISE was explained with four key words: interoperability; improving situational awareness; efficiency; and subsidiarity. Interoperability means that the EU has to find a way to enable the information exchange between sectoral systems. Improving situational awareness implies that the information obtained in CISE should improve the situational awareness within the EU. Efficiency means that CISE should contribute to avoiding duplication in the collection of information and reducing the financial costs for all actors involved; specifically, more than 50% of gathered information was collected solely by defence communities and the maritime safety and security community. Subsidiarity means the enhancement of coordinating the collection and verification of information from all their agencies.

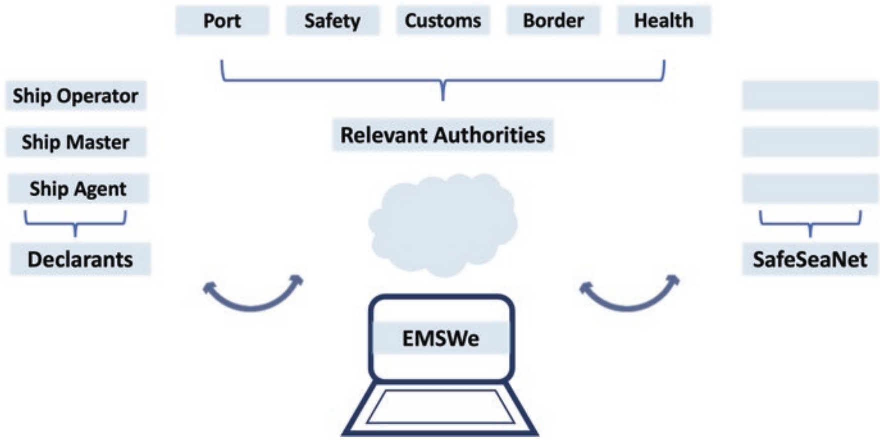

Fig. 8.1 European Maritime Single Window environment (EMSA, n.d.)

The single window concept implemented in 2015 was rechristened as the European Maritime Single Window environment (EMSWe) (Fig. 8.1) in 2019 via Regulation (EU) 2019/1239 (EC, 2019), repealing Directive 2010/65/EU. The corresponding maritime National Single Window (mNSW) implemented in each Member State constitutes the comprehensive reporting entry point (listed in Table 8.2) for maritime transport operators, performing the functionalities of data collection from the declarants and data distribution to all relevant competent authorities and providers of port services. The front-end interfaces of the mNSWs on the side of the declarants are harmonized at the EU level by the use of common interface software for system-to-system exchanges of information developed at the EU level. The European Commission developed the interface module and provides updates when needed, while the Member States are charged with the responsibility of integrating and managing the interface module and updating the software as and when new versions are provided by the Commission. An easy-to-use graphic user interface (see examples in Figs. 8.2 and 8.3) with common functionalities forms part of the mNSWs for manual reporting by declarants (see, e.g. EMSA, 2014; Swedish Maritime Administration, n.d.).

The mNSWs are supported by several common databases that enable the reuse of the information provided and facilitate the submission of information by declarants. The EMSWe Central Ship Database (Table 8.3) includes a reference list of ship particulars and their reporting exemptions, as reported to the respective mNSW, and currently holds information on more than 300,000 ships, including more than 120,000 active ships. The Central Geographical Database manages, stores, and shows the Member States and EMSA maritime applications reference geographical features that include geographical areas of common interest, such as the exclusive economic zone, fisheries areas, traffic separation schemes, and territorial waters. The submission of information by declarants is facilitated by the Common Location Database that holds a reference list of location codes, including the United Nations

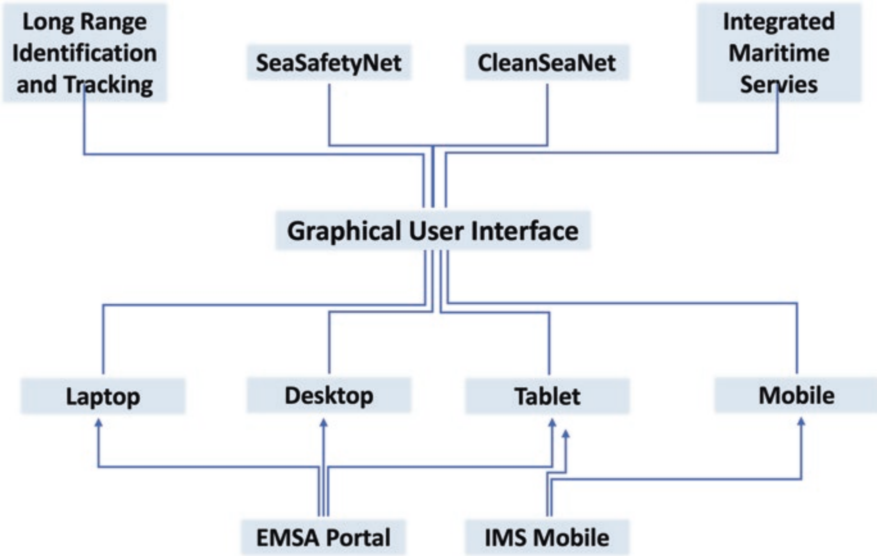

Fig. 8.2 SafeSeaNet Ecosystem Graphical User Interface (EMSA, n.d.)

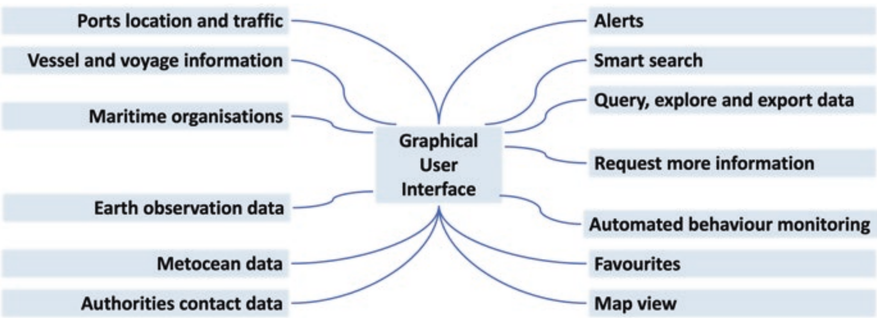

Fig. 8.3 SafeSeaNet Ecosystem Graphic User Interface data layers and functions and services (EMSA, n.d.)

Code for Trade and Transport Locations (UN/LOCODE), the SafeSeaNet-specific codes, and the port facility codes as registered in the Global Integrated Shipping Information System of IMO. Furthermore, the Common Hazmat Database incorporates a list of dangerous and polluting goods that are to be reported to the mNSW, and the Common Ship Sanitation Database enables receipt and storage of data related to the Maritime Declarations of Health. EMSA provides the elaboration of the EMSWe specifications, namely, the EMSWe dataset, which includes all the information that might be requested by national authorities or port operators for administrative or operational purposes when a ship makes a call in any port of the

Table 8.3 EMSWe central ship database: data sources and set of ship information (EMSA, 2022)

Central ship database: data sources	Central ship database: set of ship information
SafeSeaNet (ship data from port call notifications, incident reports, ship mandatory reporting systems and exemptions) EU LRIT Cooperative Data Centre (ship data from the EU LRIT ship database) THETIS (ship data from port state control inspections) Fishing vessels record (information on EU fishing vessels) Commercial data provider IHS Markit (information on commercial ships of 100 GT and above)	Ship identification (e.g. IMO number, name, MMSI number, fisheries IR number) Inmarsat call number Ship type (different code lists: IHS, UN, PSC) Construction details (dates of ship construction) Status (from IHS and THETIS) Dimensions (e.g. gross tonnage, length overall, length between perpendiculars) Dimensions for fishing vessels (classes) Company information (ISM company, owner) Technical details (e.g. hull, engines) Technical details for fishing vessels (e.g. fishing gears, segment) Port state control information (bans) Fisheries control information (equipment and license indicators) Reference list for fishing vessels (RFMO and SANCO lists)

IHS IHS Maritime (formerly Lloyd's Register-Fairplay), *IR number* information request number for fishing vessel, *ISM company* company as defined in the IMO International Safety Management (ISM) Code, *MMSI* Maritime Mobile Service Identity, *PSC* port state control, *RFMO* Regional Fisheries Management Organization, *SANCO* Directorate General Health and Consumers, European Commission, *THETIS* EMSA port state control inspection database, *UN* United Nations Fleet segmentation, of the fishing fleet, as adopted by the Food and Agriculture Organization of the United Nations, is based on the dominant gear used in terms of percentage of time: more than 50% of the time at sea using the same fishing gear during the year. The segments include polyvalent vessels using more than one gear, with a combination of passive and active gears, seiners, dredgers, trawlers, and longliners

European Union and includes technical specifications, standards, and procedures for the EMSWe.

A pilot study on interoperability (EMSA, 2022) mapped together all pieces of information that were common to several reporting formalities in EU waters to apply the reporting-once principle. The study resulted in the definition of an overall dataset of 478 individual data elements in EMSWe that were structured in 46 datasets (Table 8.4).

As of January 2024, the common web interface, the SafeSeaNet Ecosystem Graphical User Interface (SEG), provides access to all EMSA's maritime applications and datasets including SafeSeaNet, Integrated Maritime Services, LRIT, and CleanSeaNet (Fig. 8.2). The SEG implements system-to-system interfaces. Its functionalities enable users to benefit from integrated data flows, options for data visualization, and services such as automated vessel behaviour monitoring (Fig. 8.3).

Table 8.4 Overview of the EMSWe data model (EMSA, 2022)

First tier	Second tier	Third tier	Fourth tier	Fifth tier
Message header	Issuer party			
	Authenticator	Authenticator location		
Voyage	Itinerary	Additional security measures taken		
		Previous port facility, period of stay		
	Person on board	Identity or travel document		
		Visa		
		Crew effects		
		Health details		
	Ship	Inmarsat number		
		Ship registry details		
		ISSC		
		Company security officer	CSO information	
		IMO company		
	Ship-to-ship activity	Security measures applied *In lieu of the approved plan*		
		Activity geographical coordinates		
	Agent at port	Agent at port communication Agent at port address		
	Transport equipment			
	Cargo	Cargo item details	Dangerous goods	DG subsidiary risk
				DG package
				DG additional information
			Transport equipment	
			Cargo item package	
		Transport contract		
		Ship to shore activity		
	Ships stores			
	Waste	Waste item		
	Additional information			
	Primary purpose of call			
	Health	Sanitary measures		
	Maritime transport statistics			
	Customs			

8.4 Contemporary Developments in European Vessel Traffic Management

Continuous enhancement of the maritime picture is an ongoing endeavour for the European Union, while VTS and other maritime service providers seek detailed, reliable real-time information about occurrences at sea to be able to perform their duties effectively. Two advanced functionalities accessed through EMSA's SEG—automated behaviour monitoring and STAR Tracking—are noteworthy. Automated behaviour monitoring algorithms for "near real-time" detect specific or anomalous behaviours (such as spoofing positions, not reporting position, sudden change of heading, sudden change of speed, etc.), alerting users within approximately 15 minutes, and "historical" automated behaviour monitoring algorithms use archived position reports or position reports from a database of specific, detected situations and events, for example, detecting port calls globally. Automated behaviour monitoring algorithms can be helpful in vessel tracking and monitoring for verification of reporting obligations or for early warning of potentially dangerous situations affecting the safety of navigation. STAR Tracking is the main ship tracking application at EMSA. It processes and stores up to 1700 ship position reports per second on a 24/7 basis from different ship reporting systems including MRS, terrestrial-AIS, satellite-AIS, LRIT, and vessel monitoring systems. Among other functionalities, STAR Tracking can merge ship positions to form ship tracks and correlate datasets with available positions to identify vessels whenever possible.

Interoperability is a current area of focus in EU vessel traffic management. Despite advancements in the provision of vessel traffic services, a lack of interoperability among a dense multitude of VTS and MRS in European waters means that ships crossing several mandatory ship reporting systems and VTS areas along their route are often required to report similar information in each area. Currently, in European waters, there are more than 16 IMO-adopted MRS in addition to more than 100 VTS, which causes avoidable reporting burdens for ships, impacts the efficiency of coastal station operators' services, and hinders awareness of their areas of control. Figure 8.4 illustrates the case of multiple mandatory ship reporting requirements for a vessel on voyage from Alexandria, Egypt, to Gdansk, Poland. Harmonized implementation of VTS and MRS, particularly in European waters is, therefore, an urgent imperative.

With regard to interoperability, a pilot project in the European Union (EMSA, 2022) demonstrated the ability for ships to electronically submit MRS and VTS reports and reuse the information available in SafeSeaNet. The pilot project, which was joined by 14 coastal states in the European Union, also explored new technologies, such as VHF Satellite Data Exchange (VDE-SAT), to communicate MRS and VTS reports between ships and the shore (Fig. 8.5).

An outcome of the EU pilot project on the facilitation of ship-to-shore reporting was a proposal to the IMO Expert Group on Data Harmonization (EGDH 2/5) in September 2020 to carry out modelling of the dataset related to the ship reporting

Fig. 8.4 Example of MRS reporting along a route from Alexandria (Egypt) to Gdansk (Poland) (EMSA, 2022; ESRI, 2016, 2018)

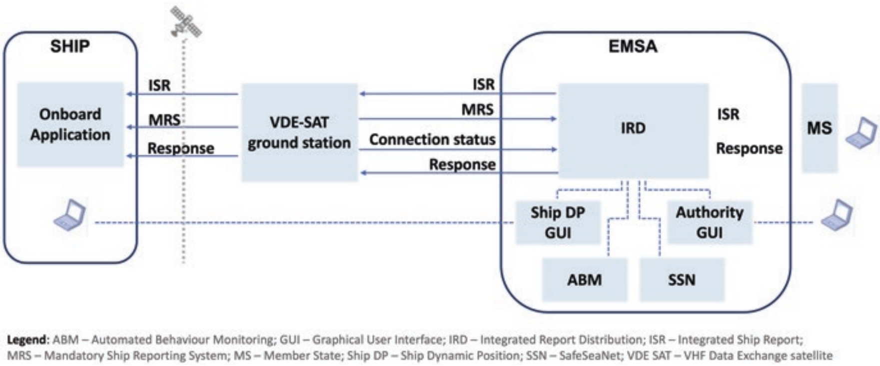

Fig. 8.5 Concept of the VHF Satellite Data Exchange capability (EMSA, 2022)

system (IMO, 2020). Consequently, a new IMO dataset on ship reporting systems (Resolution A.851(20)) was submitted to the 46th session of the IMO Facilitation Committee (9–13 May 2022) (IMO, 2022b, c) for inclusion in the IMO Compendium on Facilitation and E-Business, which is a tool for software developers that design the systems needed to support electronic data exchange of information. By harmonizing the data elements required during a port call and by standardizing electronic messages, the IMO Compendium facilitates the exchange of information between ships and the shore and the interoperability of single windows, reducing the administrative burden for ships linked to formalities in ports.

Sea traffic management (STM) is yet another concept that emerged from an EU co-financed project in 2019 to improve the exchange of information between ships and between ships and the shore for increased situational awareness and to act as a catalyst for improving the safety of navigation in the Baltic Sea area in addition to optimizing capacity utilization and just-in-time operations. The set of systems and procedures at the core of the STM concept attempting to guide and monitor sea traffic is a route exchange protocol and an organized traffic management entity called the Sea Traffic Management Centre that is similar

Table 8.5 Sea traffic management: brief description of potential services (Swedish Maritime Administration, n.d.)

Service	Description
Route cross-check	Can be done prior departure or on arrival at designated area Can include, under keel clearance, air draught, no violation of no-go areas, maritime safety information and compliance with mandatory reporting
Route optimization	Get ships' route optimized from different service providers Would include best route in terms of weather forecast, surface currents, fuel consumption, no-go areas regarding draft, areas with sensitive nature, conflicts with other ships' routes, etc.
Enhanced monitoring	Shore centres will be able to detect if planned schedule is not kept or if ship deviates from planned route Shore centres can foresee possible dangerous situations and suggest route modifications (geographic and/or speed) due to traffic or other impending conditions
Ship-to-ship route exchange	Will provide the intentions of other ships Will provide a new tool which helps the officer on watch to plan ahead, foresee possible dangerous situations, and reduce route detours due to traffic conditions
Port call synchronization	Makes sure that the ship does not arrive before the port is ready Ship and port exchange estimates to find the first available time when all resources to handle the port call are available Early estimate to let ship adjust speed and save fuel Ultimate goal: all ships arrive just in time and no need for anchoring
Port call optimization	Key actors make port call plans transparent Efficiency in the whole process chain Improved resource utilization for all port actors

to air traffic management. STM seeks to integrate the entire shipping and port logistics chain by using standards and creating interoperability, thereby opening the possibility for offering a number of value-added services including route cross-checks, route optimization, ship-to-ship route exchange, port call synchronization, port call optimization, winter navigation, and importing pilot routes as briefly described in Table 8.5 (Swedish Maritime Administration, n.d.; Lind et al., 2014).

8.5 An Outlook on Vessel Traffic Management System of the Future

In the future, there will likely be an exponential demand for vessel traffic management systems (VTMS) in increasingly complex maritime systems, particularly for real-time monitoring and analysis of vessel traffic. In a digitalized world, the huge volumes of data generated by onboard sensors, AIS, radar systems, and weather systems, among others, underscore the need for data-driven solutions. In terms of system capabilities, the burgeoning demand on VTMS comprises, among others, enhanced operational efficiency and safety; predictive capabilities for minimizing risks and optimising routes for fuel efficiency and just in time arrivals; identifying abnormal vessel behaviours; detecting potential threats for aiding timely intervention; and monitoring and ensuring compliance with regulatory norms. Future supervision of navigation in coastal areas by a VTMS will require the ability to manage a massive amount of data and receive, elaborate, and return navigation strategies to each ship. Emerging trends in VTMS to achieve multifarious demands include the infusion of advanced technologies such as artificial intelligence and machine learning and increasing the integration of VTMS with other systems such as weather monitoring and systems for enhanced safety, security, and efficiency. Market research on current trends suggests that by the end of 2030, the market share of VTMS installations, maintenance, and operations worldwide will reach approximately USD 7.13 billion (Gupta, 2023).

The next-generation VTMS (NG-VTMS) is expected to serve fully automated ports. NG-VTMS would deploy artificial intelligence to identify traffic hotspots and intervene, when needed, by warning ships to avoid hotspots and to take alternate routes up to 30 minutes in advance. High-speed computing would aid in quickly analysing data from multiple sensors, such as radar and video surveillance, and supporting time-sensitive decision-making to prevent collisions. Maritime, 5G base stations would provide secure and reliable real-time data transfers between ships as well as between ships and the port, enabling NG-VTMS to ascertain precise and real-time information on vessel movements (Hirdaramani, 2023).

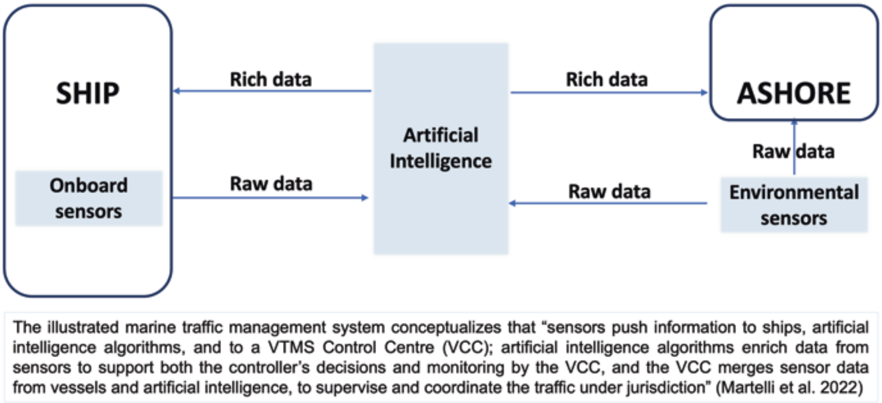

Fig. 8.6 Concept of a marine traffic management layout for autonomous ships (Martelli et al., 2022)

With the growth of Industry 4.0[9] and ships with different degrees of autonomy, with uncrewed vessels likely operating in the same environment as human-crewed vessels, new and technologically advanced VTMS will need to be established along coasts worldwide. With the advent of maritime autonomous surface ships, advances in VTMS design are imperative to facilitate autonomous ship interactions for safe navigation. Martelli et al. (2022) conceptualize a VTMS framework for autonomous ships founded on four pillars: navigation control, orchestration, communication, and data analysis as illustrated in Fig. 8.6 with an accompanying brief explanation. However, such a VTMS framework for maritime autonomous ships is easier to conceptualize than implement, with design challenges spanning the pillars of the framework.

To sum up the discussions in this chapter, through collaborative initiatives and cutting-edge digital platforms and a shared vision of safety and efficiency, Europe appears to be charting a pioneering path in redefining VTM for the future. The harmonization of practices, strong emphasis on interoperability, adoption of digital tools, and forward-thinking regulatory frameworks echo Europe's commitment to remaining at the forefront of global maritime safety and efficiency.

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[9] Industry 4.0 is a major driver of the fourth industrial revolution, also referred to as the New Industrial Revolution. It refers to the current phase of rapid technological transformation comprising cyber-physical systems which focus significantly on interconnectivity, automation, machine learning, and real-time data.

According to the World Economic Forum, the current paradigm change goes beyond Industry 4.0: "The Fourth Industrial Revolution … is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres". The technologies today include artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. https://www.unido.org/sites/default/files/files/2020-06/Unido_industry-4_A4_09.pdf

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Part III
Marine Spatial and Environmental Planning

Chapter 9
Area-Based Management for Arctic Shipping Governance: An Exploratory Study

Weishan Wang and Claudio Aporta

Abstract This chapter will conduct an exploratory study to analyse how Arctic marine traffic can be governed through area-based management and collaborative planning among the government, Indigenous peoples, and industry partners. It is expected that the Northern Low-Impact Shipping Corridors initiative can provide an opportunity for Canada to enhance safe maritime navigation while respecting Indigenous rights and taking into Indigenous perspectives. Moreover, Canada's existing area-based management practices can provide insights into Arctic shipping governance and inform better governance of the Corridors initiative. One example to compare and examine is the Voluntary Protection Zone (VPZ) for shipping along the west coast of Haida Gwaii.

Transport Canada has announced that, during the next phase of Canada's Oceans Protection Plan, the focus of the Corridors' development will concentrate on the following areas, namely, creating a governance framework for shipping corridors, and identifying priority areas for vessels to avoid. This chapter will identify several issues and challenges that will be encountered during the implementation and governance of the Corridors initiative. This chapter explores how these identified issues have been addressed within the VPZ through an unprecedented collaboration between the Council of the Haida Nation, the provincial and federal governments, and the maritime shipping industry. The findings will include several potential policy directions for supporting better decision-making and governance in the Corridors initiative.

Keywords Marine shipping · Arctic shipping · Shipping governance · Marine spatial planning · Indigenous rights · Indigenous peoples · Indigenous engagement · Governance framework · Shipping risks · Collaborative planning · Northern

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Low-Impact Shipping Corridors initiative · Voluntary Protection Zone · Policy · Decision-making · Area-based management

9.1 Introduction

Shipping is both the result and the enabler of industrial and commercial development in the Arctic. As climate change increasingly affects the Arctic, biophysical changes in the region open prospects for marine shipping in different sectors, such as fishing, resource exploitation, commercial transportation, community resupply, cruise tourism, research, and government ice-breaking services (AMSA, 2009).

Since the 1990s, the Arctic marine traffic volume and the total distance travelled by vessels in the Canadian Arctic have increased dramatically (Dawson et al., 2014, 2018; Pizzolato et al., 2014, 2016). Longer navigable seasons and the substantial growth of marine shipping activities have generated some benefits for Arctic coastal communities (mostly Inuit), as less limited (by ice) shipping seasons open up opportunities for the exploration and exploitation of resources that once were out of reach or too expensive to pursue. Inuit communities across the Inuit Nunangat (Inuit homeland in Canada) are experiencing and will likely experience some economic and social benefits (Argetsinger, 2020) as a result of increasing shipping, such as increased job opportunities, income, community resupply, and infrastructure development (Alvarez et al., 2020; Kelley & Ljubicic, 2012; PCT, 2016). While the benefits (present and potential) are not to be neglected, the risks associated with increased shipping are prominent. More concretely, increased shipping activities in Arctic waters may lead to accidents (e.g. grounding, collision, and oil spills) due to the lack of visibility, infrastructure, and charted waters, with negative impacts on marine life and ecosystems (Vincent et al., 2023). Shipping in remote waters could also result in challenges for search and rescue operations and pose challenges for sovereignty, government surveillance, as well as political tensions (Boylan, 2021). Furthermore, the disturbance caused by shipping activities and by the development of infrastructure (ports) can disrupt traditional Indigenous practices, such as hunting or fishing, impacting local cultures (Dawson et al., 2020; van Luijk et al., 2022).

Thus, proper governance arrangements that can mitigate these risks and involve Indigenous peoples from the outset are required for Arctic shipping. However, shipping governance is inherently complex, particularly in the Arctic context, where Indigenous rights are significant factors in decision-making. Arctic shipping governance involves international and domestic maritime laws and policies, Indigenous/Aboriginal rights laws, international conventions, and industry standards (Chircop, 2022, 2023; see also Chap. 5 in this volume), as well as a multitude of interests across different geographic, economic, legal, and political scales, from local to global. In the Arctic, shipping governance encompasses a multitude of stakeholders and rightsholders within a broader context of geopolitical, environmental, and economic interests (AMSA, 2009; VanderZwaag et al., 2008). Thus, it is necessary (and urgent) to explore how Arctic shipping governance can be improved through a more dynamic and equitable governance strategy that can balance multiple interests and, especially, move in the direction of reconciliation with Indigenous peoples (Wang, 2023a).

Transport Canada has implemented the Oceans Protection Plan (OPP) with an emphasis on facilitating stronger partnerships among Indigenous peoples and coastal communities (TC, 2023). Progress has been made to engage Inuit in Arctic shipping governance, with several initiatives under the OPP involving Inuit contributions of knowledge, observations, and perspectives in Arctic shipping. These include the Northern Low-Impact Shipping Corridors (the Corridors) initiative, the Cumulative Effects of Marine Shipping (CEMS) initiative, the Enhanced Maritime Situational Awareness (EMSA) initiative, and the Proactive Vessel Management (PVM) initiative (see Chap. 6 in this volume). Among them, the Corridors initiative, which is in the consultation stage, is currently the most likely opportunity to advance Arctic shipping governance by enhancing intergovernmental collaboration, facilitating Indigenous engagement, and applying area-based measures. During the second phase of the OPP, Transport Canada announced its plans for the Corridors initiative, with a focus on both delivering a governance framework and identifying priority areas for vessels to avoid (TC, 2022). However, implementing such large-scale integrated planning in the Canadian Arctic, where resources are unavailable, infrastructure is not well developed, and community capacity is limited, presents many challenges.

Canada has abundant experience adopting integrated ocean governance frameworks and applying area-based measures for marine shipping (Wang, 2023b). These initiatives and measures have proven to be advantageous in governing marine shipping activities through government collaboration and Indigenous peoples' engagement (Zhang, 2022). For example, the Voluntary Protection Zone (VPZ) for shipping along the western coast of Haida Gwaii established a collaborative approach to enhancing navigation safety, minimizing risks, and protecting the marine environment (Transport Canada, 2021). This chapter aims to undertake an exploratory analysis to explore how the VPZ may be used as a model to inform the Corridors initiative by enhancing Indigenous engagement, establishing a robust governance framework for shipping corridors, and identifying priority areas for implementation.

9.2 Methodology

This chapter relies on an exploratory case study approach, which involves analysing and contrasting two or more cases to identify similarities, differences, patterns, or relationships between them. The exploratory case study approach has been widely adopted by researchers in ocean studies, including in those analysing coastal countries' policies, regulations, and approaches for integrated ocean governance (e.g. Balgos et al., 2015; Juda, 2003; Rothwell & VanderZwaag, 2006). Researchers have also analysed marine spatial planning practices in Canada and other coastal countries (e.g. Rodriguez, 2017; Sander, 2018). Other studies have explored area-based measures for shipping on Canada's three coasts (e.g., Wang, 2023b) and examined the trends, perspectives, policies, and regulations for shipping in the Canadian Arctic (e.g. Hartmann, 2018; Lasserre & Têtu, 2015; Olsen et al., 2019).

The cases analysed in this article consist of the successful trial of the VPZ for shipping on the North Pacific coast and the Corridors initiative in the Canadian Arctic (which is still under consultation and development). This chapter aims to provide a deeper understanding of how marine shipping activities are governed on different coasts and how to improve the development and governance of the Corridors initiative by having an exploratory discussion on the case of Haida VPZ. The subsequent sections of this chapter provide descriptions of the Corridors initiative and the VPZ trial, respectively. A dedicated discussion section identifies the challenges may be encountered in the implementation of Arctic shipping corridors and critically analyses how the insights gained from the VPZ trial can improve the governance of the Corridors initiative, fostering better practices and outcomes.

9.3 Selected Cases

9.3.1 Northern Low-Impact Shipping Corridors Initiative

The Northern Low-Impact Shipping Corridors initiative represents the latest interdepartmental governance initiative or framework introduced by Canada in the context of Arctic shipping. The development and implementation of the Corridors initiative is a collaborative effort led by three federal departments/agencies, namely, Transport Canada (TC), the Canadian Coast Guard (CCG), and the Canadian Hydrographic Service (CHS). The Corridors initiative is part of the OPP, Canada's national, whole-of-government plan to protect Canada's coasts and waterways while enhancing maritime safety, the growing the marine economy, and developing Indigenous partnerships (TC, 2023). The Corridors initiative is dedicated to minimizing the adverse impacts of shipping on the sensitive Arctic marine environment (e.g. wildlife habitats) and on significant socio-cultural areas identified by Arctic Indigenous communities (TC, 2017).

Drawing upon historical shipping data derived from the automatic identification system (AIS), these corridors are proposed as voluntary shipping routes (Chénier et al., 2017). If implemented, these corridors will provide maritime operators with navigation recommendations, guidelines, and enhanced services. Compared to other comprehensive and integrated ocean governance initiatives and specific area-based measures for shipping in Canada, the Corridors initiative stands out because it not only adopts strategic policy frameworks but also develops a series of shipping lanes with site-specific planning to guide the development and operations of Arctic shipping activities (PCT, 2016). By doing so, the Corridors initiative is capable to enhance the overall management and regulation of shipping practices in the Canadian Arctic waterways.

However, most of the designated corridors overlap with marine areas that are traditionally and currently used and occupied by Inuit (Dawson & Song, 2023). Consequently, there is significant potential for conflict between Inuit marine uses and shipping activities within the corridors. For instance, increasing maritime traffic may pose negative impacts on Arctic marine ecosystems (e.g. pollution, disturbance, and collision) and threaten Inuit traditional fishing, hunting, and on-ice traveling activities (Dawson et al., 2020; van Luijk et al., 2022). Large vessels and their need for search and rescue capacity also pose challenges to small and scattered Inuit communities (ICC, 2014). To reduce conflicts and enhance Indigenous engagement, federal departments initiated an Indigenous consultation process (TC, 2022) and funded research projects to optimize the Corridors initiative by integrating Inuit perspectives on shipping. The Arctic Corridors and Northern Voices (ACNV) project has developed a research partnership to collect, interpret, and apply Inuit knowledge and values to refine the location of shipping corridors (Dawson et al., 2020). Developing such a research partnership is critical to the governance of the Corridors initiative and helps to ensure that the corridors will be designed in a way acknowledges and considers the rights and interests of local communities while promoting Arctic shipping's sustainable development and coexistence with the natural environment. To be specific, the development and governance of the shipping corridors should be able to respect Inuit rights that are articulated in the *Constitution Act 1982* (CA, 1982) and the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP, 2007), including rights to using land/water and resources; environmental protection; decision-making; giving Free, Prior, and Informed Consent (FPIC); and applying indigenous knowledge (Wang, 2023a).

In 2022, Transport Canada announced its plans for the Corridors initiative, including delivering a governance framework and identifying priority areas for vessels to avoid (TC, 2022). Although three federal departments have spent many years preparing for the Corridors initiative, it is foreseeable that it will encounter multiple challenges, such as increasing compliance rate in remote waters, ensuring Indigenous engagement in shipping governance, and building up search and rescue capacity, when implementation starts. Meanwhile, Canada's previous and existing integrated ocean planning and governance initiatives, along with specific area-based measures for shipping, can inform better governance of the Corridors initiative in terms of enhancing intergovernmental collaboration, facilitating Indigenous engagement, and applying area-based measures (Wang, 2023b).

9.3.2 Voluntary Protection Zone for Shipping

The Pacific coast of Canada experiences a high volume of ship traffic encompassing a variety of vessel types, including cargo ships, tankers, tugs, and passenger vessels (Clear Seas, 2020). In particular, the southern coastal waters have experienced significant maritime activities due to vessel traffic into the ports of Vancouver and Seattle (Erbe et al., 2014). In contrast, northern coastal waters, although presently less congested, are expected to face increased traffic owing to the growing cruise tourism sector and proposals for the development and expansion of container ports and liquefied natural gas facilities (NRCan, 2023).

The intensification of marine shipping operations has presented considerable challenges to the marine ecosystem and local communities on the Pacific North Coast. Extensive research has been conducted to examine the adverse effects resulting from ships, the potential risks associated with accidents, and pollution related to shipping activities (e.g., underwater noise, pollutants, wastes, and oil spills) (Erbe et al., 2014; Irvine & Crawford, 2011). These investigations shed light on the environmental impacts of marine shipping while also acknowledging its potential influence on the well-being and livelihoods of local and First Nation communities. Currently, efforts have been made to address these concerns through enhanced comprehensive planning, regulatory frameworks, and collaborative initiatives between governments, First Nations, and industry partners (e.g. the Pacific North Coast Integrated Management Area (PNCIMA, 2007) and the Marine Plan Partnership for the North Pacific Coast (MaPP) (Diggon et al., 2022)).

Haida Gwaii is an archipelago situated on the edge of the continental shelf off the northern coast of British Columbia. Foreseen growth in vessel traffic in waters within and surrounding Haida Gwaii has amplified shipping hazards and potential adverse effects (e.g. ship-based pollution and accidents including collision, grounding, and oil spills), raising the need to develop a more effective governance framework to mitigate shipping risks and enhance marine safety (Robertson et al., 2020). Since time immemorial, Haida Gwaii has served as the ancestral home of the Haida people. This unique marine environment not only sustains the essence of the Haida Nation but also shapes the well-being of Haida communities and culture, acting as an integral component of their identity and livelihoods. For more than four decades, the Haida Nation has engaged in cooperative efforts with provincial and federal governments to establish and enforce co-management strategies pertaining to their terrestrial and marine resources. Nevertheless, it was not until the occurrence of the M/V *Simushir* "near miss" incident in 2014[1] that the Haida Nation formally brought forth the matter of vessel drift and grounding (Robertson et al., 2020, 1). Subsequently, the Haida Nation actively participated in tripartite shipping discussions involving federal and provincial agencies, as well as industry associations (Haida Marine Planning, 2016; Zhang, 2022). These efforts to govern marine traffic led to a pilot project under the PVM initiative, which sought to address the issue of vessel drift grounding accidents along the coastlines encompassing Haida Gwaii. By proactively managing vessel operations and implementing measures to mitigate risks, this pilot project aimed to safeguard the coastal areas surrounding Haida

[1] The M/V *Simushir* "near miss" incident refers to a significant maritime event in which the Russian container ship *Simushir* lost power and came dangerously close to running aground and potentially causing an environmental disaster off the coast of Haida Gwaii (Rowland, 2014).

Gwaii and minimize the potential ecological and socio-cultural impacts associated with vessel grounding incidents.

A collaborative effort between Nuka Research (an environmental consulting firm) and the Council of the Haida Nation Marine Planning Program resulted in the delivery of a comprehensive report addressing marine traffic patterns and potential measures for traffic management in Haida Gwaii. One of the proposed strategies involved the establishment of a designated safe distance offshore to effectively mitigate shipping risks (Robertson et al., 2020). The findings of this study directly informed the development of the Voluntary Protection Zone, one of the two pilot projects of OPP's PVM initiative. The VPZ, which commenced in September 2020, was a voluntary trial to introduce specific guidelines for safe navigation in the region. Within the VPZ, vessels with a gross tonnage (GT) of 500 or greater are asked to maintain a minimum distance of 50 nautical miles (M) west of Haida Gwaii, with the exception of those engaged in trade between ports in British Columbia, Washington, and Alaska, which were requested to maintain a distance of 25 M from the shore (VPZ-25) (TC, 2021). Similarly, cruise ships were advised to maintain a distance of 12 M from the shore (VPZ-12). Fishing vessels, tugs, and barges were exempted from this trial. The participation of vessels in the VPZ trial was entirely voluntary and contingent upon the absence of anticipated adverse consequences to safe navigation and the well-being of the vessel, crew, passengers, and cargo.

The VPZ trial showed notable success. Evaluations conducted by Nuka Research and the Council of the Haida Nation Marine Planning Program (2022) as well as the monthly monitoring reports (see, e.g. Voluntary Protection Zone for Shipping West Coast of Haida Gwaii, 2023) revealed an impressive overall compliance rate exceeding 90 per cent within the VPZ. This achievement highlights the significant willingness of vessel operators to adhere to the designated guidelines within the VPZ. There were instances of ships entering the VPZ, but the primary reasons were associated with weather-related considerations and safety concerns (Nuka Research and the Council of the Haida Nation Marine Planning Program, 2022). The VPZ trial concluded on 31 October 2021, but the VPZ remains in effect until further notice.

The process of developing and executing the trial for the VPZ encountered multifaceted challenges within the realm of shipping governance. A paramount challenge pertains to the coordination of First Nations, diverse government departments, and industry partners to govern shipping activities and ensure marine safety within waters that remain utilized by First Nations. The development of Arctic shipping corridors confronts comparable challenges, particularly in regard to the imperative of informing and partnering with Inuit communities in the context of shipping governance. It is suggested that conducting an in-depth comparison among these cases would contribute to the ongoing discussion on the development of the Corridors initiative. Some insights derived from the successful VPZ trial hold the potential to enhance the governance of Arctic shipping corridors.

The VPZ trial and the Corridors initiative have commonalities. Firstly, they address the governance of shipping activities within waters traditionally utilized by Indigenous peoples over extensive periods. Indigenous communities historically conduct traditional practices within these marine areas and stand to be variably impacted by increased shipping. Both initiatives need to respect Indigenous rights and mitigate impacts from shipping activities on Indigenous communities. Second, the VPZ trial encompasses expansive offshore regions, while the Corridors initiative establishes an extensive network of shipping corridors across major waterways in the Canadian Arctic. Lastly, the voluntary nature of these initiatives introduces challenges concerning implementation and compliance. With these similarities, insights drawn from the VPZ trial possess the potential to refine the implementation of the Corridors initiative.

However, it would be inappropriate to directly apply the lessons gleaned from the VPZ to the Corridors initiative due to the different contexts in which they have evolved. Firstly, the Canadian Arctic's maritime navigational environment presents heightened challenges, characterized by less charted waterways with extensive ice cover for the majority of the year and the remoteness of numerous small, scattered Inuit communities. These communities face significant constraints in terms of search and rescue capabilities, infrastructure, communications, and trained personnel. In the contrast, the Haida Nation has a long history of negotiations with provincial and federal governments, coupled with over two decades of collaboration and partnership-building. Second, while the Haida Nation is governed by the Haida Council, Inuit communities, while sharing cultural values and experiences, have place-based and wide-ranging diversity in knowledge, priorities, and needs. For instance, the four Inuit co-management organizations, established under the Nunavut Land Claims Agreement (NLCA, 1993), occasionally hold differing perspectives on the ways to work with federal and territorial governments and on the respectful and sustainable development of Arctic shipping corridors. Inuit do not have one voice regarding Arctic shipping governance. Consequently, there is an urgent need for supplementary consultation processes involving not only TC, CCG, CHS, and Inuit communities but also various Inuit organizations. The following discussion delves into an analysis of these parallels and disparities, extracting lessons that could improve the Corridors initiative.

9.4 Discussion

Transport Canada has recently proposed two prospective pathways to enhance the implementation of the Corridors initiative, namely, the development of a governance framework and the identification of priority regions (i.e. priority areas for vessels to avoid) for pilot projects (TC, 2022). These endeavours are expected to encounter certain challenges. The discussion here delves into the challenges encountered during the implementation of Arctic corridors while simultaneously examining how the experience from the VPZ trial can contribute to improved decision-making and policy formulation for the Corridors initiative.

9.4.1 Development of a Governance Framework

Under Section 10(c) of the *Canada Shipping Act, 2001*, the Minister of Transport or the Minister of Fisheries and Oceans and the Canadian Coast Guard may enter into an agreement with any local authority or "other entity authorized to act on behalf of an Indigenous group" to delegate powers, duties, or functions under the Act (CSA, 2001). The Corridors initiative could and should become an opportunity for respecting Inuit interests and protecting Inuit rights, especially their decision-making rights, in Arctic waters. The governance framework of the Corridors initiative should be able to reflect Section 10(c) and enable TC to delegate certain powers to Inuit representative organizations and authorities with respect to their interests, such as pollution prevention, environmental protection, and maintaining the safety and security of life within the corridors. However, a policy or governance framework to support Inuit in exercising their decision-making rights in the shipping governance regime is not yet in place.

A model to consider could be the tripartite governance arrangement among First Nations, federal and provincial governments, as well as industry partners on the North Pacific Coast that led to the successful VPZ trial. This tripartite arrangement relies on a long-term tradition of co-governance and years of effective communication and collaboration between the three parties. For nearly four decades, the Haida Nation has been pursuing inherent rights and co-management regarding marine resources and ocean spaces (e.g. co-management of marine protected areas and closing of herring fisheries) (Akins, 2017; Jones et al., 2017; Mays, 2021; von der Porten et al., 2019). The Gwaii Haanas Agreement with the Government of Canada (1993) marked the beginning of co-management relationship and power sharing agreement between Parks Canada and the Haida Nation. The Archipelago Management Board seeks to ensure that there is a mandated 50 per cent Haida representation in the planning, operation, and management of Gwaii Haanas (Lee, 2012, 8). In 2010, the Government of Canada and the Haida Nation signed the Gwaii Haanas Marine Agreement, which defines the scope and concept of Haida Gwaii marine areas. These written agreements and policy frameworks ensure formalized working protocols and facilitate collaboration with other federal departments and jurisdictions (Zhang, 2022). VPZ represents a project in the new era of co-management between the Government of Canada and the Haida Nation under the Reconciliation Framework Agreement for Bioregional Ocean Management and Protection (RFA) and in light of Canada's adoption of *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP, 2007) and the establishment of comprehensive ocean planning initiatives, such as the PNCIMA and the MaPP. In particular, the MaPP initiative has provided the Haida Nation with opportunities to get involved in shipping governance. For instance, in collaboration with Transport Canada and the shipping industry, the Council of the Haida Nation has developed a geographic response plan and several associated area-specific strategies regarding marine traffic (MPA Network, 2022). The VPZ is one of the outcomes of these efforts, and its success relies on long-term relationships of mutual understanding and cooperation.

There are three main factors that allow the tripartite arrangement to evolve and facilitate these initiatives, namely, a four-decade-long history of collaboration, a written agreement to recognize the rights of the Haida Nation in marine spaces, and a platform to ensure that the Haida Nation has equal decision-making power. However, involving Inuit as one voice in a tripartite framework may not align well with the political context of the Arctic. As briefly discussed above, Inuit, with their diverse communities and organizations, may have distinct perspectives and voices regarding their priorities. Establishing a tripartite governance system for Arctic shipping corridors could encounter even more intricate challenges compared to the VPZ. Nevertheless, this does not negate the possibility of establishing a collaborative governance framework to coordinate resources and capacity of Inuit organizations, federal and territorial governments, and shipping industry partners for the Corridors initiative. Inuit have also spent decades pursuing their inherent rights and have signed four comprehensive land claims agreements that incorporate principles of co-management. To develop a collaborative governance framework for the Corridors initiative, there are two aspects that need future research and study.

First, to facilitate Canada's implementation of the *United Nations Declaration on the Rights of Indigenous Peoples Act* (UNDRIP Act, 2021; Government of Canada, 2023) and Section 10(c) of the CSA 2001, additional research should examine how authority can be delegated to different Inuit organizations and how to identify the role of Inuit representative organizations and authorities in governing Arctic shipping activities within the corridors. In this sense, there is a need to clarify which Inuit organization or organizations can represent the voice of the Inuit in Arctic shipping governance. The Nunavut Marine Council (NMC), a mechanism to coordinate the four co-management boards on issues affecting marine spaces, is well positioned to become a key voice in representing Inuit and shaping shipping policy-making (NMC, 2018; Wang, 2023a). Future research may need to explore how NMC can coordinate four Inuit co-management boards, engage federal and territorial governments and industry partners, and even have decision-making power delegated.

Second, the delegation of authority within the governance framework may need to be underpinned by a written agreement. In a context where Inuit communities may still lack the resources and capacity to initiate a co-governance framework for Arctic shipping, it is therefore worth exploring whether the Corridor initiative can provide an opportunity to create a formal written document outlining the collaborative framework between government departments and Inuit for Arctic shipping governance, specifying mechanisms for Inuit involvement and support. This framework can be developed through a memorandum of understanding agreement or potentially through a set of guidelines under the terms of reference for a collaborative working group or governance framework. If so, the establishment of a written agreement or framework that considers Inuit as a government partner within the context of the OPP has the potential to engender a sense of trust-building at the institutional level. However, in this process, since Inuit Nunangat comprises four land claims regions—namely, Nunatsiavut (Northern coastal Labrador), Nunavik (Northern Quebec), the territory of Nunavut, and the Inuvialuit region of the

Northwest Territories—reaching such a written agreement would inevitably entail negotiations with Inuit organizations from these four Inuit regions, making it considerably more challenging.

In summary, creating a governance framework for the Corridors initiative may be a high priority during the next phase of planning and implementation. Such a framework could fundamentally set the stage for Canada to fulfil its reconciliation commitment to Indigenous peoples and establish a foundation for co-governance between Inuit authorities and federal and territorial governments. If the governance framework can be written and signed by all parties, as is the case with the VPZ, it will have much greater legal and political implications and will be of great benefit to the future development of the Corridors initiative.

9.4.2 Identifying Priority Areas for Implementation

At the time of writing, the Corridors initiative was still in its planning and consultation stages. It will take time for the Corridors initiative to receive recognition from other Arctic states, intergovernmental organizations, and industry partners. To accelerate this recognition process, various essential measures can be considered. These include the initiation of pilot programmes and public awareness campaigns, demonstrating vessel operators' efforts to comply with these voluntary policies, and enhancing engagement with stakeholders and rightsholders. Among these measures, it is crucial to implement the Corridors initiative in priority areas through the development of pilot projects that can be tested and readjusted. As planned by TC, the second phase of the Corridors initiative will focus on piloting and implementing the project (TC, 2022). Finding pilots for a project as comprehensive and large as the Corridors initiative is a key step and a challenging task in advancing its implementation. As described above, Haida Gwaii is one of the two pilot sites chosen for the PVM initiative under the OPP, and the reasons and factors behind making this selection should provide some insights for the Corridors initiative as well.

One of the triggers that allowed Haida Gwaii to be selected as a PVM pilot was the strong motivation and need of the Haida Nation to protect their waters after the M/V *Simushir* incident. According to lessons learned from the *Simushir*, federal and provincial agencies, Haida Nation, and industry stakeholders jointly discussed possible measures to prevent the occurrence of another such incident. This, combined with the fact that shipping data in this area had already been collected by Clear Seas, provided the basis for the pilot plan (Clear Seas, 2020; Robertson et al., 2020). Moreover, there are a number of ongoing projects and initiatives related to shipping governance in the region, such as the emergency towing initiatives and the Haida Gwaii Marine Awareness Project (Robertson et al., 2020). The possible linkages between several projects have, in a way, also contributed to the implementation of the VPZ trial.

Therefore, future research on the Corridors initiative could start by analysing where potential priority areas for implementation are. Based on lessons learned from the VPZ trial, areas of socio-cultural significance and interest to Inuit and areas where there are already other OPP initiatives in place (such as the CEMS initiative, the EMSA programme, and the PVM initiative) would be a place to start. Because of these existing initiatives, some Inuit communities have a little bit more capacity than other Inuit communities to support the future implementation and governance of the Corridors initiative. TC should consider pioneering pilot projects of the Corridors initiative in these communities or locations. For example, Cambridge Bay (in Nunavut) is hosting pilot projects under the PVM initiative and the CEMS initiative (Greenley, 2021), thereby having pre-existing cooperation between the government and the Inuit community. The Corridors initiative can benefit from the PVM initiative or other community-based initiatives, as they all use policies and area-based measures (i.e. identifying a protection zone and slow down measures with these zones) to govern marine traffic and share common goals and objectives in mitigating shipping risks, supporting environmental protection, enhancing safety and security, and protecting Inuit well-being (Greenley, 2021). Furthermore, through the ACNV project, Cambridge Bay community members have identified some socio-culturally significant areas, and these areas need to be avoided (Carter et al., 2018). Ultimately, initiating a pilot project in Cambridge Bay may bring opportunity for expanding the implementation of the Corridors initiative to include other Inuit communities, representing a viable approach to promote the development and governance of marine shipping within the corridors.

9.4.3 Building Capacity and Applying Inuit Knowledge in the Corridors Initiative

Knowledge co-production through the use of both scientific and Inuit knowledge has been used as a practical way to inform Arctic shipping governance and optimize the location of shipping corridors (Dawson et al., 2020). However, Inuit knowledge and stewardship practices in evidence-based and science-based decision-making processes have yet to be incorporated in Arctic shipping governance, although Inuit have used their knowledge and local experience and played a major role in emergency response to oil spills, coastal clean-ups, and search and rescue at the local/community level (ICC, 2023).

Successful experiences from the VPZ trial and the MaPP prove that there are opportunities to incorporate First Nations knowledge into interactive spatial planning tools and apply Indigenous knowledge to inform better planning and decision-making. The Haida Gwaii Marine Plan 2015 shows that Indigenous ethics, values, and visions regarding spatial zoning can be incorporated to improve marine management practices in the context of reconciliation (MaPP, 2015). The VPZ trial proves that Indigenous knowledge and values can be combined with well-established government practices to facilitate shipping governance and enhance marine safety through appropriate tools and systems. Thus, as discussed above, due to different contexts, while there is some risk in the matter of directly applying VPZ's experience to the Corridors initiative, some insights should be drawn from the experiences of the VPZ and its area-based management approaches, especially regarding how to build capacity to empower Inuit organizations to apply Inuit knowledge and participate effectively in shipping governance through area-based management.

First, there is a need to establish robust collaboration between Inuit organizations, federal and territorial governments, and industry partners to create comprehensive training and capacity-building initiatives that specifically address the distinctive needs and challenges faced by Inuit communities. This collaboration can be facilitated through outreach programmes at the community level, ensuring active participation and awareness among individuals within Inuit communities.

Second, there is a need to develop knowledge co-production platforms and programmes that foster the sharing of Inuit knowledge and experiences. This aims to bridge the existing gap between Inuit knowledge and ongoing shipping governance initiatives. It is imperative for government departments and industry partners to provide essential training, funding opportunities, and technical resources, including advanced data visualization and management technologies, to support Inuit organizations in using these knowledge co-production platforms.

Furthermore, the development of long-term strategies for capacity-building is essential. This approach acknowledges that empowerment is an ongoing process, requiring the continual recognition of Inuit inherent rights and even a written commitment to respecting Inuit decision-making rights within the realm of Arctic shipping governance.

9.5 Conclusion

In the near future, the Corridors initiative can become an opportunity for Canada to facilitate shipping governance within Arctic waterways through knowledge co-production, Inuit engagement, and a planning framework that includes area-based measures and policies to cope with the dynamics and reflect local realities of the Canadian Arctic. Notably, the establishment of low-impact shipping corridors in Arctic waters has been already initiated by the Arctic Council based on circumpolar Arctic states' area-based measures and policies for shipping (PAME, 2021). Canada's Corridors initiative has the potential to demonstrate the potential for improving Arctic shipping governance through the true participation of Indigenous communities and developing guidelines and policies that can be extended outside the Canadian experience.

The future implementation of the Corridors initiative will face challenges, particularly in light of the limited capacity of Inuit communities along the designated corridors. Therefore, it is imperative to draw insights from Canada's other shipping governance practices. Within this context, this chapter proposed that the use of the VPZ for shipping west of Haida Gwaii and governance arrangement or framework of the VPZ can be explored to effectively facilitate and enhance the governance of shipping corridors in the Arctic. The findings of this study reveal that the Corridors initiative significantly benefits from VPZ practices, particularly in three key aspects: the establishment of a tripartite governance framework, ways to identify priority areas, and appropriate and respectful integration of Inuit knowledge.

With retreating sea ice, Canada's Arctic shipping may shift from focusing on small-scale and destinational operations to developing potentially large-scale trans-oceanic operations. The more work the Canadian government does now, the better it will be able to support this transition, protect Indigenous peoples, and ensure an environmentally friendly, efficient, and sustainable future for Canadian Arctic shipping.

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Chapter 10
Exploring Risk Governance Deficits for Marine Oil Spill Preparedness and Response in Canada

Jessica Cucinelli, Floris Goerlandt, and Ronald Pelot

Abstract Preparedness for and response to marine oil spills are important for protecting the Canadian marine areas, as these risks can have significant environmental, economic, and socio-cultural impacts. The vast sea areas under Canadian jurisdiction, combined with the wide range of maritime activities taking place in these, pose significant challenges to efficient preparedness and response planning and operation. The multitude of national and international regulatory commitments, rightsholder and stakeholder interests, and prospects of changes to shipping activities especially in the Canadian Arctic due to climate change justifies the need for effective societal risk governance and risk management. This chapter first outlines the regulatory context and governance practices for spill preparedness and response in Canada, focusing on the legal basis, responsibilities of different actors, engagement activities with rights- and stakeholders, and decision-making processes. It then highlights how these measures can be understood as an implementation of area-based management tools to mitigate oil spill risks. Subsequently, risk governance deficits in the preparedness and response governance and management systems are explored through interviews with experts from federal civil services, based on commonly found deficits identified by the International Risk Governance Council. The results indicate that the main deficits pertain to factual knowledge about risks, evaluating risk acceptability, implementing and enforcing risk management decisions, organizational capacity for risk management, and handling dispersed responsibilities. The results serve as a basis for developing initial strategies for alleviating the deficits, improving oil spill preparedness and response and environmental protection, and guiding further scholarship.

Keywords Area-based management of oil spill risk · Environmental prevention and response national preparedness plan · Exploratory research · Indigenous knowledge · International Risk Governance Council · Maritime environmental protection · Maritime transportation · Oil spill · Oil spill response organizations ·

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Pollution preparedness and response · Risk acceptance · Risk assessment · Risk governance · Risk governance deficits, risk management · Risk perception · Shipping risk · Stakeholder engagement

10.1 Introduction

Through provisions in international conventions, of which Article 194 of the *United Nations Convention of the Law of the Sea* (UNCLOS) is arguably one of the most important, coastal states have a duty to set up and operate measures to prevent, reduce, and control pollution of the marine environment (UNCLOS, 1982). While there are many sources of marine pollution, the release of toxic substances, especially oil spills, is a particularly severe threat to coastal states, due to their possibly very severe implications to ecosystems, economic activities, and socio-cultural activities and artefacts, over multiple time frames (Chang et al., 2014). Hence, a coastal state's capacity for preparedness and response to marine oil spills is an essential component for protecting the marine environment and for the sustainable use of marine ecosystem services.

It is therefore unsurprising that there has been significant academic and industrial efforts to understand the fate and impacts of oil to marine environments (Wang et al., 2021), to develop models and techniques to monitor and predict oil spill drift and fate (Nelson & Grubesic, 2020), to propose risk assessment and management models and tools (Parviainen et al., 2021; Wu et al., 2021), and to develop technologies and strategies to respond to spills (Li et al., 2016; Yang et al., 2021).

Whereas most academic work on oil spill risk management has focused on empirical work, developing risk analysis models and decision support tools, there is a growing recognition of the importance of scholarship on organizational and inter-organizational risk management. For instance, Sepp Neves et al. (2015) proposed an oil spill management process based on the ISO 31000 risk management standard, Haapasaari et al. (2015) proposed a proactive approach for shipping risk policy-making tailored to the case of the Gulf of Finland, Pålsson et al. (2018) presented a social network analysis of the Swedish oil spill crisis management collaboration, and Parviainen et al. (2019) proposed an approach to incorporate ambiguity and multiple stakeholder frameworks of understanding risk into a collaborative knowledge production process.

The importance of improving the risk governance of oil spill preparedness and response in Canada is evident considering the effects of climate change, where ongoing and projected decreases in ice cover in Arctic Sea areas (Barnhart et al., 2016) provide prospects for increased shipping activity in the Canadian Arctic. Most traffic in the Canadian Arctic has historically been destinational (Brooks & Frost, 2012), which will likely only modestly increase due to population growth and given a moratorium on licences for exploration and exploitation of oil and gas resources in the area (CIRNAC, 2018). Uncertainties about transit shipping are largely due to technical, economic, and geopolitical factors (Lu et al., 2014; Beveridge et al., 2016; Fedi et al., 2018; Lasserre, 2022), but there are signs that in some market segments, notably cruise and tourism industries, activities are increasing (Halliday et al., 2018; Palma et al., 2019). Hence, there is a need for continued focus on preparedness and response to marine oil spills and improved governance processes to assess and manage the associated risks.

A useful approach to improve risk governance practices is systematically investigating deficits in existing risk governance mechanisms, which can be used as a basis for formulating pathways for improvement. This has been done, for instance, for search and rescue risk governance at offshore platforms in Greece (Liaropoulos et al., 2016), and frameworks have been proposed in the risk research community to systematically investigate such deficits (IRGC, 2009).

Recognizing qualitative differences in risk types in terms of complexity, uncertainty, and ambiguity, and anticipating the differences this nuanced and contextual understanding of risk implies for designing and implementing appropriate risk governance approaches, for example, in how risk perceptions are considered and what stakeholders are involved in the decision-making processes and in what capacity, has been put forward as essential qualities for good risk governance (Renn et al., 2011; Aven & Renn, 2018). Consequently, Goerlandt and Pelot (2020) explored the application of the International Risk Governance Council's Risk Governance Framework (IRGC-RGF) in the context of shipping risks in the Canadian Arctic, proposing it as a suitable basis for making progress in improving governance of shipping risks in Canada. Cucinelli et al. (2023) performed an exploratory analysis of risk governance deficits for search and rescue in Canadian marine areas, using the IRGC framework as a basis for identifying deficits.

Considering the above, the aim of this chapter is to systematically explore the risk governance deficits of oil spill preparedness and response in Canada, distinguishing practices in different Canadian marine areas. This is done using an exploratory research design approach, through a combination of interviews with experts from federal agencies and a literature search, building on a framework of risk governance deficits based on the IRGC-RGF (IRGC, 2009), to ensure compatibility with the exploratory work by Goerlandt and Pelot (2020). To support this analysis, the current risk governance practices are briefly described, including the legal basis, roles and responsibilities, engagement mechanisms, and decision-making processes.

The remainder of this chapter is organized as follows. In Sect. 10.2, the research methods and protocols are described. Section 10.3 gives a brief overview of the current practices of oil spill preparedness and response governance in Canada. Section 10.4 presents the results of the analysis, distinguishing deficits related to the assessment and understanding of risks and deficits concerning risk management. A discussion is provided in Sect. 10.5, interpreting the findings from an area-based management (ABM) perspective and outlining some implications for policy and management and an initial set of directions for improving the current situation. It also highlights some study limitations and avenues for future work.

10.2 Methods and Data

An exploratory research design is selected to achieve the stated objectives in Sect. 10.1. Such a design is appropriate for generating insights into a phenomenon to determine its main features, serving as a basis to generate initial ideas and direct further research (Bhattacherjee, 2012). It is an appropriate design for knowledge domains about which there is no systematic understanding, which is the case for risk governance of marine oil spill preparedness and response in Canada.

A multi-method approach, combining insights from semi-structured interviews and the literature, is used as data to generate a systematic understanding of risk governance deficits of oil spill preparedness and response in Canada, similar to, for example, Fedi et al. (2018) and Cucinelli et al. (2023). Interview questions were developed based on a list of risk governance deficits (IRGC, 2009), allowing consistency in terminology and enabling the drawing of comprehensive insights. The specific research protocols and methods, and the scientific basis of these risk governance deficits, are described in the following subsections.

10.2.1 Research Methods and Protocols

Data for this research was obtained through interviews and a literature search. The interview participants were selected using a purposive and snowball sampling approach, with experts recruited from civil servants in federal government agencies. According to Gläser and Laudel (2009), experts are people with special knowledge of a phenomenon or topic of concern. A strong understanding of rightsholder and stakeholder engagement, risk-based management, and maritime risk analysis in the context of oil spill preparedness and response was taken as selection criteria. Candidates were identified based on a three-stage process: (1) prior contacts of the research team, (2) the Government Electronic Directory Services, and (3) snowball sampling, where candidate participants are asked to recommend further candidates. In total, members of four organizations agreed to participate in the study: Transport Canada (TC), the Department of Fisheries and Oceans-Canadian Coast Guard division (DFO-CCG) (national and Pacific), and Environment and Climate Change Canada (ECCC). Nine interviews with experts from these organizations were conducted from September to December 2021. Notwithstanding the relatively small number of interviews, the organizations covered the intended target audience with the needed expertise well, in line with the selected exploratory research design. Ethics approval for the interview research was obtained under the authors' institutional ethics board under file REB#2021-5458.

Participants received an interview package including a consent form, glossary, project objectives, and interview questions in advance to facilitate obtaining more in-depth, well-considered, and reliable responses. The interviews lasted between 1 h and 1.5 h each and were conducted via an online meeting platform. The participants were asked to provide their insights on possibly present risk governance deficits listed in the Appendix to this chapter. A conversational strategy to interviewing was adopted, seeking a natural flow of interaction (Patton, 2002), an approach generally used when interviewing experts (Berry, 2002; Fedi et al., 2018). Each deficit in the Appendix was handled in sequence. If no issue was identified, nothing was reported, and the next deficit was considered. All interviews were recorded, transcribed verbatim using O-Transcribe software, and deidentified to the agency level, according to research protocols described by Ograjenšek (2016). Thematic analysis was then conducted using NVivo software (Wong, 2009), which allows the identification, analysis, and reporting of themes within the textual data. The key themes emerging from the considered list of risk governance deficits of the Appendix were then aggregated and reported, noting also in which response regions they were identified.

The results from this interview study were further supplemented using a narrative literature review process (Grant & Booth, 2009). The search was primarily devised from government documents published by the participating agencies (i.e., TC, DFO-CCG, and ECCC) using the Government of Canada virtual directory (Government of Canada, 2021). Additionally, documents published in Novanet Catalogue, an online consortium of academic libraries in Nova Scotia, Canada, were also considered (Novanet, 2022). This platform was selected over other popular academic search engines such as Scopus or Web of Science (Li et al., 2021) as it contains additional Canadian book and report sources. Search words for both inventories included combinations of the following: "marine", "oil spill", "preparedness and response", "risk governance", "risk governance deficits", "International Risk Governance Council (IRGC)", "Ship-Source Oil Spill Response and Preparedness Regime", and "Oceans Protection Plan (OPP)". The results of this search were filtered based on information provided in the abstract. Subsequently, the documents were thematically analysed using the same classification of risk governance deficits shown in the Appendix, using the NVivo software similar to the interview transcriptions.

10.2.2 Questions for Semi-structured Interviews: IRGC and Risk Governance Deficits

The questions used in the semi-structured interviews focus on understanding risk governance deficits. This of course requires a sound basis of what constitutes good governance of risks and why it is important. There is a wide consensus in the literature that stakeholder and rightsholder inclusion, equity, transparency, and accountability are key aspects of good risk governance (Graham et al., 2003; Ammann, 2006; UNDP, 2010). These four pillars promote trust-building and increase the legitimacy of risk-informed decision-making (Aven & Renn, 2018).

While there is varied literature on the principles of good governance, the risk governance deficits considered for our purposes are derived from the IRGC-RGF, shown in Fig. 10.1, and described in detail by IRGC (2017). This is a comprehensive framework for risk governance in democratic societies based on extensive academic work in the risk research community (Klinke & Renn, 2002; Renn et al., 2011). It consists of pre-assessment, appraisal, characterization and evaluation, and management phases and considers these in the context of cross-cutting aspects,

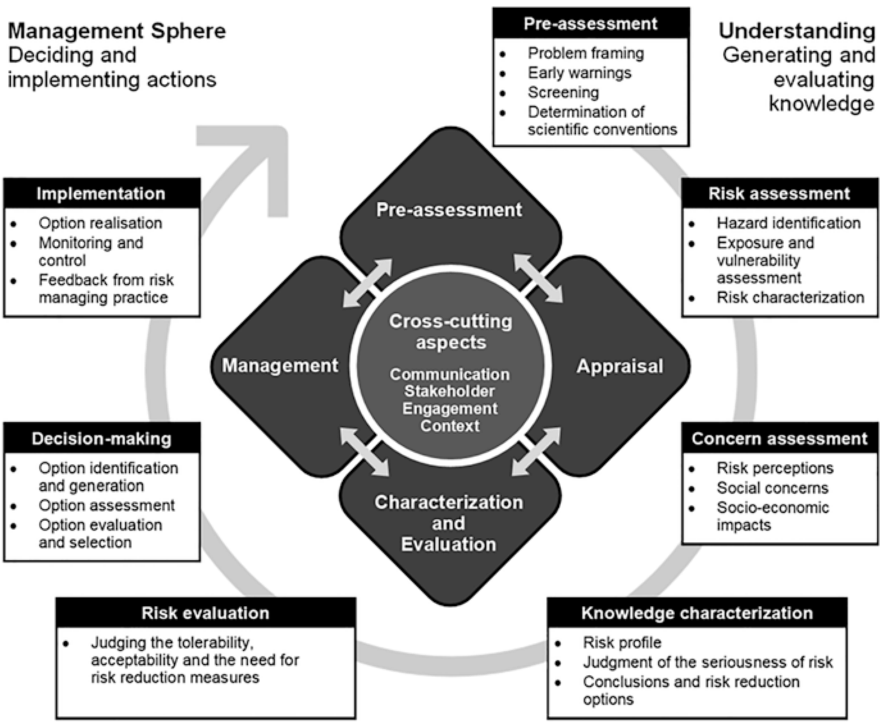

Fig. 10.1 IRGC Risk Governance Framework (IRGC, 2017). (Reprinted from IRGC 2017. Copyright permission from IRGC. This reproduction is an adapted copy of an IRGC work and was not produced in affiliation with, or with the endorsement of IRGC.)

covering communication, stakeholder engagement, and contextual factors. Each aspect consists of several elements, collectively covering the generation of knowledge about the risk, the value considerations necessary to determine risk acceptability in consultation with stakeholders, and the decision-making risk treatment activities for real-world impacts. The IRGC-RGF has recently been applied to shipping risks in the Canadian Arctic, focusing on the pre-assessment phase in terms of risk characteristics, including complexity, uncertainty, and ambiguity, from which recommended paths for stakeholder engagement strategies, suitable discourses and communication approaches, and feasible roles for risk perceptions are elaborated (Goerlandt & Pelot, 2020). Given its comprehensiveness, academic rigour, and prior application in the context of shipping risks in the Canadian Arctic, the IRGC-RGF is taken as a suitable basis for our current purposes. This is because it explicitly considers different worldviews, for instance, in Western scientific thought and the worldviews of Indigenous peoples (Beveridge, 2020), which is relevant especially in Arctic areas (where pollution preparedness and response are particularly important) given the large uncertainties about shipping risks (Fu et al., 2021) and the significance of ambiguity (Parviainen et al., 2019).

The IRGC risk governance deficits, which form the basis of the semi-structured interviews, are listed in the Appendix to this chapter. These are organized into two clusters, broadly covering the knowledge dimension (understanding and assessing risk) and the value dimension (managing risk), a distinction commonly made in risk research (Hansson & Aven, 2014). "Cluster A" focuses on deficits in the pre-assessment and appraisal phases, whereas "Cluster B" addresses the characterization and evaluation and management phases. These provide a comprehensive set of guide questions to explore shortcomings in the overall governance of marine oil spill preparedness and response in Canada.

10.3 Marine Oil Spill Preparedness and Response in Canada: Regulatory Context and Current Practices

This section briefly outlines some key international and national legislation governing marine oil spill preparedness and response. It also identifies the roles and responsibilities of key partners in the Canadian context, opportunities for stakeholders and rightsholders to become involved, and how decisions are made.

10.3.1 Legislation

The International Maritime Organization (IMO) is the main platform for developing international regulations, standards, and best practices for marine shipping, while signatory Member States such as Canada adopt these into national law through their national legislative processes (Chircop, 2015). Canada has ratified the following international agreements: the *United Nations Convention on the Law of the Sea* (UNCLOS, 1982), which governs the delimitation of maritime boundaries and the associated sovereign and jurisdictional rights and responsibilities of flag, coastal, and port states for safety of navigation and environmental protection; the *International Convention for the Safety of Life at Sea* (SOLAS, 1974), which sets out standards for safe construction, equipment, and operation of ships; and the *International Convention for the Prevention of Pollution from Ships* (MARPOL, 1973/78), which sets forth regulations for minimizing pollution risks from ships, including oil spills.

Most other legislation governing oil spills and marine shipping in Canada relies very heavily on international and/or national cooperation. For example, the *International Convention on Oil Pollution Preparedness, Response and Co-operation* (OPRC, 1990) aims to build response capacity by promoting resource sharing and contingency planning between member states to enhance cooperation during an incident and develop more integrated response plans. Canada has also signed a cooperation agreement with the United States to bolster response capacity in the Great Lakes (Government of Canada, 2017; TC, 2019). This agreement includes annexes which provide further details about how collaboration is established and performed in transboundary oil spill cases, for instance, in the Atlantic (CANUSLANT, 2016) and Great Lakes (CANUSLAK, 2022) areas. The Arctic Council is a political body mainly for Arctic states and Indigenous peoples living in the Arctic, involving also several non-Arctic states, promoting collaboration on various scientific and practical areas such as marine environmental protection, sustainable development, and ecosystems and human health monitoring. The Emergency Prevention, Preparedness, and Response Working Group addresses pollution-related issues including guidelines for Arctic marine risk assessment and collaboration on research on oil spill remediation (Arctic Council, 2020). It has also facilitated the adoption of the *Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic* (Arctic Council, 2013), which strengthens cooperation, coordination, and mutual assistance on oil pollution preparedness and response in the Arctic.

The Polar Code (2014/15) is a key regulatory instrument for area-based management of shipping risks, adopted by IMO's Maritime Safety Committee (MSC) in 2014 and by the Marine Environment Protection Committee (MEPC) in 2015 and entered into force in 2017. It is implemented into Canadian law through the *Arctic Shipping Safety and Pollution Prevention Regulations* (ASSPPR, 2017) under the *Canada Shipping Act, 2001* (CSA, 2001) and the *Arctic Waters Pollution Prevention Act* (AWPPA, 1985). The Polar Code outlines additional safety and environmental requirements for vessels operating in Arctic areas, for instance, stricter discharge requirements for ship-sourced oil pollution near the poles. The CSA 2001 is the leading legislation governing marine shipping in Canada, enabling various regulations to promote marine environmental protection from ship-sourced pollution, such as *Small Vessel Regulations* (2010), *Response Organizations Regulations* (1995), *Oil Pollution Prevention Regulations* (1993), *Pollutant Discharge Reporting Regulations 1995* (1995), *Vessel Pollution and Dangerous Chemicals Regulations* (2012), and *Environmental Response Regulations* (2019). At the national level, AWPPA 1985 and its supporting regulations prohibit the discharge of any kind north of the 60 degrees parallel, in addition to pollution offenses included in CSA 2001, the *Fisheries Act* (1985), the *Migratory Birds Convention Act* (MBCA, 1994), and the *Canadian Environmental Protection Act* (CEPA, 1999), which are applicable nationally. The *Marine Liability Act* (2001) addresses liability and compensation for pollution damages at the private law level.

The National Oil Spill Preparedness and Response Regime and Environmental Prevention and Response National Preparedness Plan (NPP) were established in support of the CSA 2001. The regime outlines the guidelines and regulatory structure to improve coordination between industry, government, and response corporations (TC, 2019). The NPP establishes national preparedness capacities in the different response areas and ensures that mechanisms are in place to provide that capacity. These response areas are the practical implementation of the NPP as an ABM tool, concretizing the governance and management measures related to oil spill preparedness and response. Canada has set out four geographical areas of responsibility for response organizations (ROs), with one each on its west and north coasts and two on its east coast (TC, 2018). The NPP also outlines the roles and responsibilities of response agencies and provides the framework to respond to marine spills (TC, 2016). This builds, inter alia, on the standards for response organizations (TC, 1995), which lay out requirements for the design and operation of the response system, addressing issues such as tiered response capabilities, response times, and equipment. These standards also define the geographic areas of response, further distinguishing designated port areas, primary areas of response, and enhanced response areas.

Other supporting legislation includes the *Environmental Emergencies Regulations* (2019), which, inter alia, requires facilities to identify hazardous substances that could pose an environmental emergency (including oil and petroleum products), prepare and implement Environmental Emergency Plans, and establish reporting requirements in case of an environmental emergency. The *Emergency Management Act* (2007) provides a framework for coordinated and effective emergency management to protect Canadians and enhance national resilience in case of emergencies, including oil spills. The *Wrecked, Abandoned, or Hazardous Vessels Act* (2019) addresses the prevention, removal, and disposal of wrecked, abandoned, or hazardous vessels to protect marine environments and public safety. Finally, the Oceans Protection Plan (TC, 2021) includes large investments to projects and activities to improve marine safety and protect Canada's marine environment and coastal ecosystems through strengthened incident prevention and response and enhanced partnerships with Indigenous and coastal communities.

10.3.2 Responsible Authorities

The organizations responsible for marine oil spill preparedness and response in Canada can be divided into three general groups: (1) those that provide technical support and scientific advice, (2) decision-makers, and (3) responders (see Fig. 10.2). Transport Canada is the lead regulatory authority and is responsible for the development of regulations and standards concerning marine shipping and pollution. TC is also responsible for developing, enforcing, and implementing the national oil spill regime and the NPP and provides technical support, guidance, and oversight as needed for their partner organizations (e.g. CCG and response organizations) (TC, 2019).

As a special operating agency under DFO, the CCG is the lead response state agency responsible for maintaining preparedness and response capacity for the oil spill regime and developing a national contingency plan for spill response (TC, 2016, 2019). CCG is also the lead decision-maker responsible for coordinating and managing the response and forming the Unified Command within the Incident Command System (ICS) (see also Sect. 10.3.4). In cases where the polluter is unwilling, unknown, or unable to respond, the CCG will step in as the on-scene incident commander (TC, 2019).

Other partners play a secondary but often essential role. Through standing agreements with shipowners, certified ROs are responsible for cleaning up the spill on behalf of the polluter and contributing to the national preparedness and response strategy (TC, 2016). If the polluter is known, able, and willing to respond, certified ROs will become part of the Unified Command and take on a leadership role as a co-decision-maker. In practice, ROs therefore often play a primary role in spill events, by providing the principal assets for spill combating.

ECCC provides technical support and scientific advice to inform the response while also leading the Environmental Unit (i.e. the Science Table) within the ICS (see Sect. 10.3.4). In addition, ECCC plays an important role in modelling spill

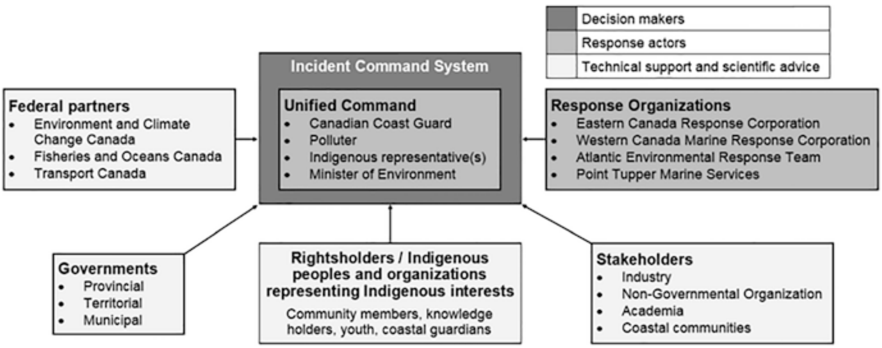

Fig. 10.2 Overview of marine oil spill preparedness and response partners

trajectories, mapping resources at risk, and tracing mystery spills back to the polluter(s) to hold them accountable for their actions. Other agencies such as DFO; provincial, territorial, and municipal governments; and coastal communities also play a similar role in that they provide advice, develop their own regional or area-based response plans, and may assist in the ICS or actively contribute to the Unified Command, depending on the situation and their willingness to participate. Overall, Canada boasts an extensive oil spill response regime with a wide range of organizations involved to develop, exercise for, and execute localized response plans. Nevertheless, considering that oil spills are relatively rare events, historic spills have indicated that there are several areas of improvement in the regime; see, for example, the action review reports of the *M/V Marathassa* fuel spill in English Bay, British Columbia (Butler, 2015).

10.3.3 Engagement

Engagement opportunities vary depending on the region, where the West Coast of Canada is known for having more defined roles for both stakeholders and rightsholders. For example, there are several OPP initiatives available such as the Cumulative Effects of Marine Shipping (CEMS) initiative, Enhanced Maritime Situational Awareness system (EMSA), the Proactive Vessel Management (PVM) initiative, and the Planning for Integrated Environmental Response (PIER) programme, which aim to increase participation and enhance marine safety (TC, 2021). The West Coast also offers opportunities for representatives from First Nations to join the Unified Command as co-decision-makers in the ICS (see Sect. 10.3.4). In the Canadian Arctic, in the context of reconciliation with Indigenous Peoples, there is a need for, and ongoing work towards, collaborative governance with First Nations in relation to shipping, where also the topic of oil spill preparedness and response has been highlighted (Wang & Aporta, 2024; Dawson et al., 2019).

Under the ISC, rightsholders and stakeholders are invited to participate in the Environmental Unit to help identify areas of priority and resources at risk, participate in response training, and participate in other areas of the ICS (e.g. community liaison, in-field, or out-field support). For a less hands-on approach, interested parties across Canada can join various dialogue forums such as those offered through the OPP, the Canadian Marine Advisory Council (e.g. the Standing Committee on the Environment), and Transport Canada's "Let's Talk Transportation" virtual platform. Moreover, vessel owners that meet the requirements may also benefit from joining the Vessels of Opportunity programme to support on-water operations.

10.3.4 Decision-Making Process

Although there is no nationally standardized process within Canada, it is evident that each region has adopted similar practices to increase collaborative decision-making regarding how oil spill risks are assessed and managed. Prior to an incident, federal response partners attend regular meetings to develop integrated area-based response plans, discuss existing and future risks, develop appropriate risk assessments, discuss legislative changes, exchange ideas, and plan training activities to enhance preparedness capacity. The frequency and breadth of topics covered during these meetings vary depending on the region. At the time of an incident, notifications are directed to a central system and shared with the relevant parties (e.g. federal, provincial, municipal government, First Nations). From there, the CCG will typically establish an ICS to coordinate spill response and facilitate information sharing to support evidence-based decision-making. Currently, the ICS is more commonly used on the West Coast, although there are plans to implement a standardized approach across the country (TC, 2020).

The Incident Commander(s), also known as a Unified Command, if more than one agency is involved, are the lead decision-makers during a response and rely on sound technical and scientific advice from supporting agencies. Additionally, there are numerous decision-support tools available to facilitate a risk-based approach to oil spill preparedness and response in Canada, including spill trajectory models, geographic information system and surveillance programmes, net environmental benefits analysis, area and regional risk-based response planning, and area and regional risk assessments. Depending on the region, the ECCC may invite affected parties (e.g., Indigenous and coastal communities) to participate in the Environmental Unit alongside federal partners. This forum aims to identify and prioritize environmentally sensitive areas, wildlife issues, archaeological and cultural issues, and socioeconomic issues resulting from a particular spill to advise the incident commander(s) on how those risks should be assessed and managed. Similar to the ICS, the Environmental Unit varies between regions and is more extensively utilized on the West Coast. These tools are not formalized in legislation and are supplementary to experiential knowledge. Ultimately, it is the responsibility of the Incident Commander(s) to implement professional judgement when executing decisions.

As mentioned in Sect. 10.3.1, there is a separate decision-making process for transboundary spill events between Canada and the United States, which is specified in the Joint Marine Pollution Contingency Plan (JCP) and its annexes. During an emergency, CCG is the lead Canadian agency in the Joint Response Team (JRT), which is a team with members from both countries. For significant incidents requiring multi-agency cooperation, a Science Table can be established to bring together relevant experts in the field of environmental protection. Members can include response agencies, all levels of government, Indigenous representatives, local communities, industries, environmental non-government organizations, and academic institutes. The JCP is tested periodically, with, for example, the CANUSLANT exercise in 2019, inter alia, focusing on implementing plans, policies, procedures, and cooperation agreements in a simulated pollution response scenario (CANUSLANT, 2019).

10.4 Results: Risk Governance Deficits in Canadian Oil Spill Preparedness and Response

Based on the data collected from the interviews and literature search, 19 of the predefined 23 risk governance deficits are present for at least one of the participating agencies, while 5 deficits were identified across all relevant agencies (highlighted in bold font) (Table 10.1). Considering each agency's mandate and responsibilities as outlined in Sect. 10.3.2, the experts from TC chose to defer all answers for Cluster B to their partners at CCG, as issues concerning response are more aligned with their responsibilities and expertise.

Table 10.1 Summary of identified IRGC risk governance deficits by organization

Deficit	ECCC national	CCG national	CCG Pacific	TC Pacific
A1		✓		
A2	✓	✓	✓	✓
A3	✓	✓		
A4	✓	✓	✓	
A5	✓	✓	✓	✓
A6	✓	✓	✓	
A7		✓	✓	
A8	✓	✓	✓	
A9	✓	✓	✓	
A10			✓	✓
B1				N/A
B2	✓	✓		N/A
B3				N/A
B4	✓		✓	N/A
B5	✓	✓	✓	N/A
B6		✓		N/A
B7	✓			N/A
B8			✓	N/A
B9	✓	✓	✓	N/A
B10	✓	✓	✓	N/A
B11				N/A
B12		✓	✓	N/A
B13				N/A

The results suggest that there are discrepancies in how risks are assessed and managed between agencies and between regions under the same agency (e.g. CCG) within Canada. This is expected as each agency operates differently in Canada, has different mandates, and must cater to their delivery to meet the specific needs in their region. For example, the relationship between stakeholders and rightsholders depends on past experiences, the level of trust between the groups, and how information has been shared. Some of these issues will be further elaborated in the discussion below as specific deficits. It should be noted here that considerations regarding transboundary spill preparedness and response, for example, between Canada and United States, are outside the scope of these findings.

10.4.1 Cluster A: Assessment and Understanding of Risks

10.4.1.1 Deficit A1: Early Warning Systems

The interviewed experts believe this deficit is present but poses little to no risk. One participant noted that although there is no formal early warning system for oil spills, the flow of information at the time of an incident is relatively smooth, allowing the responsible agencies to respond quickly depending on the severity of the incident. In general, participants believe that improvements could be made, for example, by increased digitalization.

10.4.1.2 Deficit A2: Factual Knowledge About Risk

The collected data suggest that there are numerous challenges pertaining to data, including issues with data collection, inconsistent data, data management, and data sharing. The deficit is location-dependent in that areas with low shipping activity (e.g. remote areas) lack scientific information to support the oil spill response regime, whereas areas with high shipping activity (e.g. major ports and corridors) are well documented. This data divide is more prevalent in the Canadian Arctic (north of the 60th parallel), while there is much more data available in the south. Interviewed experts expect this deficit to diminish in importance over time as new studies emerge, assuming there is enough capacity to maintain and update the information, which depends on resources such as funding and time.

10.4.1.3 Deficit A3: Perceptions of Risk

The data suggest that this deficit is present due to a lack of effective two-way communication between responsible agencies and rightsholders and stakeholders. There are ongoing efforts to close this gap, primarily through implementing various OPP initiatives aiming to increase rightsholder and stakeholder participation, offering platforms to exchange knowledge and build common understanding such as the EMSA and PVM initiatives (TC, 2021). In recent years, representatives from the provincial and federal governments have been working to inform the public of the various risks, explain how the oil spill regime works in Canada, and explain how the system is set up to respond. However, several cases indicate that the public's perception of risk does not align with the factual data. For example, a 50 litre diesel spill located near a coastal community may be considered significant by an affected community expecting immediate remediation. However, from a federal government perspective, the spill is quite small and likely does not pose a significant risk to the environment or society. Thus, it is not always feasible or necessary to deploy a response team, and efforts could be allocated elsewhere. Experts agreed that more work is needed to increase mutual understanding and balance expectations to better align risk perceptions. It is important to recognize that this deficit is unintentional and not present due to the purposeful omission of knowledge as the definition of A3 implies (see Appendix to this chapter).

10.4.1.4 Deficit A4: Stakeholder and Rightsholder Involvement

The collected data indicate that this deficit is present due to time and financial limitations and the limited capacity of communities to participate, impeding stakeholder and rightsholder involvement. Historically, the emphasis has been on consultation rather than meaningful engagement. The OPP initiatives aim to increase engagement, although these opportunities are not available consistently across the country. For example, the PIER programme aims to engage rightsholders and stakeholders in the development of integrated regional and sub-regional oil spill response plans. However, this programme is currently only available on the West Coast. Similarly, on the West Coast, representatives from First Nations are invited to become co-decision makers in the Unified Command and participate in preparedness and response. However, other regions do not seem to have a formalized role in this type of engagement. In other regions, rightsholders and stakeholders are involved during the risk assessment process but remain absent from planning and response. Thus, the assessment parameters may not meet the needs of the participants, further reducing the legitimacy of the risk assessment process. More work is needed to address this deficiency, especially outside the Western region.

The federal government recognized that engagement can be expensive and that it is often the financial responsibility of the participants. To help alleviate this burden, Transport Canada has created the Community Participation Funding Program to increase involvement in decisions surrounding marine shipping (TC, 2021).

10.4.1.5 Deficit A5: Evaluating the Acceptability of Risk

The collected data indicate that this deficit is present across Canada. Interviewed experts recognize the opportunity to establish an Environmental Unit prior to an incident to help alleviate this deficit, as relevant parties (e.g. stakeholders, rightsholders, and scientists) work together to prioritize risks. However, the Environmental Unit is typically only established during a response, in which case, there is no formalized process for evaluating risk tolerance or acceptability. Experts added that discussions about risk acceptance are currently missing from the risk assessment process, which can be exacerbated if information about risks is incomplete (A2), if perceptions of risk are misaligned with factual knowledge (A3), and if rightsholder and stakeholder engagement processes are not well established (A4).

It was mentioned that because risks can be subjective, there is no clear understanding of what is acceptable and where decision-makers should “draw the line”. In the absence of focused discussions, they rely on the best available data and their professional judgement to make difficult decisions for the greater good. This deficit will likely continue to persist without additional resources to encourage these discussions among stakeholders early on.

10.4.1.6 Deficit A6: Misrepresenting Information About Risk

Experts linked the presence of this deficit to deficits A2 and A3, which identified issues with missing, outdated, and inconsistent data and the lack of consideration of risk perception. Thus, there is a potential to misrepresent information about risk due to the quality of the available information (A2) and the lack of a common understanding of perceived risks (A3). Experts considered this deficit, understood as indicated above, to be unintentional and currently unavoidable. There was general agreement that federal agencies are not purposefully misrepresenting information. Nevertheless, this finding strengthens the argument to improve factual knowledge about risk and to better understand and balance risk perceptions.

10.4.1.7 Deficit A7: Understanding Complex Systems

This deficit is present and is best captured by this quote from CCG-National:

> The oil spill regime is very complex, and while individuals within the regime may know their part to play within the regime, there is still significant work to be done to build a common understanding of the complex interactions of oil spill risks across different consequences, as well as the relations to roles and mandates.

Similar to many government programmes, there is a push to shift from a highly compartmentalized approach to a more integrative approach to promote greater understanding of the problem space and to enhance collaboration. The experts believed that the ongoing OPP initiatives aiming to develop comprehensive response systems for marine oil spills and strengthen partnerships (e.g. government, industry, coastal, and Indigenous communities) are helpful to reach a common understanding of the system. For example, the Seamless Regime Response aims to develop an integrated framework for the preparedness and response of marine spills (TC, 2021). Although these initiatives do help bring all the partners together, some participants still feel that there is room for improvement. From an ECCC perspective, federal employees work within their capacity to assess and address the multiple dimensions of oil spill risks and their potential consequences.

10.4.1.8 Deficit A8: Recognizing Fundamental or Rapid Changes in the System

Rapid change is inherent to emergency preparedness and response. For example, shipping is dynamic as trade patterns and ship technology evolve, marine environments change, and society's priorities and legal requirements change. It takes time to recognize these changes, communicate them, and adapt or react effectively. This is challenging due to the complexity of the oil spill risks and the preparedness and response system in its entirety (cf. A7), where a change that may immediately affect one agency or department can create ripple effects in other areas of the regime. Thus, it is important to understand how changes in the system affect the entire regime and to create appropriate channels to communicate these changes as they arise to ensure mutual understanding and appropriate adaptation. The interviewed experts raised this as a deficit, noting that little has been done to systematically address this issue, simply stating "we don't do this". Experts proposed more comprehensive education and outreach activities to increase awareness among federal partners as pathways forward.

10.4.1.9 Deficit A9: The Use of Formal Models

This deficit was identified at the national level as the oil spill regime lacks a truly common preparedness or operating picture that is accessible across all regions and departments/agencies. However, the interviewed experts did note that they are working towards improving models within their own department or agency to enhance decision-making and data management, which has resulted in the development of robust models that operate at a much finer scale, for example, based on net environmental benefit analysis approaches. The development of more integrated models and tools could, however, further facilitate better preparedness planning and a more rapid response by minimizing the time spent collating data from multiple sources that are not easily accessible between agencies due to compatibility issues or legal constraints. An expert from TC noted that:

> The reliance on models varies drastically. In some cases, we see an over-reliance while in others we see an under-reliance. The models that are used have not been vetted or standard-

ized. A standardized suite of vetted models is needed in Canada, similar to how the HELCOM "OpenRisk" project introduced a common suite of risk management tools to the Baltic states.

One participant noted that it is common practice for decision-makers to leverage experiential knowledge and execute professional judgement when data and/or tools are lacking. As a result, this expert felt the current approach is acceptable and is not currently causing a significant deficit, noting, however, that there is always room for improvement.

10.4.1.10 Deficit A10: Assessing Potential Surprises

The collected data indicate that there are cognitive barriers that have been institutionalized, which contribute to the presence of this deficit. For example, the Canadian oil spill regime is designed around a 10,000 ton response capacity (TC, 2016, 2019). However, this number was determined by a risk assessment in the late 1980s, whereas the risks have likely changed over time due to increases in marine shipping since then and due to larger vessel sizes. Thus, it is possible that target response capacity is no longer a realistic metric for preparedness, which may limit Canada's ability to respond adequately to greater spills. Some experts expressed concerns that "it is nearly impossible to assess all different scenarios".

However, participants at the national level strongly believe that Canada is well equipped to overcome challenges with potential surprises such as exceptionally large spills and that the operators have the experience needed to draw on multiple resources to fill in any gaps as needed. ECCC-National emphasized that their situational assessments do focus on outliers (i.e. rare, high-risk scenarios), recognizing that these events have the potential for greater consequences.

10.4.2 Cluster B: Management of Risks

10.4.2.1 Deficit B2: Designing Effective Risk Management Strategies

The interviewed experts identified this deficit given the lack of clear objectives and common risk-informed response strategies across the country. Various agencies have developed their own risk management approaches and best practices, such as ECCC's net environmental benefits analysis and response planning within the CCG. However, response planning is departmental and not carried out consistently across the country, resulting in certain regions likely having more effective strategies than others.

Participants also noted that although the ICS may be helpful during a response to identify and inform decisions on how to manage risks resulting from a spill as outlined in Sect. 10.3.4, its primary function is to coordinate the response, not to design risk management strategies as such. The ICS also poses similar challenges, as it is not currently used consistently across Canada; it does not have specific risk-based targets, and is not inculcated in legislation. Thus, there is no obligation to use ICS. Respondents noted that American ICS offers a more structured approach that may be useful in Canada if implemented consistently.

10.4.2.2 Deficit B4: Designing Efficient and Equitable Risk Management Policies

Interviewed experts suggested that risk management policies are typically developed in silo, without much room for public input. This is further exacerbated by deficit A5, as it is difficult to design efficient and equitable risk management policies when there is a common understanding of what is acceptable is lacking. For example, if the risks posed by a spill (e.g. small scale, far from sensitive habitat) are considered acceptable, then there would be no need to deploy valuable resources to respond, whereas if the risks were unacceptable, then a response may be necessary. Currently, risk management policies do not reflect these nuances, and it is up to the discretion of CCG to initiate what they believe is a reasonable response depending on the incident.

10.4.2.3 Deficit B5: Implementing and Enforcing Risk Management Decisions

The interviewed experts generally agreed that there is little to no enforcement around risk management decisions and that the oil spill regime lacks effective enforcement measures. Moreover, without proper enforcement, it is difficult to ensure compliance. This deficit will likely continue to exist until there is a national risk management strategy (cf. B2) and a common understanding of risk acceptability in Canada (cf. A5).

10.4.2.4 Deficit B6: Anticipating Side Effects of Risk Management

Generally, participants believed that side effects are well considered given the nature of emergency response, where time is often the limiting factor. At the time of an incident, responders use the best available data and their professional judgement to make informed decisions to minimize residual impacts. However, this process is rarely documented, as decisions are made quickly to prevent the situation from worsening. Only one participant identified this deficit as present, noting that a more thorough evaluation could be conducted prior to decision-making, finding that making trade-offs based on limited information can be too demanding during emergency situations, possibly leading to poor consideration of the full spectrum of effects.

10.4.2.5 Deficit B7: Reconciling Time Horizons

Impacts from oil spills usually dissipate over time as the oil breaks down, eventually resulting in trace amounts in the environment. Moreover, oil spills can impact environmental, economic, and socio-cultural dimensions over different time frames. The interviewed experts highlighted this deficit because Canada does not have a formal recovery regime or policies to dictate how many resources should be invested in long-term monitoring across different impact dimensions.

This links back to deficits A5 and B4, as without a proper understanding of what is acceptable, it is difficult to develop efficient and equitable risk management strategies. For example, from an ECCC perspective, the spill response is complete once a decreasing trend in the amount of oil remaining in the environment is determined, while rightsholders or stakeholders might continue to push for long-term recovery monitoring for socioeconomic or cultural reasons, requiring a greater investment of time and resources. Thus, depending on the situation, it may be difficult to reconcile timeframes.

Moreover, seasonality poses an issue as the time of year influences response capacity and capability, which is particularly important for incidents occurring in the North. For example, the spill response is much more difficult outside the peak shipping season, as the presence of ice poses a significant barrier and limits the use of equipment such as booms. Similarly, if an incident occurs while many community members are away on the land (e.g. during hunting season), then there are fewer people who can be readily tasked in the area, and response assets may need to be sourced from southern areas, increasing the delay.

10.4.2.6 Deficit B8: Balancing Transparency and Confidentiality

The interviewed experts believe that there has been a lot of progress with respect to increasing transparency of the federal government, for example, through the *Access to Information Act* (1985), relationship building, and data sharing agreements. However, there are still issues with data sharing including legal constraints (e.g. privacy laws and nondisclosure agreements) and concerns with sharing sensitive information (e.g. Indigenous knowledge that is of sacred or cultural significance). This is thought to be less of a concern on the West Coast as First Nations are more heavily integrated in the response and decision-making through ICS and where there are processes in place and a mutual understanding to safeguard sensitive information. For example, ECCC has noted that “Indigenous Nations sometimes have data and information on the environment that they do not want to share, and this is fine, and we respect that”. In addition to these limitations, participants noted that there is also a lack of policy in place to support data sharing within the government as a whole, limiting transparency across regions. This deficit can act as a barrier to incorporating Indigenous knowledge in decision-making processes, for instance, if such knowledge is not appropriately considered or protected in decision support systems used for response planning purposes, as discussed in Chap. 6 in this volume.

10.4.2.7 Deficit B9: Organizational Capacity

The interviewed experts identified several deficits concerning organizational capacity. The most common is that agencies are not entirely clear on their exact roles and responsibilities related to risk governance (cf. A7 and B10). It was suggested that this exacerbates deficits pertaining to a lack of clear risk management objective strategies (B2) and mutual understanding of what are acceptable risks (A5). As a result, it is difficult for agencies to identify which risks are the priority, how much time and resources should be allocated to manage these risks, and how many people are needed to facilitate the desired response. In the absence of risk-based targets, it is difficult to predict whether more capacity is needed and where to allocate future resources to support long-term decisions.

Finally, participants identified a lack of community training to help share this responsibility among rightsholders and stakeholders to ensure that coastal communities have the needed capacity and are equipped to respond if tasked. Nevertheless, certain regions have been more successful at developing programmes to facilitate this, for example, through the PIER programme mentioned in Sect. 10.3.3.

10.4.2.8 Deficit B10: Dealing with Dispersed Responsibilities

The interviewed experts agreed that the Government of Canada has traditionally worked in silos but is actively seeking to address this through increasing collaboration by implementing horizontal initiatives. This deficit is closely related to deficit B9, where there is still a need to clearly define the responsibilities of each group (i.e., Coastal First Nations, stakeholders, and the Government of Canada agencies) and how they are expected to work together and support each other. Participants also noted that there are recent pilot projects and initiatives in place through the OPP that aim to enhance clarifying and aligning responsibilities, although not all programmes have been rolled out across Canada and their permanence depends on future funding.

10.4.2.9 Deficit B12: Managing Conflicts of Interest, Beliefs, Values, and Ideologies

The interviewed experts found this deficit to be present, adding that although conflicts may arise, they do not prevent effective risk management during an emergency response. Participants noted that one of the most common conflicts arises when traditional knowledge and western knowledge do not align, making it more difficult to agree in preparedness planning, on endpoints for response operations, and for determining which course of action is most appropriate. Recognizing that decisions made in the Unified Command are not always satisfactory to all parties, the CCG has noted that certain entities within the oil spill regime have agreements in place that outline the terms for conflict resolution when dealing with emergencies. These agreements ensure that once the emergency has subsided, there is a mechanism in place where those involved can regroup outside of the ICS and resolve the matter in hopes of preventing future conflict. However, these agreements are voluntary and are not always common practice across the country.

10.5 Discussion

10.5.1 Policy and Management Implications for Area-Based Management of Marine Oil Spill Preparedness and Response

As mentioned in Sect. 10.3.1, the geographical areas (shown in Fig. 10.2) in which the ROs are responsible for implementing the oil spill pollution preparedness and response management measures can be understood as the practical geographical implementation of the NPP as an ABM tool. These areas are associated with further legislative mechanisms stipulating requirements for shipowners, operators, and responsible authorities and specifying roles and processes for decision-making, scientific support, and engagement with stakeholders such as coastal communities and non-governmental organizations and with Indigenous rightsholders.

The complex structure of the legislative basis, the responsible authorities, engagement, and decision-making processes outlined in Sect. 10.3 can be seen as a description of a governance structure to establish preparedness and response mechanisms to mitigate the risks of oil spills in Canadian waters. Referring to Chap. 2 in this volume, the main risk object of these ABM tools is oil spills, with ships as the risk agent (the object causing the harm) and the marine and coastal spaces as the risk absorbing system (the object being harmed). In terms of the risk management phases (mitigation, preparedness, response, and recovery), it is evident that the focus of this analysis is on the preparedness and response phases of oil spill risk management.

Finally, while the risk problem type according to the IRGC-RGF is not explicitly assessed in the interviews with the experts, it is evident that aspects of complexity, uncertainty, and ambiguity are relevant for area-based management of oil spill risks. Complexity is, for example, evident from the multiple interdependent pathways in which oil spills can lead to harm to ecosystems, human health, economic activities, and socio-culturally significant sites, recognizing that data and information about these complex interrelations are not comprehensively available for all marine areas in Canada (cf. deficit A2). Complexity is also evident in the oil spill regime itself, from the multitude of legal instruments relevant to area-based management of spill preparedness and response, and from the wide array of actors, stakeholders, and rightsholders involved in decision-making processes, and in consultation and outreach activities, leading to challenges to attain a common understanding of the response system (cf. deficit A7). Uncertainty is relevant to oil spill risk, for instance, because of the challenges with the availability, consistency, and sharing of data about oil spill risks and its different pathways to impacts (cf. deficit A2), as well as due to challenges related to comprehensively including Indigenous knowledge in decision-making processes due to issues related to transparency and confidentiality (cf. deficit B8). Finally, ambiguity is present especially because the risk perceptions of rightsholders and southern Canadian actors and stakeholders may substantially differ (cf. deficit A3) and because the risk acceptability can therefore be understood differently by Indigenous peoples and other actors and stakeholders, due to their reliance on different worldviews and knowledge systems (cf. deficit A5, B4).

Identifying potential deficits is essential when seeking to improve policies and management approaches to achieve good governance. This research used an exploratory approach to understand deficits of preparedness and response risk governance in Canada, pointing to common issues across response regions and highlighting expert views on possible avenues for improving current practices.

While the analysis is not focused on the different geographical response areas of the ROs per se and does not specifically address issues related to transboundary preparedness and response, it is important to note that the identified deficits may present differently across the country. For example, some deficits were only identified within certain regions or were limited to certain agencies. This can be attributed to differences in programme availability, capacity of the response system (assets and personnel), geographical context (e.g. shoreline sensitivities, culturally significant areas), and relationships between government agencies and rightsholders and stakeholders. It was determined that standardized approaches to designing risk management strategies are lacking and that decisions are largely left up to the incident commander(s) at the time of the response. Although developing standardized processes is believed to be generally beneficial, for instance, by streamlining decision-making processes between different actors, stakeholders, and rightsholders, it is worth exploring in greater detail the benefits and downsides of standardization. Increased standardization may, for example, lead to burdensome bureaucratization or not be sufficiently attuned to local cultural differences, possibly reducing the agility and resilience of the pollution preparedness and response system.

The results suggest that it is difficult to fully eliminate all deficits, especially due to limitations in organizational capacity, that is, time, finances, and personnel. Correspondingly, certain deficits have been identified as being currently unavoidable but unintentional. For example, the unintentional misrepresentation of risk due to insufficient quality of the available information or a lack of a common understanding of the risk (deficit A6), together with challenges to anticipate outcomes of decisions (which stem from the complex system of the pollution risks and the various associated consequence dimensions; see deficit A7), can lead to insufficiently anticipating the side effects of risk management (deficit B6). Furthermore, certain deficits have the potential to pose a greater risk when coupled together. For example, in cases where there are inefficient and inequitable risk management policies and practices (deficit B4), this can lead to insufficient organizational capacity, with unclear roles and lack of local community capacity (deficit B9). In other cases, one deficit can act as a root cause leading to the manifestation of other deficits. For example, when lack of reliable scientific information about shipping risks or spill consequences is present (deficit A2), this can be seen as a cause of challenges of misrepresenting information about risk (deficit A6), for instance, by not adequately considering some ecosystem impacts or socio-culturally relevant consequences. Thus, the nature of relationships between deficits should be considered when developing management plans to understand the overall impacts of deficits and to improve current practices.

Certain deficits have been identified for having common stressors. In such cases, it is important to alleviate root causes to prevent cascading impacts. For example, the failure to properly manage conflicts of interest, beliefs, values, and ideologies (B12) may perpetuate issues in being able to anticipate the side effects of risk management (B6), designing efficient and equitable risk management policies (B4), and evaluating risk acceptability (A5). Experts from CCG proposed that efforts could be directed to develop a forum to promote standard practices for oil spill preparedness and response across the country. This aligns with the view by TC respondents to develop and decide on a set of commonly used risk assessment models and tools, similar to those developed for the Baltic Sea area (Laine et al., 2021).

A common challenge has been identified around the appropriate use of Indigenous versus Western knowledge. This is a pertinent issue because Indigenous peoples are rightsholders, having constitutionally protected rights in matters relating to resource development on their lands or that could infringe on their rights (Boyd & Lorefice, 2019). Given the conceptualizations of marine spaces by, for instance, Inuit people in their worldview, it could be argued that this right extends into marine areas (Beveridge, 2020). Generally, they have a right to be consulted; their free, prior, and informed consent is needed; and they can resort to legal procedures when this right is violated. The exact relation between risk perceptions and risks understood in Indigenous worldviews based on traditional knowledge and the implications this has for risk governance is not yet accurately understood (Goerlandt & Pelot, 2020). Nevertheless, it may be considered appropriate to increase education and give an appropriate role to both knowledge systems in the oil spill regime and formalize an approach to spill response guided by Two-Eyed Seeing. This approach fosters the development of collective knowledge to inform the "bigger picture" and can help strengthen relationships and collaboration. Moreover, Two-Eyed Seeing is a recognized approach to promote integrative science and has been adopted in numerous environmental plans, policies, and programmes across Canada over the past decade (Bartlett et al., 2012). This supports its potential role in the risk governance of marine oil spills in Canada.

Efforts are already ongoing to mitigate many of the identified deficits. A long-standing mechanism to compensate victims of oil pollution damage (including prevention-related costs) caused by ships, recovering the costs from the polluters or other responsible parties (if known) through the Polluter Pays Principle, concerns the Ship-source Oil Pollution Fund. Recent efforts by this Fund to alleviate, for example, deficit B9 (lack of organizational capacity), include increased outreach efforts to municipal, local, and Indigenous governments and launching a compensation handbook targeted at these stakeholders and rightsholders (SOPF, 2023).

In recent years, the Government of Canada has invested in numerous horizontal initiatives to promote interdepartmental collaboration (B10) such as the OPP (TC, 2021). The Treasury Board of Canada Secretariat (2021) has also published guidelines including a Horizontal Initiatives Framework detailing how departments are expected to work together to achieve shared outcomes. The OPP is thought to alleviate certain deficits (e.g. A2, A3, A4, A7, B10) by improving marine safety, environmental protection, and Indigenous engagement (TC, 2021). Specific initiatives include but are not limited to increasing data collection (e.g. Coastal Environmental Baseline Program), updating legislation (e.g. CSA, 2001 and *Marine Liability Act*), investing in modern environmental response equipment, increasing training, hiring additional staff, investing in Indigenous partnerships (e.g. PIER programme), investing in oil spill research (e.g. the Multi-Partner Research Initiative), and increasing situational awareness (e.g. EMSA). However, the OPP was designed as a 5-year plan with funding from 2017 to 2022, so that many of these initiatives were established as short-term pilot projects. In August 2022, the Government of Canada announced an additional 2 billion dollar investment over a 9-year period to renew the OPP (i.e. OPP 2.0) aimed at funding new projects. However, at the time of writing, it is unclear which of the existing initiatives will secure funding. This uncertainty may lead to future vulnerabilities in the system, an issue highlighted under deficit B7. Attention should be given to which OPP initiatives are most effective at alleviating the relevant deficits from a pollution preparedness and response perspective and efforts directed to adopting them into policy. Should existing initiatives not be renewed, then it may be worthwhile to reassess the identified deficits, particularly focusing on how the sustainability of effective activities implemented under the pilot programmes can be ensured, for instance, by expanding the PIER programme for all Indigenous coastal communities. The deficits identified through the presented exploratory analysis could also serve as input for prioritizing future initiatives.

Considering that many deficits have a lack of information sharing, communication, and engagement as root causes, it is recommended that the Government of Canada develop knowledge-sharing policies and data management systems to document and share data tailored to specific needs. In cases where such systems already exist, efforts should focus on cleaning and updating them. Standardized guidelines for record-keeping could be developed to promote consistency and to ensure that files are maintained in a format that is easily understood and accessible during emergencies.

Finally, the Government of Canada could direct efforts to establish a common operating picture to facilitate greater collaboration and domain awareness, where multiple agencies can access the same information during a spill response, possibly through online decision support tools such as the Next-Generation Smart Response Web (NG-SRW) developed for the Baltic Sea area (Fetissov et al., 2021). This would collate all relevant information to increase transparency (B8) and usability, enhance rightsholder and stakeholder engagement (A4), and enhance the capacity to understand complex systems (A7), among others. The information could be organized into a series of submodules based on need, as explained by Baber et al. (2013). For example, information specific to response measures could be separated from the information on sensitive areas, while the overall structure could allow users to toggle between nodes and information layers, exploring the various relationships depending on the level of needed detail. Using a formalized structure may also reduce human error and alleviate pressures on decision-makers as the connections are mapped out for them, outlining who should be involved in which processes and where that information is held to facilitate rapid response. Much of this information already exists in separate databases held within various agencies, so an integrated decision support platform could also help alleviate the deficit of dealing with dispersed responsibilities (B10). While the interviewed respondents did not make an explicit link to places of refuge (sites where a ship in need of assistance can work to stabilize its condition, among others for environmental protection), such an integrated platforms can help improve common situational awareness between actors, stakeholders, and rightsholders under the National Places of Refuge Contingency Plan framework (TC, 2007; John, 2010).

10.5.2 Study Limitations and Avenues for Future Research

As the aim of this work is to explore risk governance deficits in the Canadian oil spill regime, only a subset of experts from federal agencies were consulted. Their answers depend on their experience and region of operation and should be considered as a basis for identifying plausible starting points for further advancing an understanding of risk governance deficits. Insights into deficiencies as understood by different actors within Canada, such as rightsholders and stakeholders (industry, nongovernmental organizations), would enrich the analysis and would enable a more comprehensive prioritization of deficits to mitigate.

As mentioned in Sect. 10.5.1, while spill preparedness and response can be understood as an implementation of legislative AMB tools, the presented analysis is not focused on particular geographic areas. Future work could be dedicated to systematically and comprehensively understanding deficits in specific marine areas, such as areas of responsibility of a given RO. Furthermore, the presented exploratory analysis on risk governance deficits focused exclusively on the Canadian response, so that the joint marine spill response for transboundary incidents is not addressed in interviews. Future work could assess the performance of such joint spill responses for the different areas considered in the JCP and its annexes through a risk governance deficit lens, exploring agreements and disagreements between US-based and Canadian actors, stakeholders, and rightsholders.

A final limitation is that the risk governance deficits are considered separately in the current work, whereas it is observed that several deficits are in practice related to each other. Thus, understanding their joint effects from a systems perspective, across different rightsholders and stakeholders, may bring additional insights and help prioritize actions to improve the system. Hence, future research to assess these deficits more comprehensively in relation to each other, using dedicated systems analysis methods, is recommended.

Notwithstanding its limitations, the findings point to several worthwhile directions for future scholarship. This includes a systematic focus on the relation between risk perceptions as studied using Western scientific methods and risks as understood based on Indigenous worldviews and knowledge systems, including the implications this has for risk governance. This is pertinent and not considered within the existing IRGC-RGF (IRGC, 2017). Given the challenges raised to determine risk acceptability across decision-makers and rightsholder and stakeholder groups, making a synthesis of existing approaches to risk acceptability, and adapting this to the context of oil spill preparedness and response in Canada, would be worthwhile.

There is also an opportunity to develop an integrated set of models and tools to prepare for and respond to oil spill risks in Canadian marine areas similar to the risk assessment toolbox and collaborative spatial decision support systems developed for the Baltic Sea area (Laine et al., 2021; Fetissov et al., 2021; Tabri et al., 2018). In this context, considering the identified deficit of challenges to reconcile time horizons and the fact that state-of-the-art risk assessment models for preparedness planning mainly focus on the immediate response phases and far less on intermediate and long-term impacts (Parviainen et al., 2021), more research and development to improve risk models to account for different time scales are advisable.

Appendix

A brief description of the IRGC risk governance deficits, adapted from IRGC (2009)

Cluster	Deficit	Description
Assessing and understanding risks	A1	**Early warning systems.** A failure to detect early warnings of risk because of erroneous signals, misinterpretation of information, or simply not enough information being gathered
	A2	**Factual knowledge about risks.** A lack of adequate factual knowledge for robust risk assessment because of existing gaps in scientific knowledge or failure to either source existing information or appreciate its associated uncertainty
	A3	**Perceptions of risk, including their determinants and consequences.** Omission of knowledge related to stakeholder/rightsholder risk perceptions and concerns
	A4	**Stakeholder/rightsholder involvement.** A failure to consult the relevant stakeholders/rightsholders, as their involvement can improve the information input and the legitimacy of the risk assessment process
	A5	**Evaluating the acceptability of the risk.** A failure to properly evaluate a risk as being acceptable or unacceptable to society
	A6	**Misrepresenting information about risk.** If biased, selective, or incomplete knowledge is used during, or communicated after, risk assessment, either intentionally or unintentionally
	A7	**Understanding complex systems.** A failure to understand how the components of a complex system interact or how the system behaves as a whole. Thus, a failure to assess the multiple dimensions of a risk and its potential consequences
	A8	**Recognizing fundamental or rapid changes in systems.** A failure to recognize fast or fundamental changes to a system, which can cause new risks to emerge or old ones to change
	A9	**The use of formal models.** The inappropriate use of formal models to create and understand knowledge about complex systems. The over- or under-reliance on models can be equally problematic
	A10	**Assessing potential surprises.** If the risk assessors or decision-makers fail to overcome cognitive barriers to imagining that events outside expected paradigms are possible
Managing risks	B1	**Responding to early warnings.** A failure to respond adequately to early warnings of risk, which could mean either under- or over-reacting to warnings
	B2	**Designing effective risk management strategies.** If objectives, tools, or implementation plans are ill-defined or absent

(continued)

Cluster	Deficit	Description
	B3	**Considering a reasonable range of risk management options.** A failure to consider all reasonable and available options before deciding how to proceed
	B4	**Designing efficient and equitable risk management policies.** A failure to conduct appropriate analyses to assess the costs and benefits (efficiency) of various options and how they are distributed (equity)
	B5	**Implementing and enforcing risk management decisions.** A failure to implement risk management strategies or policies, to enforce them and provide a method to ensure compliance
	B6	**Anticipating side effects of risk management.** A failure to anticipate the consequences, particularly negative side effects, of a risk management decision and to adequately monitor and react to the outcomes
	B7	**Reconciling time horizons.** An inability to reconcile the timeframe of the risk issue with decision-making pressures and incentives (which may prioritize visible, short-term results or cost reductions)
	B8	**Balancing transparency and confidentiality.** A failure to adequately balance transparency and confidentiality during the decision-making process, which can have implications for stakeholder/rightsholder trust or for security
	B9	**Organizational capacity (includes assets, skills, and capabilities).** A lack of adequate organizational capacity and/or one of a suitable culture for ensuring managerial effectiveness when dealing with risks
	B10	**Dealing with dispersed responsibilities.** A failure of the multiple departments or organizations responsible for a risk's management to act individually but cohesively or of one entity to deal with several risks
	B11	**Dealing with commons problems and externalities.** A failure to deal with the complex nature of commons problems, resulting in inappropriate or inadequate decisions to mitigate commons-related risks
	B12	**Managing conflicts of interests, beliefs, values, and ideologies.** A failure to resolve conflicts where different pathways to resolution may be required in consideration of the nature of the conflict and of different stakeholder/rightsholder interests and values
	B13	**Acting in the face of the unexpected.** Insufficient flexibility or capacity to respond adequately to unexpected events because of bad planning, inflexible mindsets and response structures, or an inability to think creatively and innovate when necessary

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Chapter 11
Ports and Harbours as Special Management Areas

Aldo Chircop

Abstract As autonomous federal entities, port authorities in Canada have long been considered as special management areas. Canada's system for ports managed by port authorities, public ports, and small craft harbours is explained with a focus on how they manage lands and waters within their jurisdiction by using their powers for land use planning and vessel traffic management. Attention is given to governance and how ports use zoning powers to promote efficiency, safety, security, and environmental concerns such as decarbonization of shipping and marine conservation. Canada's port and harbour practice is assessed from the perspectives of spatial use, governance powers, and environmental protection. The chapter concludes on the practice of ports to treat land use planning and marine spatial planning as a continuum.

Keywords Biodiversity · Decarbonization · Environment protection · Governance · Land use planning · Marine spatial planning · Pollution · Port authorities · Public ports · Small craft harbours · Sustainability · Vessel traffic management

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11.1 Introduction

Canada has a complex system of ports and harbours in the Atlantic, Arctic, Pacific, and Great Lakes regions serving not only commercial shipping but also coastal communities and other ocean uses. There are 550 commercial ports in the National Ports System subject to Transport Canada (TC) oversight under the authority of the *Canada Marine Act* (CMA, 1998, sch; Transport Canada, 2019). Harbours are smaller and for small craft to service the local fishing industry, coastal communities, and recreational ocean users. There are more than 1000 small craft harbours under the oversight of Fisheries and Oceans Canada (DFO) (DFO, 2022).

Ports and harbours may be described as special management areas administered by a mostly federal legal regime. The administering authorities have area-based management (ABM) responsibilities to govern the terrestrial and marine spaces within their remits in a safe, productive, and sustainable manner. They also provide reception facilities for wastes from ships, prevent pollution from activities within their control, comply with the requirements of marine protected areas (MPAs) in waters within their jurisdiction, and use their powers to mitigate the impacts of navigation on marine species in waters within their jurisdiction. At times, ports and harbours also serve as places of refuge for ships that need shelter from bad weather or to stabilize their condition after suffering calamity at sea.

This chapter explores the governance of Canada's system for ports and small craft harbours. The focus is how ports are governed as special management areas to service marine transportation and how ABM tools are used for various purposes with an emphasis on environment protection. The chapter concludes with general observations on the management of port and harbour areas.

11.2 Governance Framework

11.2.1 Jurisdiction

Canada's constitution has no head of power dedicated to ports, but jurisdiction over ports and harbours resides primarily within the federal level (*BC v. Lafarge,* 2007, para 36). Federal powers over federal public property, trade and commerce, navigation aids, navigation and shipping, and quarantine provide the basis for jurisdiction over ports and harbours and their activities (Constitution Act, 1867, s 91). Crown lands, as federal public property, are subject to exclusive federal jurisdiction, but other lands held by port authorities are not (*BC v. Lafarge,* 2007). Navigation and shipping include the corollary infrastructure and control over shipping lanes and waterways (ibid, para 62). Claims concerning shipping, including services provided to ships by ports, such as dock charges, harbour dues, and charges for related facilities, are subject to federal maritime law (FCA, 1985, s 22(2)(s)). The federal power over navigation and shipping tends to be broadly construed so that national transportation "cannot be allowed to be hobbled by local interests" (*BC v. Lafarge,* 2007, para. 64).

While there is no constitutional power expressly dedicated to ports, the *Constitution Act* designates "public harbours" as federal property (Constitution Act, 1867, scheme III). Defining "public harbours" has historically been a complex question, but at a minimum such ports and harbours that were vested in the provinces in pre-confederation times are deemed to be public harbours transferred to Canada on confederation (La Forest, 1963). This includes the major ports of Halifax, Montreal, Quebec, Toronto, and Vancouver (ibid., 527). The CMA has clarified the legal status of ports, and agreements between the federal government and the provinces have also served to clarify property rights in public ports.

The fact that ports are vested in the federal government in a proprietary sense does not necessarily mean that the application of provincial law is excluded in its entirety (*BC v. Lafarge,* 2007; Ballantyne, 2016, 69; La Forest, 1969, 49 et seq.). There can be situations where provincial law applies to port activities that overlap with provincial constitutional powers over local works and undertakings and property and civil rights (Constitution Act, 1867, s 92(1)). Generally, the provincial power to regulate local works and undertakings must not concern domestic shipping, or extend beyond provincial limits, or apply to international shipping, or regulate works declared by the Parliament to be of national importance or for the benefit of more than one province (ibid). Moreover, the Parliament can restrict the exercise of proprietary rights, such as waterfront ownership in the interests of navigation and shipping (*Montreal (City of) v. Montreal Harbour Commissioners,* 1926, 848–849).

The fact that certain activities in port may be subject to provincial jurisdiction should not be surprising. Ports are often located in urban environments, and the provinces (and municipalities created by them) are responsible for land use planning, which includes zoning and building regulations. Hence land use planning in a port or harbour environment has both federal and provincial aspects (*Hamilton Harbour Commissioners v. City of Hamilton,* 1976, 484). Certain activities in ports may have "double aspects", that is, they are subject to both federal and provincial regulation because both levels have compelling interests. For example, the waterfront lands may be publicly or privately owned, and depending on the purpose of their development, they may be subject to federal or provincial regulation (*BC v. Lafarge,* 2007, paras 37, 62). If the development is for purely residential purposes, provincial law will apply, and if the development is for shipping purposes, federal law will apply. If the purpose is shipping-related and there is no applicable federal law, provincial law may still apply, but if there is applicable federal legislation and there is operational conflict between federal and provincial law in terms of purpose and operation, the federal paramountcy doctrine dictates that federal legislation takes precedence over provincial legislation (ibid, paras 76–77). Further, port authority land use planning in support of navigation and shipping in areas that are not public property will prevail over general provincial land use planning and regulation.

Much of the discussion on federal authority over ports and complementary provincial jurisdiction applies to small craft harbours. Harbours are also within the ambit of provincial and municipal legislatures (*Re Sturmer and Town of Beaverton,* 1911). The federal government may delegate some of its management responsibilities to the public or private body that has responsibility for the harbour and/or related facility. These could include, for example, the power for spatial planning and safety management (*Durham v. Todd,* 2010; Epstein, 2017, 180–181, 188–189). Powers related to navigation and shipping may also be shared between federal and provincial levels based on agreement, for example, with respect to boating safety regulations and enforcement (VORR, 2008).

A particular consideration in the discussion of ports and harbours in the Canadian context is the role of Indigenous rights where the location of the port or harbour is within ancestral lands or territories or when the activities of the port affect Indigenous rights. The port or harbour may be totally located on Indigenous lands subject to land claims agreements known as modern treaties. The common law prescribes a duty to consult with respect to development that affects the exercise of Indigenous rights (Mayer, 2016, 136–137).

11.2.2 Types of Ports and Harbours and Their Powers

As noted above, federal law distinguishes between ports managed by port authorities, public ports, and fishing and recreational harbours also known as small craft harbours.

11.2.2.1 Ports Managed by Canada Port Authorities

Initially, the CMA created 18 port authorities (now 17) and designated other ports as public ports. While 34 remote ports remain under TC supervision, some 150 smaller ports have been devolved to provinces or municipalities. The largest and most important commercial ports are managed by port authorities incorporated under the CMA and are responsible for the governance of port areas.

Port is defined as “navigable waters under the jurisdiction of a port authority and the real property and immovables that the port authority manages, holds or occupies” as set out in the Letters Patent issued by the Minister of Transport (CMA, 1998, s 5). Within a port, port facility means “a wharf, pier, breakwater, terminal, warehouse or other building or work that is located in, on or adjacent to navigable waters that is used in connection with navigation or shipping, land incidental to its use and any land adjacent to navigable waters that is used in connection with navigation or shipping” (ibid, s 2(1)). The *actual* geographical extent of a port, and hence a port authority’s jurisdiction, is set out in the port’s Letters Patent. For example, Vancouver harbour has 233 kilometres of coastline (United States border/Roberts Bank through Sturgeon Bank, English Bay, and Burrard Inlet to Port Moody), and the Vancouver Fraser Port Authority (VFPA)—consisting of the Vancouver Port Authority, the Fraser River Port Authority, and the North Fraser Port

Authority as amalgamated in 2007—has proprietary jurisdiction over 150 kilometres of shoreline, including seabed areas and reclaimed lands.

Port authorities are responsible for the port's governance system, powers, and activities to be undertaken in the lands and waters assigned to it, which include "the navigable waters that are within the port authority's jurisdiction" (CMA, 1998, s 8; TC, 2019). They function as Crown agents in performing their traditional activities related to shipping, navigation, carriage and handling of goods, and passenger transportation (CMA, 1998, s 7(1)). However, they function on their own behalf when undertaking other necessary commercial activities to support port operations, such as those that help generate revenue for the port (ibid, s 28(2)–(3)). They are endowed with management, permitting, and regulatory powers to enable them to operate their respective port lands and waters and certain enforcement powers (PAOR, 2000, Pt 3; CMA, 1998, s 28(1)). The powers are limited to activities concerning shipping, navigation, carriage of goods and passengers, cargo handling and storage, and other activities as set out in legislation and in the Letters Patent and must be exercised in compliance with that mandate (CMA, 1998, s 28(2) & (4)).

Currently, port authorities have limited policy-making and regulatory powers, and current port policies are restricted to commercial operations and do not constitute public policy. They have the power to make by-laws to regulate the affairs of the port authority and the duties of officers and employees (ibid, s 30). In the case of the VFPA, the Letters Patent include regulatory power for "development, application, enforcement and amendment of rules, orders, bylaws, practices or procedures and issuance and administration of authorizations respecting use, occupancy or operation of the port" (VFPA, 2007, art 7(1)(a)).

Port authorities conduct a wide range of activities related to the movement of maritime trade and consequently have complex infrastructure consisting of terminals, docks, wharfs, buildings, and other structures to support commercial activities. Typically, ports are home to clusters of maritime industries and services, including bunkering, chandlers, warehousing, ship repair, pilotage, towage, and salvage. Major ports provide vessel traffic services in their geographical remit, which usually includes coastal and inshore waters. The inshore waters within their jurisdiction may include not only the area enclosed by the mouth of the port but also riverine areas and offshore anchorages and the approaches to the port covered by traffic service zones. Hence, port authority ABM powers extend to the orderly use and management of ports to ensure there are no interferences with navigational uses and creation of safety risks to persons and ships due to obstructions, interference with authorized activities, diversion of physical features as to reduce depth of waters, nuisance, and compromised sediment or water quality (PAOR, 2000, s 5).

Significantly, the *Impact Assessment Act* (IAA) empowers port authorities to conduct environmental reviews (IAA, 2019, s 82). Port authorities enjoy land use planning powers within their geographical remit, which requires the development of a land use plan as in the case of the VFPA (2020). The consequence is that the stakeholders of a port will include municipalities and communities affected by their land use plans, thus necessitating public consultations in development planning. A port authority's land use plans are not regulations, and their provisions apply only to lands owned by the authority (CMA, 1998, s 48(9)).

A port authority's power to conduct and monitor operations includes port traffic control, and there is currently a legislative proposal to strengthen this power. Bill C-33 will include a new purpose in the CMA to "manage traffic, including mooring and anchorage, in order to promote the efficiency of supply chains" (Bill C-33, 2022, s 100). Currently, the port authority's power in this regard is to promote safe and efficient navigation and environmental protection in port waters and includes monitoring of ships in or entering port waters, establishing vessel practices and procedures, requiring ships to have the capacity to use specified radio frequencies, to proceed at a certain speed and/or with assistance, avoidance of certain areas, and establishing traffic control zones (CMA, 1998, s 56(1)). Typically, port areas tend to be subject to mandatory pilotage regulated by the regional pilotage authorities established under the *Pilotage Act* and regulations (Pilotage Act, 1985). Regulations under the CMA empower port authorities to require information to be submitted by ships for traffic clearance, to impose conditions for traffic clearance, and to require vessel information after traffic clearance is granted (CMA, 1998, s 56(2); PAOR, 2000, s 32). A port's vessel traffic services are expected to be consistent with national standards and practices established under the *Canada Shipping Act, 2001* (CMA, 1998, s 56(3); VTSZR, 1989). Unless there is an urgent situation, a proposed vessel traffic services measure must give reasonable notice and consider representations by stakeholders (CMA, 1998, s 57).

Port authorities may designate persons to exercise powers concerning ships in or about to enter their ports. These persons may issue traffic clearances, direct the master or officer on watch or pilot on board to provide information on the ship, direct the ship to use specified radio frequencies in communications with the port station or other ships, and specify the time for ships to arrive at or leave berth, leave or refrain from entering any area, or to proceed to or remain at a specified location (ibid, s 58(1)). However, there must be reasonable grounds for requiring a vessel to proceed to or stay at a particular location, and such instruction must be founded on specified circumstances. For example, a berth might not be available; there is pollution or a reasonable apprehension of pollution in the traffic control zone; the proximity of animals to the ship whose well-being could be endangered by the ship; an obstruction to navigation in the traffic control zone exists; the presence of a ship in apparent difficulty or presenting a pollution threat or other hazard to life or property; proximity of a ship navigating in an unsafe manner or that is unseaworthy; vessel traffic congestion posing risks; and efficiency of port operations could be compromised (ibid, s 58(2)). Ships are required to follow the directions issued (ibid, s 58(3)).

A port authority's powers and duties include the taking of appropriate measures to maintain order and safety for persons and property in the port and subject to regulations under the *Marine Transportation Security Act* (ibid, s 61(1)–(2); MTSR, 2004). This power includes restricting access to port areas and facilities.

11.2.2.2 Public Ports

Public ports and public port facilities *are designated by the Governor in Council* under the CMA (CMA, 1998, ss 2(1) & 65). Their geographical scope is defined by Schedule 1 of the *Public Ports and Public Port Facilities Regulations* (PPPPFR, 2001). While ports under port authority management have broad national and international significance, public ports have regional importance. They may be owned by the federal government or other entities such as provinces, municipalities, and not-for-profit bodies. As in the port authority-managed ports, while the federal level retains primary jurisdiction in accordance with constitutionally allocated owners, provincial law may apply to particular matters.

Public ports do not enjoy the autonomy ascribed to port authorities, and hence their powers are limited, with the Minister of Transport performing the key responsibilities. Unless they fall under the authority of another minister, the Minister of Transport is responsible for the administration of the federal real property and immovables forming part of a public port or facility, issuing leases and licences concerning federal real property and immovables, disposal or transferring the administration of federal real property and immovables, fixing fees for port use, and entering into agreements to provide services, rights, or privileges in the public port (CMA, 1998, ss 66, 67–69, 71–72). Harbour masters or wharfingers for public ports and facilities are appointed by the Minister (ibid, s 69). The Minister may also enter into agreements with a person or body concerning the management or operation of a public port or public port facility (ibid, s 70). The person or body designated by the Minister may take traffic control zone measures as in the case of port authorities (ibid, s 76).

The powers of public port officials for the orderly use, management, and protection of public ports are largely analogous to those of port authorities to ensure there are no interferences with navigational uses, safety risks to persons and ships due to obstructions, interference with authorized activities, diversion of physical features, nuisance, compromise of physical features, and adverse effects on public port operations (PPPPFR, 2001, s 44). Similarly, public port officials may remove refuse, polluting substances, cargo, ship's gear, and other objects interfering with navigation at the expense of the perpetrator (ibid, s 22). Port officials may instruct port users to cease an activity or take precautionary measures with respect to the above risks (ibid, s 29(1)). Port officials themselves have similar duties to take appropriate measures with respect to activities they propose to mitigate or prevent the above risks and considering safety concerns, environment protection, and public port infrastructure (ibid, s 30). As in the case of port authorities, public port officials may authorize public port uses by specific persons, with or without conditions, insurance cover, or performance or damage security (ibid, ss 35–36). Authorization may be withdrawn on similar grounds, and instructions to cease, remove, return, and restore may be issued. In the case of non-compliance, the port official may remove the object at the expense of the person concerned (ibid, ss 37, 39). A public port official may order the removal of a ship from one port area to another or if it interferes with navigation, and in the case of non-compliance, may have it removed at the expense of the person concerned (ibid, s 43).

11.2.2.3 Small Craft Harbours

The legal status and governance of small craft harbours are set out in the *Fishing and Recreational Harbours Act* (FRHA) (FRHA, 1985). Again, they may be owned by the federal government or other entities such as provinces, municipalities, and not-for-profit bodies. They are land-marine spaces where fishing and recreational vessels and their occupants are accommodated and serviced, and they are mainly of two types (ibid, s 2). The first includes harbours, wharfs, piers, breakwaters, slipways, and marinas, including their machinery, works, land, and structures. The second includes any other facilities installations and works located on or adjacent to water. As in the case of ports, fishing and recreational harbours are scheduled in the regulations (ibid, scheme 1). Although DFO owns many small craft harbours, a substantial number are run by not-for-profit local harbour authorities, and many are divested, mostly to local municipalities (DFO, 2022).

The legal status of harbours is like ports. Harbours are owned by the Crown, but ownership may be transferred to provinces, municipalities, Indigenous communities, and not-for-profit organizations. Although there may be delegation or divestiture of management responsibilities to persons or bodies in a province, the DFO Minister remains responsible. And, as in the case of ports, the federal level retains primary jurisdiction, while provincial law may apply to particular matters.

The DFO Minister is responsible for the use, management, maintenance, enforcement of regulations, and collection of charges in scheduled harbours (FRHA, 1985, s 4). Ministerial powers include undertaking projects to acquire, develop, construct, improve, and repair scheduled harbours and to enter into an agreement with a province or person for this purpose, financing of projects, and undertaking studies (ibid, s 5). The Minister is empowered to lease scheduled harbours and to grant licences for their use for up to a 20-year period and to enter into an agreement with a province for the occupancy, although leases and licences must preserve public access to the harbour (ibid, s 8; FRHR, 1978, s 6).

The DFO Minister may appoint harbour managers, officers, and employees for the operation, administration, and management of scheduled harbours (FRHA, 1985, s 27). The Minister is also empowered to designate enforcement officers who have significant authority to enforce the regulations and even to prohibit the use of a scheduled harbour in cases of non-compliance (ibid ss. 10–11). The enforcement officer may direct the removal of abandoned vessels and goods that impede, interfere, or render it difficult or dangerous to use the harbour and has the power of removal for this purpose (ibid, s 14).

Harbour managers have extensive powers to ensure orderly and safe use of harbours. For example, a harbour master may prohibit dangerous goods, provide directions for berthing, mooring, and moving of vessels and loading and unloading, authorization of supply and receipt of bunker fuels, and instructions for the disposal of garbage and sewage or other wastes (ibid, ss 8, 14, 25).

DFO runs the Small Craft Harbours Program to promote a national network of harbours managed and maintained by self-sufficient harbour authorities representing the interests of local communities and stakeholders (DFO, 2022). The programme enables the transfer of ownership of non-essential harbours and recreational harbours to other federal departments, provinces, municipalities, Indigenous communities, and not-for-profit organizations. Harbour authorities are incorporated as not-for-profit organizations run by boards of directors representing local stakeholders and managing, operating, and maintaining harbours through lease agreements (DFO, 2017). DFO maintains manuals for the governance of harbour authorities and including environmental management responsibilities (DFO, 2011, 2012a, b, 2021). Harbour authorities are usually required to develop an environmental management plan and have pollution prevention responsibilities.

11.2.3 Other Pertinent Instruments

In addition to the core roles played by the CMA and the FRHA and their regulations, other federal instruments are relevant for ABM in ports and harbours. The *Canada Shipping Act 2001* (CSA, 2001) and regulations apply to safety measures and procedures, such as for marine communications and vessel traffic management (CSA, 2001, s 126). The *Pilotage Act* promotes safe navigation by regulating the certification and use of pilots, most especially in ports where pilotage tends to be mandatory (Pilotage Act, 1985). Some cargoes have special requirements concerning loading, unloading, storage, and labelling because of their inherent nature, as is the case for the classes of dangerous goods regulated by the *Transportation of Dangerous Goods Act, 1992* (TDA, 1992). The security of ships and port facilities servicing them is addressed by the International Maritime Organization (IMO)'s International Ship and Port Facility Code as implemented by the *Marine Transportation Security Act* and by regulations under the CMA (ISPS Code, 2002; MTSA, 1994; NMHNUR, 2005, s 3).

Federal environmental law applies to different aspects of port operations. With respect to decarbonization, port activities are captured by the 2050 net-zero target for national greenhouse gas (GHG) emissions adopted under the *Canadian Net-Zero Emissions Accountability Act* and eventual reporting of Canada's Nationally Determined Contribution (NDC) under the *Paris Agreement* (CNZEAA, 2021, s 6; Paris Agreement, 2015). Bill-C 33 will strengthen ports' ability to pursue decarbonization (Bill C-33, 2022, s 107(2)). Similarly, for the purpose of the IAA, ports are designated federal authorities which, as part of the government of Canada, are expected to foster sustainability and respect for Indigenous peoples and apply the precautionary approach (IAA, 2019, ss 2, 6(2), scheme 1). Hence, port authorities conduct impact assessment reviews of activities within their remit in accordance with the IAA (CPAEAR, 1999).

The *Canadian Navigable Waters Act* and its regulations address activities that could produce obstructions to navigation in navigable waters (CNWA, 1985). However, several major ports are exempted from the application of this act,[1] although an impact assessment must be undertaken (PAOR, 2000, ss 21, 22 & scheme 2). The Act does not apply to ministerial determinations as to whether works interfere with navigation in other ports, although presumably the requirements of the IAA would still apply (ibid, s 2). Perhaps more pertinent is the *Wrecked, Abandoned and Hazardous Vessels Act* (WAHVA) governing the regimes for problem vessels that are abandoned in ports, salvage of vessels in distress, and the removal of wrecks (WAHVA, 2019). The Ministers of Transport and Fisheries, Oceans, and the Canadian Coast Guard (DFO Minister) enjoy powers to address problem vessels in ports, harbours, and navigable waters generally and to delegate powers for this purpose to port and harbour authorities.

The protection of marine and other species under the *Canada Wildlife Act* (CWA), *Migratory Birds Convention Act* (MBCA), and *Species at Risk Act* (SARA) extends to the geographical areas of ports and harbours (CWA, 1985; MBCA, 1994; SARA, 2002). Moreover, MPAs that potentially affect parts of a port or harbour's geographical area may be designated under the *Canadian National Marine Conservation Areas Act*, *Canada Wildlife Act*, and *Oceans Act* (CNMCAA, 2002; CWA, 1985; Oceans Act, 1996). In some instances, parts of a port or harbour may also be designated as national parks under the *Canada National Parks Act* (CNPA, 2000).

Pollution prevention provisions with respect to dumping in the *Canadian Environment Protection Act* (CEPA), management of various wastes on board ships and discharge of pollutants under the CSA 2001, and discharge of substances deleterious to fish and habitats under the *Fisheries Act* and their respective regulations similarly apply to activities in ports and harbours (CEPA, 1999, s 125; CSA, 2001, s 187; Fisheries Act, 1985, s 36(3)). While there are no major ports in Arctic waters north of 60 degrees, numerous small harbours, together with shipping, are governed by the *Arctic Waters Pollution Prevention Act* and its regulations prescribing a zero-to-controlled discharge regime for wastes (AWPPA, 1970; ASSPPR, 2017). The *Oil Tanker Moratorium Act* is also relevant for minimizing the risk of oil pollution accidents in British Columbia because it creates prohibitions for oil tankers carrying more than 12,500 metric tons of crude and/or persistent oil with respect to ports and marine installations north of 50°53′00″ north latitude and west of 126°38′36″ west longitude, unless they enjoy a limited exception or ministerial exemption (OTMA, 2019, ss 4–6). The prohibitions include mooring, anchoring, loading, and unloading, as well as assisting such vessels to circumvent the prohibitions. Further, the WAHVA is pertinent as the removal of problem vessels in ports and waters may also help abate pollution of the port and marine environment (WAHVA, 2019).

[1] Belledune Port Authority, Halifax Port Authority, Montreal Port Authority, Prince Rupert Port Authority, Quebec Port Authority, Saguenay Port Authority, Saint John Port Authority, Sept-Îles Port Authority, St. John's Port Authority, Trois-Rivières Port Authority, and Vancouver Fraser Port Authority

Public health matters in the port and harbour environment are subject to the *Quarantine Act*, overseen by the Public Health Agency of Canada (Quarantine Act, 2005). The Act implements the *International Health Regulations* which, among other, establish procedures for reports with respect to ships that may have persons with infectious diseases on board (IHR, 2005). Customs matters overseen by the Canada Border Services Agency, fiscal arrangements subject to a federal provincial arrangement, taxation, and federal immovable property are subject to other federal legislation (CCA, 1985; FPFAA, 1985; PLTA, 1985; FRPFIA, 1991). Immigration matters are overseen by the Department of Immigration and Citizenship under the *Immigration and Refugee Protection Act* (IRPA, 2001).

11.3 Environmental Protection

11.3.1 General

Port authorities must operate ports in a sustainable manner, and for this purpose every major port has articulated its own environmental mission based on its Letters Patent and drawing on maritime, port, and environmental regulation.[2] By way of example, the VFPA's regulatory power on environmental matters in its Letters Patent includes the development and operation of port infrastructure, environmental assessment, audit, remediation and rehabilitation of marine habitat and marshes, dredging and waste disposal, navigational services and aids, emergency planning and response, salvage and seizure, harbour patrol services of the port's navigable waters, provision of vessel refuelling stations, vessel towage, management of waterways and foreshore, and complying with any international convention, agreement, or arrangement to which Canada is a party (VFPA, 2007, arts 7, 11.1).

While from an environmental perspective the purposes of the CMA are to promote sustainability and provide for a high level of environmental protection, the Act itself does not contain the full suite of ABM and other regulatory tools applicable to port and harbour authorities. The regulations concerning sustainability and environment protection are spread across several federal statutes and subsidiary regulations.

[2] For example, Port of Halifax, Environmental Policy, https://www.portofhalifax.ca/policies-and-planning/environment/environmental-policy/; Port of Montreal, Sustainable Development Actions, https://www.port-montreal.com/en/the-port-of-montreal/social-responsibility/sustainable-development; Port of Vancouver, Environment Protection at the Port of Vancouver, https://www.portvancouver.com/environmental-protection-at-the-port-of-vancouver/

11.3.2 Promotion of Sustainable Port Activities

Although the national transportation policy as stated in the *Canada Transportation Act* declares that it “contributes a sustainable environment”, its provisions have little environmental content, let alone placing sustainability at the centre of transport policy (CTA, 1996, s 5). Somewhat similarly, while the CMA sets out a “high level of environment protection” in its purposes, the pursuit of sustainability in an integrated manner is not an express objective of the Act (CMA, 1998, s 4(d)). Hence Bill C-33 proposes an important amendment to the CMA to strengthen climate regulation (Bill C-33, 2022, s 107(2)). The FRHA makes no reference whatsoever to sustainability.

The IAA and its regulations are the principal federal instruments that mandate and set out procedures for the pursuit of sustainability across the federal government and thereby also in ports and harbours. Indeed, the first expressed purpose of the IAA is to foster sustainability, which is defined as “the ability to protect the environment, contribute to the social and economic well-being of the people of Canada and preserve their health in a manner that benefits present and future generations” (IAA, 2019, ss 2, 6(1)(a)). A corollary purpose is “to protect the components of the environment, and the health, social and economic conditions that are within the legislative authority of Parliament from adverse effects caused by a designated project” (ibid, s 6(1)(b)). The IAA applies to all federal activities on federal lands, which are defined as lands that include those owned by the Crown (including waters and airspace), internal waters, and territorial sea, thus encompassing all geographical areas within the remits of ports (ibid, s 2). Among the prohibitions in the Act are activities in the marine environment that produce change to species and habitats protected under the *Fisheries Act*, SARA, and MBCA (ibid, s 7(1)(a)).

Designated projects are physical activities on federal lands pre-designated in a list in the *Physical Activities Regulations* (PAR) or designated by the Environment and Climate Change Canada Minister (ECCC Minister) in situations where the Minister is of the opinion that the physical activity “may cause adverse effects within federal jurisdiction or adverse direct or incidental effects, or public concerns related to those effects warrant the designation”, and may include adverse effects on Indigenous peoples (IAA, 2019, ss 2, 9(1)–(2); PAR, 2019). Specific examples of designated projects in the port environment include new marine terminals, new waste management facilities and waste disposal at sea in protected areas, and generally construction, operation, and decommissioning of new terminals to handle ships larger than 25,000 deadweight tons (PAR, 2019, s 2(1) & sch). Prior to the IAA, the construction of new terminals on existing port lands was exempted for public policy reasons.

The IAA establishes an impact assessment system in five phases that include planning, impact statement, impact assessment, decision-making, and post-decision follow-up for designated projects, underscored by public access to information and consultation and a focus on Indigenous peoples and their constitutionally protected rights. At the planning stage, the Impact Assessment Agency of Canada (IAAC) determines whether to proceed with the assessment and if it needs to coordinate with other federal authorities (such as ports), provinces, or Indigenous bodies (ibid, s 14). As experts in their fields, ports are required to cooperate with the IAAC (ibid, ss 13, 23).

The designated federal authorities tasked with undertaking impact assessments of effects of designated projects include port authorities (ibid, ss 2 (definition of federal authority), 109(a) & scheme 1). Ports are required, among others, to pursue sustainability and environmental protection and to ensure that designated projects under the Act are "considered in a careful and precautionary manner to avoid adverse effects within federal jurisdiction and adverse direct or incidental effects" (ibid, ss 6(1)(a), (b), (d), (l)). Ports must pursue designated projects in accordance with the IAA, unless the IAAC determines no impact assessment for the project is required or where the effects of the projects are deemed to be in the public interest (ibid, s 8). In addition to the impact assessment requirements of physical activities on the designated list and determinations by the ECCC Minister, ports are still required to undertake assessments for other activities. A port authority must not carry out a project or exercise any power under the CMA unless it first determines that the carrying out of the project is not likely to cause significant adverse environmental effects or the project is likely to cause such adverse effects and the Governor in Council decides they are justified in the circumstances (ibid, s 82). An interesting example is the establishment of new bunkering facilities in ports for the various types of renewable fuels currently under consideration, such as hydrogen and ammonia, which are not among the designated physical activities. Although this activity facilitates the decarbonization of shipping and promotes a port's competitiveness, it is an activity that would require impact assessment by the port authority concerned.

In undertaking impact assessments, ports are expected to track the requirements of the IAA. However, if a proposed project is a designated project under the IAA's *Physical Activities Regulations*, the proponent is expected to first engage with the IAAC. Some port authorities have developed their own impact assessment review process for non-designated projects. One of the most advanced, in the opinion of this author, is the VFPA Project and Environmental Review Process, which sets out the principles, review categories, and review steps (VFPA, 2022).

11.3.3 Decarbonization

Canada committed to developing a plan to set itself on a path to achieve net-zero emissions by 2050 and legislated the *Canadian Net-Zero Emissions Accountability Act* as a framework for this purpose, and the Minister is tasked with establishing GHG emission targets and reduction plans for each milestone year (CNZEAA, 2021, ss 6–9). Canada's 2021 NDC did not single out the contribution of ports in reducing emissions, and the only reference to marine emissions concerns the 1%

contribution of all shipping to Canada's emissions and a commitment to international cooperation in the decarbonization of the industry (Canada NDC, 2021).

The regulation of GHG emissions from international shipping is primarily the responsibility of IMO, which recently finalized its GHG strategy (IMO, 2023). The IMO GHG Strategy recognizes the important role that could be played by ports in facilitating the decarbonization of shipping, although IMO regulation per se does not address ports and at the most can only make recommendations in their regard (Chircop, 2019, 500–501). Further, although the GHG emissions of international shipping are not reported at the national level, emissions from port activities and cabotage are considered domestic emissions and are therefore reported as part of the NDCs (ibid). Against this backdrop, ports are responsible for reducing their emissions and play a potentially significant facilitative role in the decarbonization of shipping.

The CMA is as weak on climate targets and decarbonization as it is on sustainability. Similarly, although the CSA 2001 and regulations address air emissions, there is relatively little on decarbonization, other than implementation of IMO indices for energy efficiency of ships—namely, the Energy Efficiency Design Index (EEDI), Ship Energy Efficiency Management Plan (SEEMP), and Energy Efficiency eXisting ship Index (EEXI)—and what there is currently provides little legal guidance for ports (MARPOL, 1973/78, Annex VI, regs 24–26).

At the domestic level, TC does not appear to have established a policy to guide ports' actual efforts to reduce GHG emissions, nor does it appear to have developed voluntary emission reduction agreements from the domestic marine sector as it has for the rail and aviation industries (Senate of Canada, 2017, 31). However, it has encouraged port initiatives to reduce port-related emissions, for example, with respect to trucking, and provides cost-shared funding for installation of shore power systems for ships at berth, most especially for cruise ships (ibid, 34; TC, 2020). It appears cruise ships are better equipped to receive shore power than other commercial vessels, which lack standardized systems to plug into grids. Only a few Canadian ports—namely, Vancouver, Prince Rupert, Halifax, and Quebec City—have shore power due to the expense involved and the need for power to be supplied at preferential rates (ibid).

As mentioned earlier, Bill C-33 will empower the Governor in Council to make regulations "respecting the impact of the operation of a port by a port authority on the environment, including climate change, and the impact of climate change on the operation of a port" (Bill C-33, 2022, s 101(1.1)). The federal government will still need to set the emissions reduction targets, presumably synched with Canada's declared NDC commitments, and sector specific share, as declared in a future NDC. Port authorities will need to develop 5-year plans for emissions and adaptation action based on public consultations. A concern for some Canadian ports is that long-term sea level rise and storm frequency could affect port operations.

Bill C-33 prescribes the content of the quinquennial plans and reports (ibid, s 116). Plans must be prepared within 1 year of the effectivity of the amendments and must contain a GHG reduction target, description of actions to achieve the target, information on material changes from the previous plan, and other prescribed information (ibid). Requirements for quinquennial adaptation plans must be prepared within 2 years of effectivity of the amendments. They must contain a description of current and anticipated impacts of climate change on port operations and assets and actions taken, description of current and future commercial opportunities arising from climate change impacts and steps taken to take advantage of them, information on material changes since the previous plan, and any prescribed information.

Port authorities have a range of powers to enable efforts to decarbonize activities and support shipping in their own decarbonization efforts. The earlier discussion of the powers of port authorities mentioned their powers concerning land use planning, permitting building construction, and transportation in the port environment. Bill C-33 tightens the requirements around publication and content of notifications of land use plans (ibid, s 118(1)).

11.3.4 Prevention of Marine and Air Pollution

The *International Convention for the Prevention of Pollution from Ships* 1973/78 (MARPOL) regulates pollution through annexes on oil, hazardous noxious substances carried in bulk, hazardous noxious substances carried in packaged form, sewage, garbage, and air pollution and includes a scheme for port state inspections for visiting ships (MARPOL, 1973/78, Annexes I–VI). Ports themselves do not undertake the inspections concerned, as this is a responsibility of TC acting as the national maritime administration, and inspections often are delegated to classification societies as recognized organizations. Rather, an integral part of the MARPOL pollution prevention system is the provision of port reception facilities for the various regulated wastes, which ports are expected to provide. The MARPOL annexes require ships to discharge oily wastes, hazardous noxious substances, sewage, garbage, scrubber residue from exhaust gas cleaning systems (EGCS), and ozone depleting substances to port reception facilities.

State parties to MARPOL Annex 1 undertake to ensure the provision of adequate reception facilities for oily residues (including oily bilge waters) in oil loading terminals, repair ports, and all other ports in which tankers and other ships have oily residues to discharge without causing undue delay to ships (ibid, Annex I reg 38). In the case of Annex II, the undertaking to provide reception facilities concerns residues of and mixtures containing noxious liquid substances (ibid, Annex II reg 18). Annex IV has similar requirements for reception facilities for sewage and Annex V with respect to garbage (ibid, Annex IV reg 12 & Annex V reg 8).

With respect to Annex VI, the undertakings concern the provision of port reception facilities for ozone-depleting substances and equipment containing such substances when removed from ships and scrubber residues from ships employing an EGCS to remove the high sulphur content in heavy fuel oil as an alternative compliance mechanism to using low sulphur content fuels (ibid, Annex VI reg 17; VPDCR, 2012, ss 111(4)(a), (6)(a), 111.1(7)(a)). Currently, Canada applies the 2009 IMO

EGCS standards, rather the 2015 or even more recent 2021 versions (IMO, 2009, 2015, 2021). It is unclear why this is the case.

Ships must obtain a certificate from the reception facility attesting to the type and amount of regulated waste discharged at the reception facility (VPDCR, 2012, ss 41(1), 80(1), 107(1)). Curiously, the regulations do not seem to require similar certification for the discharge of ozone depleting substances and for scrubber residues, although the master is still required to record the transfer of ozone depleting substances to a reception facility in the Ozone Depleting Substances Record Book on board (ibid, s 124.1(2)(d)). Neither the 2009 IMO ECGS Guidelines not the Canadian regulations that implement them have anything to say on certification of receipt of scrubber residue discharged at a port reception facility. Further, while regulating the discharge of grey water, the regulations do not require its discharge at a port reception facility (ibid, s 131.1). However, new grey water (and sewage) treatment, management, and discharge measures for cruise ships in Canadian waters include periodic reporting on compliance with the measures to TC (2022).

The North American Emission Control Area (NAECA) designated under Annex VI is of relevance to Canadian ports and harbours in the Atlantic and Pacific, the Laurentian region, St Lawrence Seaway, and Great Lakes (MARPOL, 1973/78, Annex VI reg 13.6.1 & app VII). The general rule concerning sulphur content (SOx) in bunker fuel prescribes that the sulphur content must not exceed 0.50% m/m (ibid, Annex VI reg 14(1)). The standard for ships operating in the NAECA is much higher at a maximum of 0.10% m/m and must be documented by the supplier (ibid, Annex VI reg 14(4)–(5)). Similarly, a higher standard for emissions of nitrogen oxides (NOx) from diesel engines applies to ships operating in the NAECA (ibid, Annex VI reg 13). The air pollution protection also significantly reduces emission of particulate matter.

11.3.5 Protection of Marine Biological Diversity

Port and harbour authorities must comply with federal pollution regulations designed to protect species and their habitats. Under the *Fisheries Act*, port and harbour authorities must not discharge any deleterious substances in waters frequented by fish or any other place where such substances may enter such waters, unless in doing so they comply with other regulations, such as the *Vessel Pollution and Dangerous Chemicals Regulations* (Fisheries Act, 1985, s 36(3); VPDCR, 2012, s 36(4)(a)). They have similar duties under the MBCA not to deposit or permit the deposit of substances (or in combination with other substances) that are harmful to migratory birds or a deposit in waters or areas frequented by migratory birds or in places where such substances may enter such waters or areas (MBCA, 1994, s 5). The CEPA forbids the deposit of prohibited substances in marine areas, unless by permit issued and gazetted by the ECCC Minister (CEPA, 1999, ss 125, 127). This is pertinent for ports and harbours because “disposal” includes the disposal of dredged material (ibid, s 122(1)).

Further habitat protection under the *Fisheries Act* relates to works and undertakings. The Act provides that no person shall carry on any work, undertaking, or activity, other than fishing, that results in the death of fish, without a permit from the DFO Minister (Fisheries Act, 1985, s 34.4). Similarly, there is a prohibition for the carrying on any work, undertaking, or activity that results in the harmful alteration, disruption, or destruction of fish habitat, unless with ministerial authorization (ibid, s 35). The requirements and procedures for permitting are set out in the *Authorizations Concerning Fish and Fish Habitat Protection Regulations* (ACF, 2019).

Where marine waters under their jurisdiction overlap with protected areas, ports and harbour activities are expected to comply with regulations under the *Oceans Act* and its regulations, marine conservation areas under the CNMCA, and marine wildlife areas under the CWA. The *Oceans Act* provides a framework for the designation of marine protected areas, and regulations under it govern specific areas (Oceans Act, 1996, s 35 et seq.). Several marine protected areas are designated in the Atlantic, Arctic, and Pacific oceans. Each protected area is regulated according to its unique context and circumstances and usually accompanied by a general prohibition of any activity that disturbs, damages, destroys, or removes marine living organisms or its habitat, as in the case of the Banc-des-Américains Marine Protected Area (BAMPAR, 2019). Some fishing activity may be permitted in some cases, and navigation rights are preserved, although there could be restrictions such as no-anchor areas and waste discharge prohibitions. Protected areas and reserves may be designated under the CNMCA, which are subject to several prohibitions. These include restrictions on the disposal of interest in public lands and that no person shall use or occupy those lands, explore or exploit specified minerals, or dispose of any substance without permit (CNMCAA, 2002, ss 12–14). Marine protected areas may be designated by the Governor in Council under the auspices of the CWA, and the ECCC Minister may provide advice relating to them (CWA, 1985, s 4). Regulations under the Act establish a long list of prohibitions that include, among others, any industrial activity; disturbance or removal of any soil, sand, gravel, or other material; and dumping or depositing of wastes or substances that could alter the quality of the environment (WAR, 2023).

Ports and harbours are also expected to observe additional habitat protections in their waters prescribed under other legislation. Regulations under the MBCA provide for the establishment of migratory bird sanctuaries, which could theoretically be in port or harbour areas; however the specified regulatory prohibitions do not appear to include activities that port and harbours would normally undertake (MBSR, 2023, s 3). The *Fisheries Act* similarly provides for the designation of ecologically significant areas by the Governor in Council on the recommendation of the DFO Minister with the effect that works, undertakings, or activities that affect such areas are screened and permitted by the Minister (Fisheries Act, 1985, s 35.1). SARA provides protections to numerous marine species and enables the competent Minister, based on consultations with the Canadian Endangered Species Conservation Council, to establish codes of practice, national standards, or guidelines with respect to the protection of critical habitat (SARA, 2002, s 56). The critical habitats of listed endangered or threatened aquatic species on federal lands or migratory birds conserved under the MBCA are protected (ibid, s 58). Species subject to recovery plans are legally protected, and critical habitats of numerous marine species are protected by dedicated regulations or orders.

Port authorities have the discretion to use vessel traffic management powers to help prevent or mitigate the impacts of navigating vessels on marine species in port and harbour waters under their jurisdiction, including in areas other than MPAs. Among the reasonable grounds for requiring a vessel to proceed to or stay at a particular location, the CMA includes the proximity of animals whose well-being could be endangered by the ship and for which vessel compliance is required (CMA, 1998, s 58(2)–(3)). Ports may use this power to fulfil their duties under conservation legislation, such as under SARA. Where the conservation measures extend over a large area, a cooperative approach involving port authorities, other federal authorities, and stakeholders is called for. For example, the critical habitat of the Southern Resident killer whale (SRKW) overlaps with areas of jurisdiction of the VFPA, and in 2014 the VFPA initiated the Enhancing Cetacean Habitat and Observation (ECHO) Program to bring together stakeholders to better understand and manage the risks posed by large commercial vessels to whales. In 2019, this initiative led to the *Species at Risk Act* section 11 Conservation Agreement to Support the Recovery of the SRKW with the participation of federal authorities (including the VFPA through the Minister of Transport) and major industry associations (SARA Conservation Agreement, 2019).[3] The agreement aims "to reduce the acoustic and physical disturbance to SRKW by large commercial vessels in Pacific Canadian waters" through voluntary efforts and threat reduction measures. The VFPA commitments consist of continuing to manage the ECHO Program (including providing an ongoing framework for engagement, collaborative development, and implementation of work plans; advancement of selected research projects; coordination to develop appropriate SRKW threat reduction targets; coordination to develop, implement, and monitor measures to reduce threats; and maintaining education outreach) and to work with TC to develop a strategy "to encourage underwater noise reduction incentives in other ports in Canada and internationally" (ibid, art 5.2.1). The initiatives pursued for specified periods have included the Haro Strait and Boundary Pass voluntary ship slowdown, the Strait of Juan de Fuca voluntary inshore lateral displacement, and the Swiftsure Bank voluntary ship slowdown trial (Port of Vancouver, 2023a).

[3] The parties to the agreement are the Minister of Fisheries, Oceans and the Canadian Coast Guard (for DFO); Minister of Transport (for Transport Canada, VFPA and Pacific Pilotage Authority); Chamber of Shipping of British Columbia; Shipping Federation of Canada; Cruise Lines International Association; Council of Marine Carriers; and the International Ship Owners Alliance of Canada.

11.4 Discussion

11.4.1 Use of Space

In discussing ABM roles in shipping, it is useful to distinguish between ports and harbours as special management areas to support shipping and the use of ABM measures concerning the mobility of ships.

First and foremost, ports and harbours themselves are designated areas for the provision of a range of services to shipping and for the location of other industries that rely on shipping for their transportation needs. Major ports are nodal points in road, rail, pipeline, and marine transportation networks and at times also aviation. They have defined boundaries and are placed under the authority of a Crown or other designated body with powers to enable them to manage the allocated space, including through the use of ABM tools within that space. Accordingly, these ABM powers include land use and marine spatial planning, as well as the coordination of the two types of planning. Where aviation is part of the transportation hub, as in the case of the Vancouver flight centre, a port may have terminals dedicated to the safe navigation and berthing of aircraft used for passenger traffic. Rules for safe mobility apply to both ships and aircraft in the vicinity of each other, for example, under the *Convention on the International Regulations for Preventing Collision at Sea*, 1972 (COLREGs, 1972).

Second, land use planning is one of the most important ABM practices a port undertakes, because ports typically are home to industrial uses as well as human settlements. Their concern is not simply the commercial and competitive operation of port services to ships but also the quality of the living environment shared by urban areas in their vicinity. Hence, land uses require a permit, and land use planning has to ensure port activities are governed by impact assessment that includes consultation processes and that industrial activity is located in appropriate areas so as to minimize adverse impacts on other uses of the port environment. For example, Vancouver has seven land use planning areas (VFPA, 2020). The plans are concerned not only about the allocation of space but also with the traffic of different transportation modes. Some port uses, such as containerized and bulk cargoes (e.g., ores and grain), have their own exclusive terminals and cargo handling equipment. Certain dangerous cargoes may be located at a distance from other cargoes, such as petroleum products in liquid and gaseous form located at bulk terminals in Burrard Inlet and Burnaby in Vancouver. However, a well-diversified port economy may have dangerous goods sites located throughout a port area (TC, 2021).

Given the close relationship between land and marine activities, planning of marine area use in ports tends to be part of or coordinated with land use planning. As discussed above, ports have vessel traffic management powers to ensure safe navigation and the overall safety of port operations. Marine spatial planning includes the allocation of space for port transits, traffic separation schemes, berthing and safe anchorage, other activities supporting shipping operations, and, naturally, other uses of port waters. As in the case of land uses, a marine activity usually requires a permit from port authorities, as in the case of the Port of Vancouver (Port of Vancouver, 2023b, c). Hence, ABM in ports tends to involve multiple land and marine interests and uses that need to be coordinated.

11.4.2 Governance Powers

Ports and harbours in Canada are endowed with different governance systems reflecting various extents of power and ministerial oversight. Placed at the top tier, port authorities are substantially autonomous entities and have increasingly seen their powers expanded to enable them to be as commercially competitive as possible while still watching out for the Crown's interests which they represent as agents in some respects. Public ports and small craft harbours have significantly less autonomy and power, depending largely on ministerial oversight and powers delegated to provinces, municipalities, or not-for-profit organizations. Differently, port authorities are run by boards of directors with substantial commercial and regulatory power to ensure commercial viability, safety, and environment protection in port operations.

11.4.3 Environmental Considerations

Ports run by port authorities, public ports, and small craft harbours are all subject to the same marine environmental law. Their contributions to environmental protection in large part depend on their compliance with the extensive federal law on the prevention of marine pollution and the protection and conservation of marine biological diversity. However, because of their autonomy, port authorities have a special role to play in ensuring sustainable development of port lands and waters based on impact assessment and due consideration and pursuit of Canada's climate change policies and international obligations. In this regard, it is interesting to observe that, to date, port authorities' abilities to regulate activities with environmental and climate impacts appear to stem largely and indirectly from their powers concerning land use planning and contracting commercial operations. They can regulate activities on port lands, such as construction and energy use and efficiency standards, in a manner that helps mitigate carbon emissions. However, port authorities' administration of existing federal law and their ability to regulate shipping are limited to approving mooring and anchoring, directing the movement of ships in waters under their jurisdiction as part of their vessel traffic management powers, and establishing conditions for the provision of services to ships, for example, shore-based power and receipt of wastes. They have corollary enforcement powers, such as taking possession of and removing ships or ordering tugs to move and moor ships to places designated by the port authority.

A critical environmental role played by all ports and harbours, but most especially ports run by port authorities which service international shipping, is the ability to prevent and reduce marine pollution. They help Canada perform its international obligations to provide reception facilities to domestic and international shipping in its ports for wastes generated by ships. They also play a vital role in helping to reduce air pollution by providing bunkering services for low-sulphur fuels. Already, several of the major ports that have developed shore power facilities are able to connect certain classes of ships (cruise ships in particular) to shore power, thereby reducing GHG and other emissions in the port environment and ensuring cleaner air. Eventually, ports will also greatly assist with the decarbonization of shipping by developing bunkering infrastructure to provide renewable fuels, such as ammonia and hydrogen.

11.5 Conclusion

As major players enjoying substantial autonomy in their special management areas, port authorities play a central role in balancing the needs of commerce, trade, environment, and social benefits. The governance of ports and harbours as spaces designated for the support of shipping is underscored by a unique ABM context that needs to be understood at multiple levels. The port and harbour area itself is geographically defined in terms of both land and marine areas setting out the extent and limits of their competence as administering authorities. That space, together with the powers allocated, is an integral part of a dedicated legislative regime but also draws on larger transportation and environmental policy and legislative frameworks. The administering authorities are empowered to use ABM measures to enable the pursuit of safe, efficient, and competitive functions both in the marine areas proper and adjacent lands within their remits. Hence, the use of ABM in ports tends to be a continuity of complementary terrestrial and marine measures. In addition to commercial purposes, the ABM measures used to address environmental concerns support sustainability through impact assessment, pollution prevention, and mitigating the impacts of port activities on habitats and species.

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Part IV
Managing Human Safety in Remote Areas

Chapter 12
Making Sense of Marine-Based Search and Rescue Response Time Using Network Analysis

Mark A. Stoddard, Ronald Pelot, Floris Goerlandt, and Laurent Etienne

Abstract Navigation in polar waters follows standard navigational practice, with special consideration for the presence of sea ice and its expected impact on safe ship operation. Experienced polar ship operators rely on timely access to authoritative sea ice analysis and knowledge of the safe operational limits of their ship to determine the navigability of polar waters. Several sea ice risk assessment frameworks exist to assist ship operators with onboard decision-making, most notably, the Polar Operational Limit Assessment Risk Indexing System (POLARIS). The result from POLARIS is referred to as the Risk Index Outcome (RIO). By adjusting ship speed in response to the RIO value, it is possible to account for sea ice risk in the estimation of ship transit time in polar waters. In this chapter we discuss the use of network analysis techniques to generate the fastest route between two locations in the Arctic and to compute surface ship incident response service areas (IRSA) and incident response isochrones (IRI) for different times of year and ship ice classes. The use of IRSA and IRI to support area-based management (ABM) tools that aim to formally incorporate historical observations of shipping activity into quantitative assessments is also discussed. Incorporating IRSA and IRI results into ABM tools would provide decision-makers with a useful tool to possibly help plan and coordinate incident response in polar waters and support ABM of commercial vessel operation and search and rescue provision.

Keywords POLARIS · Service area · Isochrone · Network analysis · Optimization

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12.1 Introduction

Reductions in sea ice due to climate change continue to affect navigability in the Canadian Arctic and other polar regions (Smith & Stephenson, 2013; Melia et al., 2016). Many of the maritime areas experiencing changes in sea ice conditions are becoming more accessible for longer periods, resulting in increased maritime activity and higher volumes of shipping traffic. As accessibility improves, global interest in Arctic maritime activity from various economic sectors will likely continue to increase (Arctic Council, 2009). Increases in Arctic shipping will put new pressures on the limited infrastructure and services supporting Arctic shipping, especially the search and rescue (SAR) capabilities of many Arctic nations. While Arctic states continue to build infrastructure and response capacity, polar ship operators must continue to demonstrate a high degree of self-reliance and sound decision-making. The International Maritime Organization (IMO) International Code for Ships Operating in Polar Waters (Polar Code, 2014/15) also provides mariners with guidance to reduce operational risks in polar waters via safety and environmental prevention measures (Fedi et al., 2018). Currently, the Polar Code requires that all vessels operating in polar waters be prepared to wait at least 5 days for SAR resources to arrive on scene (Polar Code, 2014/15). The combination of the remoteness of the Canadian Arctic and lack of SAR infrastructure has the potential to push maritime-based SAR response well beyond 5 days, and in some cases the incident location may be inaccessible by available maritime-based SAR assets.

Accessibility in the Arctic can be assessed using navigability and expected ship transit times as proxy indicators. Navigability is commonly determined using risk-based methods to identify go/no-go areas for a particular polar ship class, on the basis of the ice risk present in an area of operations (Mudryk et al., 2021). Ice risk is typically determined by ship bridge watch officers and/or qualified ice navigators using a variety of frameworks developed by transportation authorities and ship classification societies. The Polar Code currently recommends the use of the Polar Operational Limit Assessment Risk Indexing System (POLARIS). A ship operator can use POLARIS to assess the navigability of an area of operation by converting observed sea ice conditions into a Risk Index Outcome (RIO). The RIO result is specific to a ship's polar class (Fedi et al., 2020). The more positive the RIO value, the more navigable the area of operation. POLARIS is already widely used by researchers to support a variety of analyses that involve Arctic navigation and navigability, such as trans-Arctic routing (Melia et al., 2016; Aksenov et al., 2017), economic analysis of polar routes (Lloyds of London, 2014; Smith & Stephenson, 2013), and modelling and simulation of shipping activity (Wei et al., 2020; Wang et al., 2022).

In this chapter we examine how variable sea ice conditions in the Canadian Arctic affect the fastest route between two locations and expected transit time. The method to compute the fastest route between two points in the Arctic accounts for changes in the navigability along a route due to sea ice risk. The method to compute transit time integrates sea ice risk assessment and knowledge of expected ship speeds in different ice regimes. The result is a transit time estimate that accounts for changes in ship speed due to varying levels of sea ice risk encountered along the route. By combining these two methods, we are now able to compute incident response service areas (IRSA) and incident response isochrones (IRI) for different times of year, different polar class vessels, and locations of interest. IRSA and IRI are analysis tools that are used to determine the reachable areas of a geographic area within a maximum response time cut-off (MRTC). All figures presented in this chapter were produced by the authors.

The use of IRSA and IRI simplifies the analysis of expected transit time from an arbitrary location in the Arctic to a point of interest, such as a SAR incident location and coastal community or area-based management (ABM) location of interest. This allows one to quickly assess and visualize many of the complex navigational challenges associated with maritime mobility in Arctic waters, supporting a variety of ABM applications. One focus of the discussion here is on the potential to apply IRSA and IRI concepts to a previous effort conducted by the National Research Council of Canada (NRC) that examined exposure time until recovery at fixed locations in the Arctic (Kennedy et al., 2013). The goals of the NRC study were to identify and assess key factors that influence exposure time and to use the results to strengthen policy and regulations relating to operational requirements and life-saving appliance testing conditions. The discussion here demonstrates how IRSA and IRI concepts could be used to better quantify the potential contribution of vessels of opportunity (VOO) in the analysis of marine-based SAR response.

12.2 Theoretical Background

12.2.1 Incident Response and Maritime SAR

In Canada, SAR is one of the primary responsibilities of the Canadian Coast Guard (CCG). Through the effective use of dedicated SAR resources, the CCG responds to approximately 6000 maritime incidents per year (DFO, 2022). Following each response operation, incident reports and logs are entered in a database known as the Search and Rescue Program Information Management System (SISAR) (Stoddard & Pelot, 2020). SISAR incident data is one of the primary data sources used to capture statistics relating to maritime SAR cases to inform demand for programme services and the achievement of outcomes (DFO, 2022). SAR incident data provides a rich multivariate spatiotemporal dataset that can support a wide range of analysis. This chapter focuses only on the location of historical maritime incidents to provide a basic understanding of the spatial distribution of historical incident locations in the Canadian Arctic, broadly supporting the ABM objectives of the CCG. Figure 12.1 provides an overview of historical maritime incidents which occurred between 2001 and 2020. Much of the analysis in this chapter is focused on the Baffin Bay region. Baffin Bay was selected for discussion for two reasons: (1) it

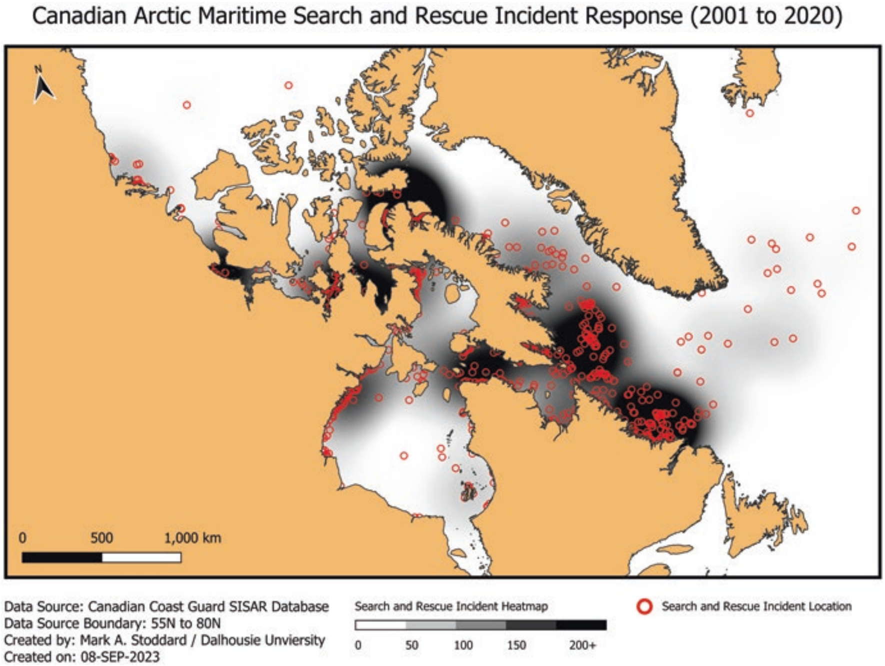


Fig. 12.1 Spatial distribution of SISAR incident data collected between 2001 and 2020

is an area of high incident occurrence, and (2) it presents a very challenging navigational environment throughout the year, especially during the yearly sea ice free-up and break-up.

12.2.2 Route Planning and Transit Time Estimation in Variable Sea Ice Conditions

Navigation risk assessment tools, such as POLARIS, are widely used to assess sea ice risk and determine its impact on safe ship operations (Fedi et al., 2018). The POLARIS assessment can be applied over wide areas using national sea ice analysis charts from the United States National Ice Center (USNIC) and Canadian Ice Service (CIS) to determine the accessibility of maritime locations in the Arctic. Accessibility is a crucial element in incident response operations, especially when considering remote maritime locations that lack supporting infrastructure in the Canadian Arctic. POLARIS is a useful tool to determine the navigability in an intended area of operations, but it does not provide extensive guidance on the selection of safe ship speeds in different RIO categories. The current guidance is limited to recommended ship speeds for polar class ships operating on RIO values between

0 and −10 (IMO, 2014a). No speed recommendations are specified in the POLARIS framework outside of this RIO value range.

Due to the spatial variability of sea ice conditions and the navigational complexity of the Arctic archipelago, standard approaches to calculate travel distance and time, such as Euclidean and Manhattan distance, are not feasible or even practical. One approach is to determine transit distance and time using network analysis methods, relying on the computation of total network distance and travel time along predefined arcs in an undirected graph (Siljander et al., 2015). Several network analysis algorithms exist to compute the shortest/fastest path between a source node and destination node in a graph, such as Dijkstra's shortest path algorithm (Dijkstra, 1959).

Smith and Stephenson (2013) demonstrated the use of network analysis methods to study new trans-Arctic shipping routes. Their method successfully combined the Transport Canada Arctic Ice Regime Shipping System (AIRSS) navigability assessment (similar to the POLARIS methodology) and sea ice data from different coupled atmosphere-ocean general circulation models (GCM) to compute trans-Arctic shipping routes and expected transit times using a terrain sensitive least-cost path algorithm. The optimal route was the route that accumulated the lowest possible travel time between origin and destination along the network arcs. The total transit time is the linear sum of the travel time of each arc in the graph that was traversed (Smith & Stephenson, 2013). Wang, Zhang, and Qian (2018) provide a complementary example of combining AIRSS with GCM outputs, to generate routes in the Arctic using a modified A* network optimization algorithm. More recently, Wei et al. (2020) generated Arctic shipping routes using a two-step process: (1) calculate the technical accessibility of a grid cell by an ice class ship, and (2) find the fastest route. Technical accessibility of a grid cell was determined using AIRSS with forecasted ice properties (thickness and concentration) from the output of a GCM. The cell-based least-cost path algorithm in a geographical information system was then used to determine the optimal path from origin to destination.

A good estimate of ship speed in different RIO categories is critical to improve the estimation of travel time and related metrics such as fuel consumption and emissions. Much research has been devoted to improving our understanding of the complex relationship between ice conditions, ship design, and operating characteristics. McCallum (1996) provided an early approach to predict expected ship speed in ice using a polynomial fit between minimum and maximum expected ship speeds for several Canadian Arctic Class (CAC) ships in different ice risk regimes. Ice risk was determined using AIRSS. Similarly, Somanathan, Flynn, and Szymanski (2006) also discuss the use of AIRSS to create a relationship between the AIRSS ice numeral and ship ice class to calculate a speed through ice. Kotovirta et al. (2009) examined the use of a mathematical relationship between ship net thrust and ice thickness/resistance. Automatic information systems (AIS) data was used for statistical validation of the transit times calculated by their method. More recently, researchers have begun to directly associate AIS data collected in polar regions with daily sea ice analysis to gain new insight into expected ship speed. Loptien and

Axell (2014) examined the relationship between AIS reported speed over ground and sea ice forecasts in the Baltic Sea to produce a mixed-effects model to predict vessel speed from forecasted ice properties, such as ice concentration, ice thickness, and ridge density. Lensu and Goerlandt (2019) and Goerlandt et al. (2017) provide two more recent examples of combining AIS and sea ice data for the Baltic Sea area to obtain insights in their relationship with operational ship speeds in ice for different types of ship operations. Lastly, Tremblett, Garvin, and Oldford (2021) used shore-based AIS data collected in the North American Great Lakes region between 2010 and 2019 to examine the distribution of observed vessel speeds in different RIO risk categories derived from CIS sea ice charts produced for the Great Lakes region. The authors do caution that POLARIS does not currently provide risk values (RV) for lake ice conditions or provide a mapping of sea ice equivalence, so great care must be taken when interpreting the results from this study.

12.2.3 Service Areas and Isochrones

An "isochrone" is defined as the line joining the equal travel time distances from any given location and has been used to understand the relationship between movement and time for more than 130 years (Dovey et al., 2017). A service area is defined as all geographic points within the polygon created by the isochrone. In this chapter we introduce the use of service areas and isochrones to study the relationship between ship movement and transit time in the Arctic. Isochrones and service areas are an effective tool to examine accessibility and mobility simultaneously, which is highly desirable when studying Arctic transportation. Determining the accessibility of and mobility in polar waters is one of the primary motivations for using the POLARIS assessment. POLARIS is used to determine if an area is accessible, meaning it is safely navigable, and to enable risk-based decisions related to safe ship speeds in ice.

The focus here is on the use of service areas and isochrones to better understand marine-based SAR response at different locations in the Arctic and response time cut-offs. Reference is made to service areas as IRSA and isochrones as IRI. IRSA and IRI have several potential uses in support of maritime ABM, but the focus here is on their use for marine-based SAR response in polar waters.

12.3 Methods

In this section we discuss data sources and analysis workflows used to produce the geospatial products presented and discussed throughout this chapter. Bi-weekly sea ice analysis data from the USNIC was used as the basis for the POLARIS calculations discussed here. POLARIS was used to compute and visualize navigational risk, and the expected transit time was determined by combining POLARIS

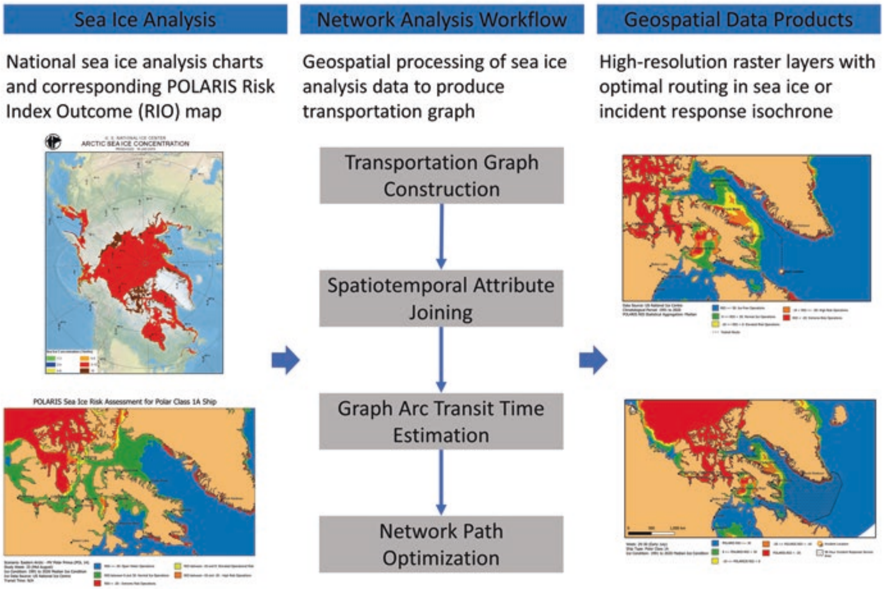


Fig. 12.2 Geospatial data processing workflow for producing optimal ship routes in ice and ISRA

RIO results with expected ship speeds in different RIO result categories as reported by Stoddard et al. (2023). Dijkstra's algorithm was used to perform network optimization and compute the fastest path between two points in a undirected transportation graph. Service area isochrones were produced by computing the concave hull of all nodes in the transportation graph from which an incident location can be reached by the fastest path within a given service level target, specified in hours. Figure 12.2 provides an overview of the geospatial data processing workflow for producing the fastest routes in ice, transit time, and incident response service areas and isochrones.

12.3.1 Sea Ice Analysis

Several authoritative sources of sea ice analysis exist, including USNIC, CIS, Danish Meteorological Institute, Icelandic Meteorological Office, and the Norwegian Meteorological Institute. To promote interoperability and data exchange, all national ice centres publish sea ice charts in a standard World Meteorological Organization (WMO) ice chart archive vector format known as Sea Ice Grid (SIGRID-3) (NSIDC, 2022). Operational sea ice charts show ice regimes as distinct polygons within a mapped region. An ice regime is defined as an area with a relatively consistent distribution of any mix of ice types, including open water. Ice analysts working for national ice centres have access to a variety of high-resolution data sources to estimate the partial ice concentrations of various ice types in an ice regime and encode the information according to a WMO standard (IOC/UNESCO, 2004).

Bi-weekly sea ice charts for the Arctic from the USNIC were selected for this study because of their circumpolar coverage and historical date coverage range. USNIC sea ice charts are produced through a detailed analysis of available in situ remote sensing and model data sources. The USNIC digital ice analysis charts (hemispheric, regional, and daily) have two main components: the shapefile containing the ice analysis ice information (ice polygons and related attributes) and the metadata describing the ice analysis data (NSIDC, 2015). Both components of the USNIC sea ice charts were used in this study.

12.3.2 Navigational Risk Assessment in Polar Waters Using POLARIS

POLARIS provides a quantitative framework to assess navigational risk in polar waters. Each polygon in a USNIC sea ice analysis chart is used to describe an area with a relatively consistent distribution of one or more ice types and may include open water. The concentration of each ice type (determined by observed stage of development and thickness) is reported in tenths. POLARIS specifies a RV for each ice type and polar class ship type. The output of the POLARIS assessment is referred to as RIO. The RIO is determined by calculating the linear sum of the RVs associated with each ice type present in a given ice polygon, multiplied by the respective ice type concentration (in tenths):

$$RIO = C_1 RV_1 + C_2 RV_2 + \ldots + C_n RV_n \tag{12.1}$$

where C_1, C_2, …, C_n are the concentrations of the ice types present in an ice regime and RV_1, RV_2, …, RV_n are the risk values provided by POLARIS. The RIO value is then evaluated, and a series of decision rules are applied to determine an appropriate operational limitation due to the presence of sea ice in the area of operation (IMO, 2014b). The decision rules applied in this study are shown below in Table 12.1.

It is possible to use POLARIS to compute and visualize the RIO for each polygon in the USNIC sea ice analysis chart for a chosen POLARIS scenario. The

Table 12.1 POLARIS RIO results decision rules and associated risk level descriptions used for this study

Decision rule	Risk level
RIO > = 30	Open water operations
0 < = RIO < 30	Normal ice operations
−10 < = RIO < 0	Elevated operational risk
−20 < = RIO < −10	High risk operations
RIO < −20	Extreme risk operations

POLARIS scenario refers to the selection of ship polar class and the decision rule used to determine the different RIO result categories. The result is a new sea ice analysis product we refer to as the single chart POLARIS scenario risk map. A POLARIS scenario risk map is unique to each polar class ship type and selection of decision rule. Figure 12.3 provides an example of a POLARIS scenario map for a Polar Class 1A ship.

For strategic navigation planning, it is often necessary to plan routes based on the ice conditions expected to be encountered during a future voyage. Stoddard et al. (2016) demonstrated how statistical aggregations of historical POLARIS RIO results can be used to support strategic navigation planning in polar waters. Using gridded CIS daily sea ice analysis charts from 2007 to 2014, the authors computed six statistical aggregations of historical RIO results throughout the Canadian Arctic including (1) minimum RIO, (2) 25th percentile RIO, (3) average RIO, (4) median RIO, (5) 75th percentile, and (6) maximum RIO.

This study focuses on the use of gridded USNIC bi-weekly sea ice analysis charts that cover the climatological period from 1991 to 2020 to compute the median POLARIS RIO value. In total, 1295 USNIC bi-weekly sea ice analysis charts were first gridded, resulting in 4,212,296 georeferenced grid cells containing the sea ice analysis attributes from each chart. The median RIO value for each grid cell was then computed on a bi-weekly basis, resulting in a final output of 26 gridded bi-weekly POLARIS scenario risk maps. Figure 12.4 shows how the features of the

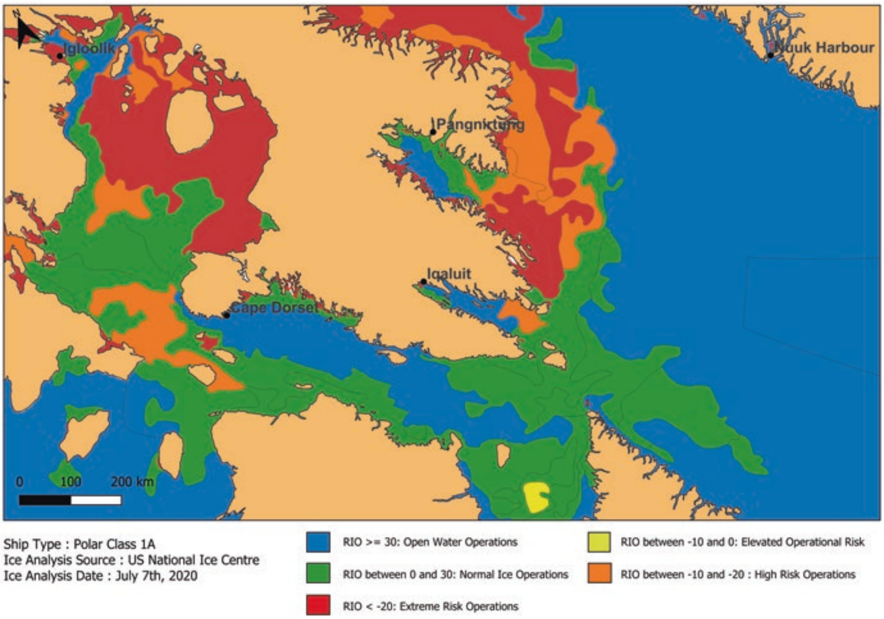


Fig. 12.3 Single chart POLARIS risk map for a Polar Class 1A ship operating in the eastern Arctic on 7 July 2020

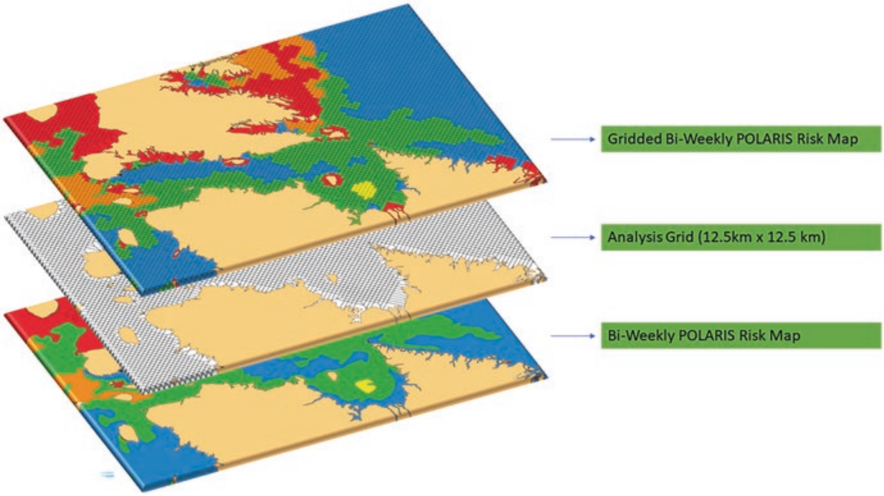


Fig. 12.4 Geospatial processing of map layers to generate the gridded bi-weekly POLARIS scenario risk map (top layer)

bi-weekly POLARIS scenario risk map are spatially joined with the analysis grid to produce the gridded bi-weekly POLARIS scenario risk map. This process is repeated for all USNIC bi-weekly sea ice analysis charts produced within the climatological period, and then a median RIO value is computed for each grid cell.

12.3.3 Transportation Graph and Transit Time Estimation

In order to utilize network optimization algorithms to compute the fastest route through an area of operations, we constructed an undirected graph for each bi-weekly analysis period, consisting of 137,494 nodes and 1,099,952 arcs. A node was created at the centroid of each grid cell in our analysis grid, with each node inheriting the sea ice analysis and POLARIS RIO attributes from the associated grid cell. Arcs were created by connecting adjacent nodes by straight line segments. The RIO value for each arc was computed by averaging the RIO value of the start and end node. The transit time for each arc was determined by dividing the arc length (km) by the expected ship speed in each RIO category (km/h). The ship speeds shown in Table 12.2 were first reported by Stoddard et al. (2023) and were derived from the visual inspection of a histogram of AIS reported vessel speed over ground in different RIO result categories observed over a 2-year period. Since the speed is specified based on the RIO result category, it is not necessary to consider the polar class of vessel when determining the appropriate ship speed along an arc. This is because the polar class of the vessel is already considered when computing the RIO value for each polar ship ice class. The fastest path is therefore the path from a start

Table 12.2 Ship speed versus RIO category

RIO category	Ship speed (km/h)	Ship speed (kts)
RIO > = 30	26	14
0 < = RIO < 30	16	8.5
-10 < = RIO < 0	9	5
−20 < = RIO < −10	5.5	3
RIO < −20	0	0

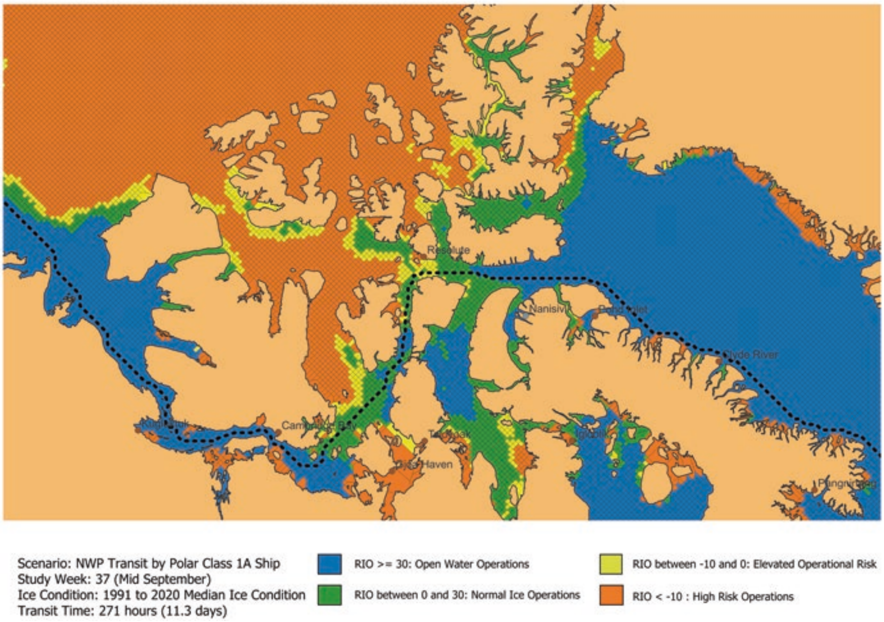


Fig. 12.5 Segment of a computer-generated trans-Arctic route from Southwest Greenland to Chukchi Sea, Alaska, for a Polar Class 1A ship in week 37 using the expected ship speed in the median RIO value observed over the climatological period from 1991 to 2020

location to an end location that minimizes the total transportation cost (total transit time).

To compute the fastest path between two points in our network, we utilized the QGIS software implementation of Dijkstra's algorithm (Dijkstra, 1959). The fastest path is the selection of arcs in the graph that minimizes the total transit time, computed by summing the transit cost of all selected arcs that form the path from start to end location. Figure 12.5 shows a computer-generated fastest route through the Canadian Arctic archipelago. This route represents the fastest route for a Polar Class 1A ship in week 37–38 (mid-September) using the 1991–2020 median RIO value.

In addition to computing the fastest path, we are also interested in computing IRSA and IRI in the Canadian Arctic. To simplify the following discussion, we first introduce the concept of the service area analysis scenario (SAAS). The SAAS

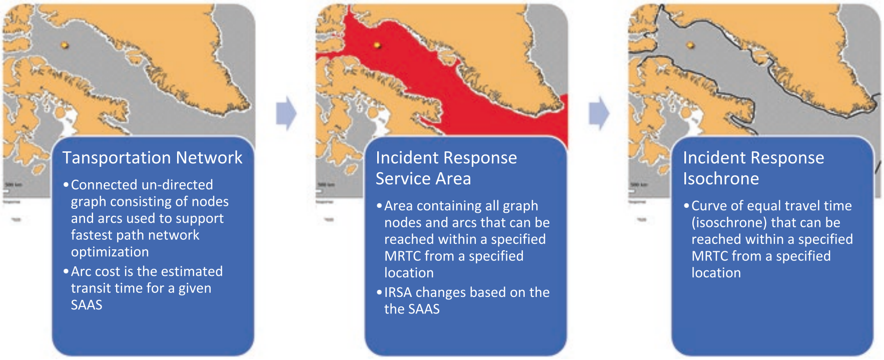


Fig. 12.6 Relationship between transportation network, incident response service area, and incident response isochrone

refers to the selection of (1) polar class ship type, (2) analysis time period, (3) RIO value statistic, (4) expected ship speed in each RIO result category, (5) MRTC, and (6) a specified geographic location of interest. The IRSA contains all the nodes and arcs of the transportation network that can be reached for a given SAAS. The IRI is a curve of equal travel time (isochrone) formed at the furthest locations in the network that can be reached for given SAAS. Mathematically, the IRSA is the concave hull formed from all nodes in the transportation graph that can be reached within the specified time cut-off. Figure 12.6 illustrates the relationship between the transportation graph, incident response service area, and incident response isochrone.

The methods discussed here are applied below to examine several different aspects of incident response in the Baffin Bay region of the Eastern Arctic. The emphasis will be on generating results that can help guide discussion related to incident response in polar waters, as well as introducing the concept of ISRA and IRI to support SAR response operations and ABM more generally. While the results shown below are focused on a notional incident in Baffin Bay, the methods are applicable throughout the Arctic region. Computational results have been produced for a variety of polar class ships, bi-weekly analysis periods, and MRTC to help draw attention to the factors that influence ISRA and IRI and their interpretation.

12.4 Results

In this section we apply the methods discussed above to examine incident response in the eastern Arctic. All results were produced using the same incident location (central Baffin Bay) to simplify the comparison of results and follow-on discussion. All POLARIS risk maps, ISRA, and IRI have been computed for an International Association of Classification Societies (IACS) Polar Class 1A ship, with some exceptions for the comparison of modelling results for different ship classes. The

1A ship ice class was chosen because it is one of the most common ship ice classes found operating in the Canadian Arctic during the navigable summer season. In practice, the methods discussed in the previous section, and shown in this section, can be produced for any incident location, time of year, ship ice class, and selection of RIO value summary statistic. The three primary results presented and discussed in this section include:

1. Fastest route in polar waters
2. Incident response service areas
3. Incident response isochrones

12.4.1 Fastest Route in Polar Waters

The fastest path is the route that minimizes the total transit time from a start node to an end node in our Arctic transportation graph. Figure 12.7 provides an overview of the fastest route between a start and end location in the eastern Arctic for a Polar Class 1A ship during each bi-weekly analysis period. The 1991–2020 median RIO value was used to assess the navigational risk throughout the year. The figure shows how the route and the corresponding transit time change throughout the year depending on the POLARIS RIO results at the time of operation. We also observe that for a significant portion of the year, there is no feasible route for a Polar Class 1A ship between the start and end location due to the severity of the sea ice conditions. This would indicate that the severity of sea ice conditions exceeds the safe operating limits of a Polar Class 1A ship during that time.

It is also possible to compare expected transit time results for different polar ship classes. In Fig. 12.8 we compare the year-round estimated transit time for a Polar Class 1A and Polar Class PC5 ship using a multi-line plot. For awareness, a Polar Class 1A is capable of summer/autumn operation in thin first-year ice (ice thickness from 30 to 70 cm), while a Polar Class PC5 is capable of year-round operation in medium first-year ice (ice thickness from 70 to 120 cm). The enhanced ice operating capabilities of the PC5 vessel allow it to operate safely over a much wider range of sea ice conditions than a 1A vessel. The result is twofold: (1) a PC5 vessel can typically operate at higher speed when sea ice is present when compared to a 1A vessel, and (2) a PC5 vessel has a longer operating season when compared to a 1A vessel.

Using the start and end location from the eastern Arctic transit scenario shown in Fig. 12.7, we computed the fastest route and expected transit for Polar Class 1A and PC5. Figure 12.8 shows the expected transit time results as a multi-line plot. For a large portion of the year, there is no feasible route between the start and end location for the Polar Class 1A vessel, that is, starting in late January/early February (week 5) and ending in late June (week 25). Periods where no feasible route exists appear as areas of discontinuity in the line plot. Notable observations from the comparison of Polar Class 1A and PC5 vessels are summarized in Table 12.3.

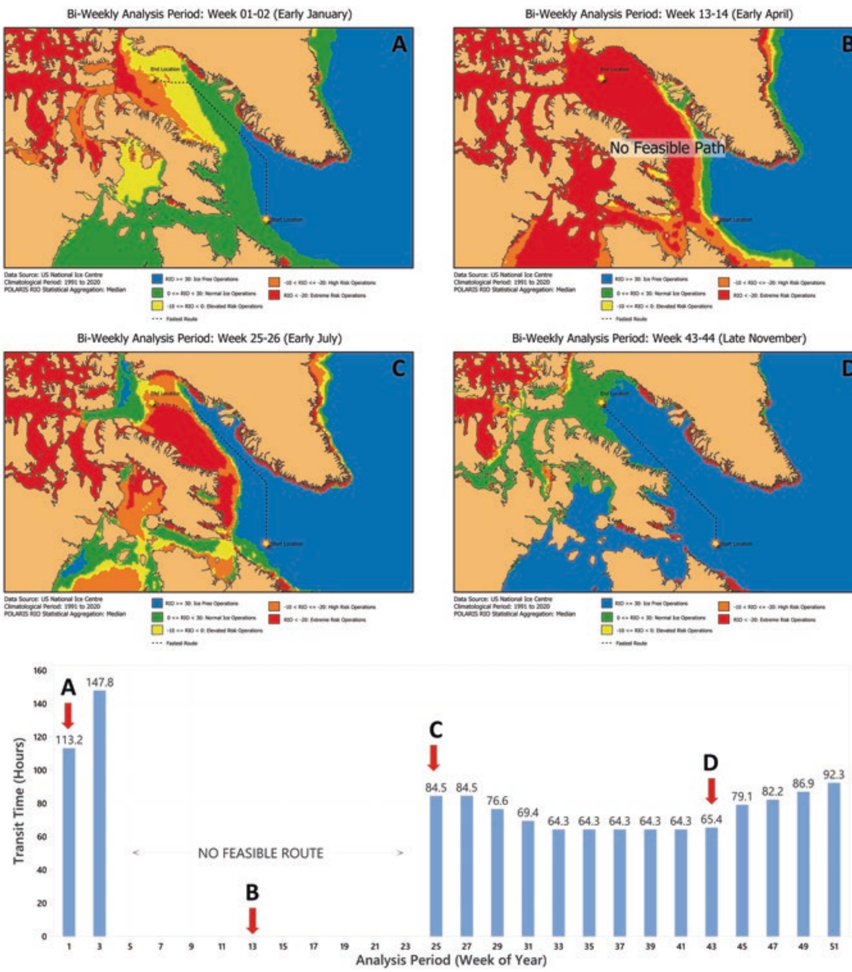


Fig. 12.7 Overview of the fastest route and expected transit time between two locations in the Arctic

12.4.2 Incident Response Service Area and POLARIS

Now that we can compute the fastest path between any start and end nodes in the Arctic transportation network, it is possible to compute the IRSA. The IRSA shown in Fig. 12.9 was generated for a Polar Class 1A ship operating in the eastern Arctic during week 29–30 using a 96-hour MRTC. The IRSA can be interpreted as containing all possible start nodes in the graph that can reach the incident location (end node) within the specified MRTC. The MRTC used for the analysis in this section is 96 hours. Figure 12.10 shows how the IRSA size changes throughout the year as the RIO changes due to varying sea ice conditions throughout the year. Other factors

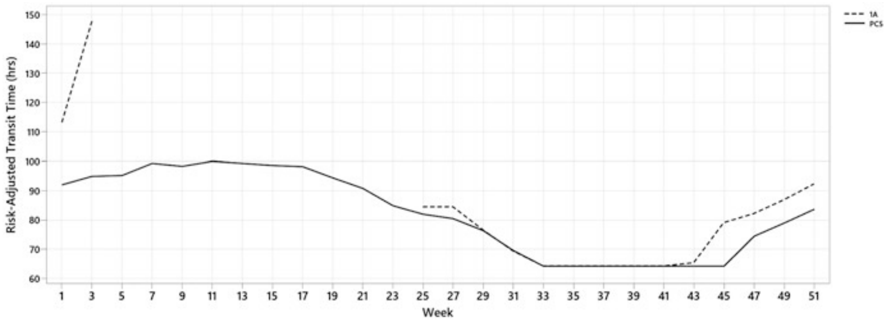


Fig. 12.8 Comparison of the year-round risk-adjusted transit time for a Polar Class 1A and PC5 ship between a start and end location in the eastern Arctic. Note: When no feasible route exists, the line is not drawn for that particular ship class

Table 12.3 Summary of year-round risk-adjusted transit time results for Polar Class 1A and PC5

	Polar Class 1A	Polar Class PC5
No feasible route (weeks)	5–25	N/A
Maximum expected transit time (hours)	147.8	100.0
Maximum expected transit time (week(s) of occurrence)	3	11
Minimum expected transit time (hours)	64.3	64.3
Minimum expected transit time (week(s) of occurrence)	33–41	33–45

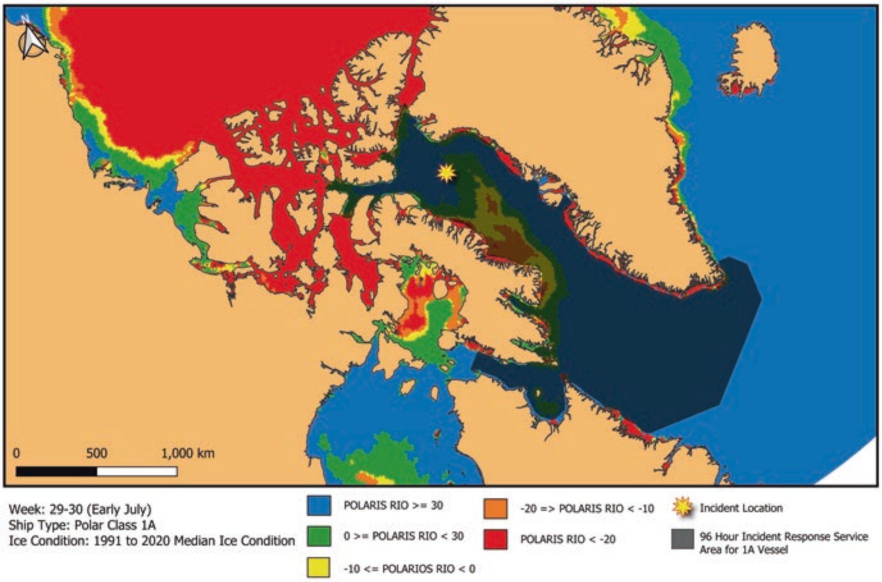


Fig. 12.9 Computed service area for a Polar Class 1A ship in week 29–30

that influence service area size are the MRTC (see Fig. 12.11) and ship ice class (see Fig. 12.12).

Sometimes it might be more convenient to visualize the MRTC isoline, which is referred to in this study as the IRI. This is the isoline formed around the maximum extent of the service area. The travel time from any arbitrary point on the isochrone to the incident location is equal to the MRTC. Figure 12.13 compares the 96-hour incident response isochrone for a Polar Class 1A and PC5 ship in week 29–30.

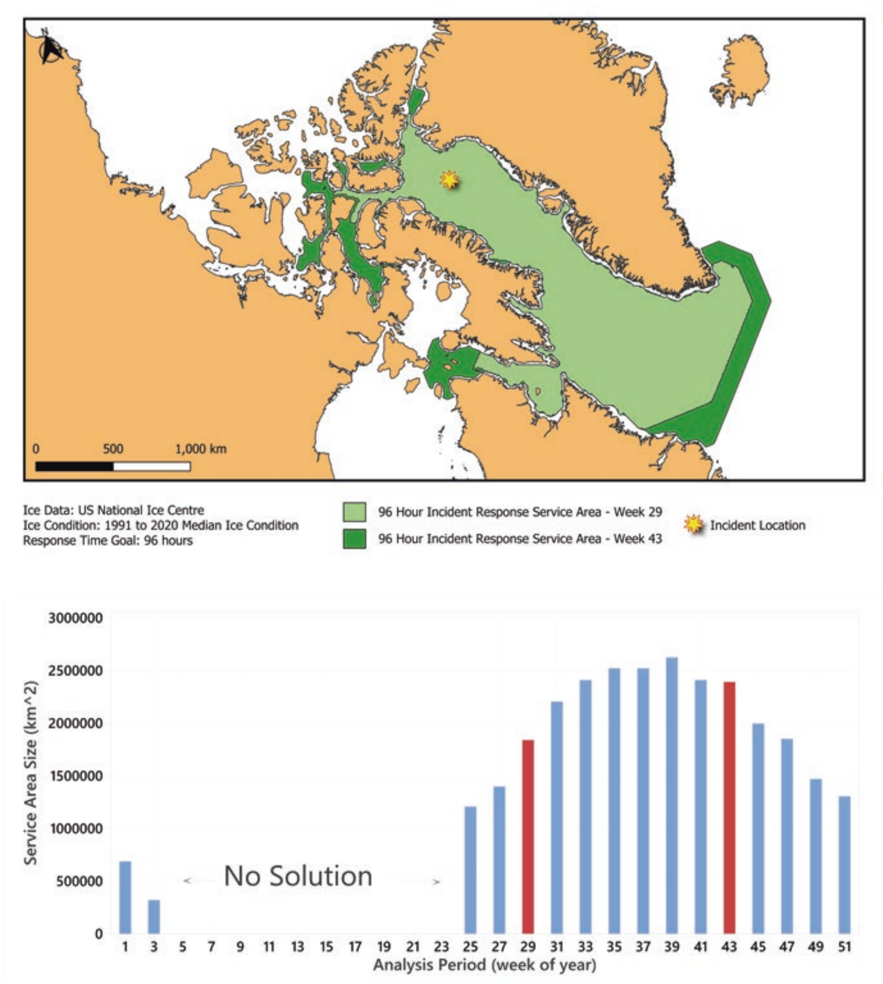


Fig. 12.10 Comparison of geographic size of the IRSA for a Polar Class 1A vessel throughout the year for a given SAAS

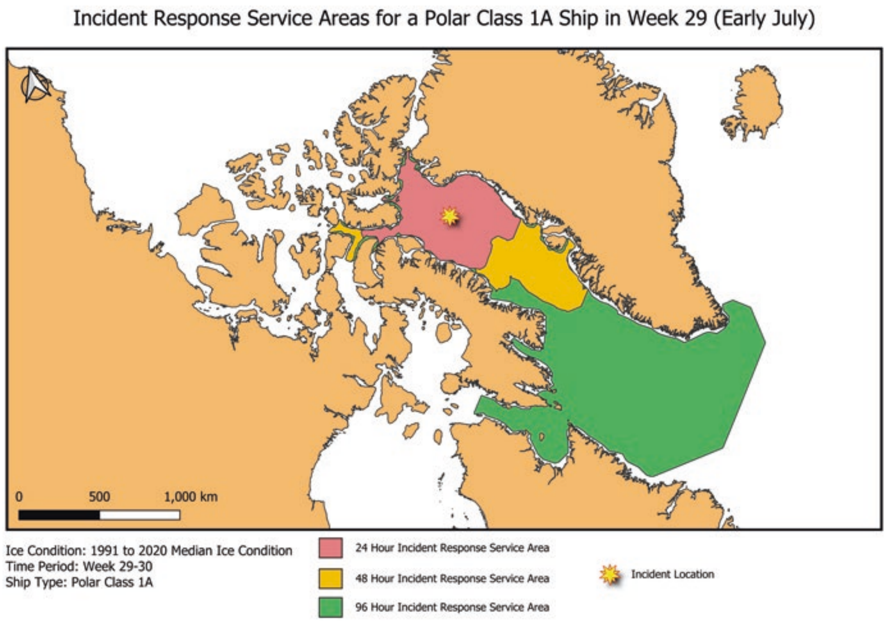


Fig. 12.11 Comparison of the IRSA size for a Polar Class 1A ship in week 29–30 for 24-hour, 48-hour, and 96-hour MRTC

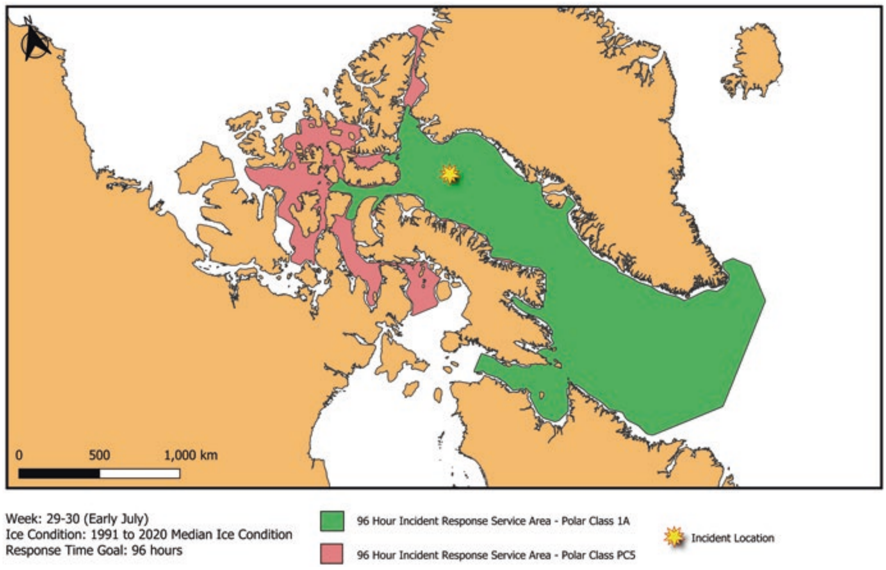


Fig. 12.12 Comparison of the IRSA for a Polar Class 1A and PC5 ship in week 29–30

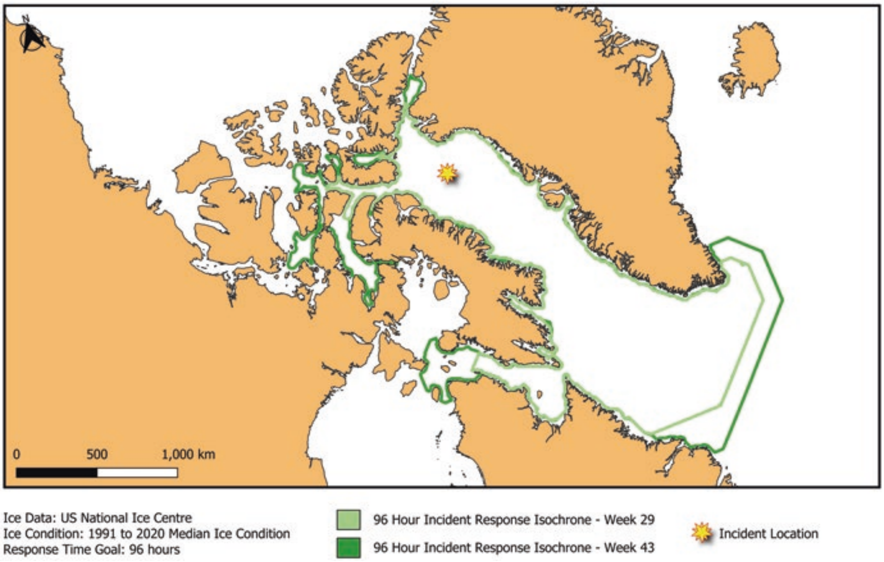


Fig. 12.13 Comparison of 96-hour IRI for a Polar Class 1A in week 29 and week 43

12.5 Discussion

The application of traditional network analysis methods to compute optimal routes in polar waters has resulted in several useful analytics and metrics with potential to support quantitative studies related to incident response and ABM in the Canadian Arctic. Our approach integrates sea ice analysis, navigation risk assessment, and network optimization to compute the expected transit time between two points in polar waters. Once computed, the expected transit time provides an objective measure to examine surface ship incident response in polar waters. The results indicate that incident response times are heavily influenced by the geographic location of the incident and responding vessel, time of year, sea ice conditions, and the ship ice class of the vessel responding to the incident.

The complex geography and variable sea ice conditions found in the Canadian Arctic archipelago are significant contributors to the spatiotemporal variability of emergency response time and overall maritime mobility. The remoteness of the Canadian Arctic and lack of infrastructure affect the timeliness of SAR response, especially maritime-based SAR response. Ships must be prepared to wait days before maritime-based SAR resources arrive at the incident location. Currently, and as mentioned above, the Polar Code requires that all vessels operating in polar waters be prepared to wait at least 5 days for SAR resources to arrive on scene (Polar Code, 2014/15). The National Research Council of Canada has previously evaluated the expected time until recovery for several geographic locations in the Arctic (Kennedy et al., 2013). The NRC study examined emergency response at eight locations dispersed throughout northern Canada but was limited to two hypothetical emergency scenarios, namely, (1) mild August environmental conditions and (2) severe August environmental conditions.

Figure 12.14 shows the location of the NRC maximum exposure evaluation sites overlaid on the SISAR incident data discussed above. The geographical locations selected by NRC were based on a number of considerations. The first was to ensure that locations were selected throughout the Canadian Arctic in order to provide results that cover the vastness of the region. The second consideration involved the frequency of travel based on current shipping routes and maritime traffic and expected future shipping activity. The third consideration was to ensure the selected locations were positioned at varying distances from existing infrastructure, such as airports, communities, and ports. A future examination of maximum exposure time could also consider using the location of historical SISAR incidents in the site selection process.

The use of IRSA and IRI to quantify and visualize the expected transit time for marine-based assets would be another possible extension to the NRC study of maximum exposure time in the Arctic. This additional analysis would allow for a greater consideration of the spatiotemporal variability of expected response time for marine-based SAR assets throughout the year. The use of IRSA and IRI computed on a bi-weekly basis would allow for a more complete analysis of expected transit time for marine-based response assets throughout the year and its impact on expected exposure time. Figure 12.15 shows the week 33 (mid-August) 12-hour, 24-hour, and 48-hour IRSA for a selected NRC maximum exposure evaluation site.

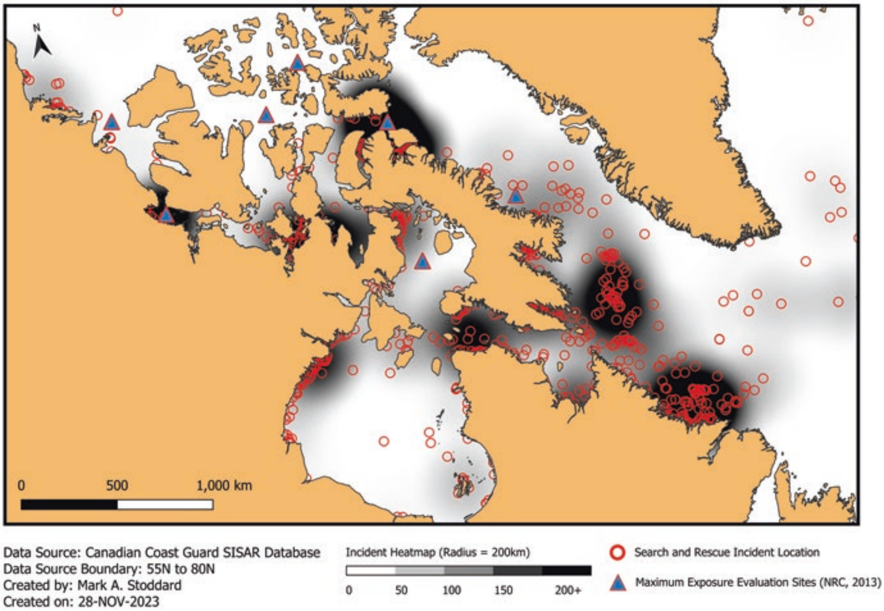


Fig. 12.14 SISAR incident data from 2001 to 2020 with an overlay of the NRC maximum exposure time evaluation sites

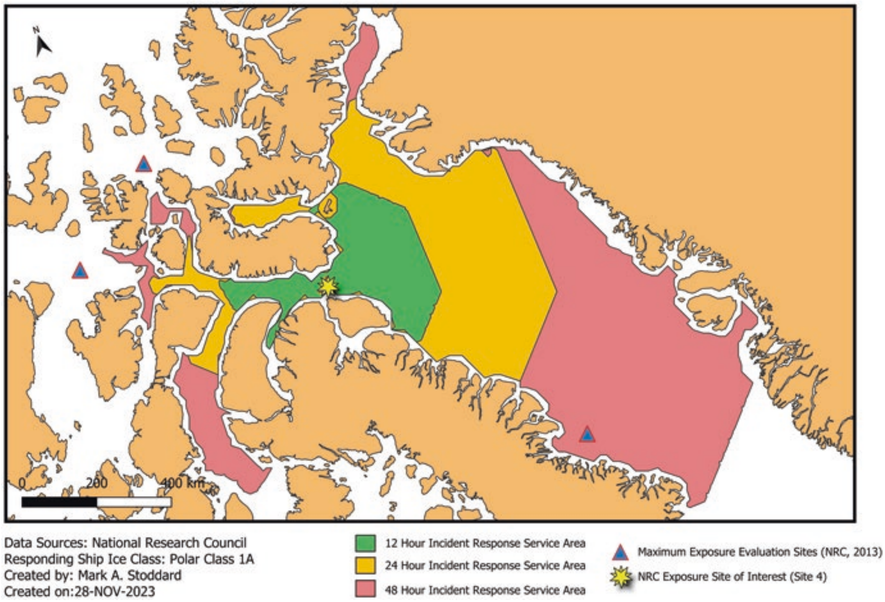


Fig. 12.15 12-hour, 24-hour, and 48-hour IRSA for a Polar Class 1A vessel operating in week 33 assuming 1990–2021 median RIO value for week 33–34

The results provide a convenient method to visualize the expected transit time for a Polar Class 1A vessel to reach the NRC evaluation site. A vessel located anywhere in a given IRSA polygon would be able to reach the location of interest within the associated time cut-off.

More specifically, the IRSA and IRI concepts could be used to extend the study results for marine-based SAR response to more formally consider the contribution of VOO in their analysis. This additional analysis would not require a significant change in the study methodology. This could be achieved by combining the analysis of historical shipping activity data (polar class ship type, time, and location) and IRSA results to determine the probability of a VOO being available and able to respond to an incident within the specified time cut-offs. This approach could also support a wide variety of ABM tools that aim to incorporate historical shipping activity into the overall assessment of marine-based SAR response for pre-selected evaluation sites in the Canadian Arctic. Figure 12.16 provides an example of how observations of shipping activity can be combined with IRSA to begin to quantify the expected contribution of VOO to incident response and maximum exposure time. In this case, we see that no VOO can reach the evaluation site within 12 hours, three VOO can reach the site within 12–24 hours, and 49 VOO can reach the site within 24–48 hours. The location and number of VOO shown in Fig. 12.16 are representative of a single instant in time. By analysing shipping traffic data over multiple years, it would be possible to statistically characterize VOO availability to support this form of analysis.

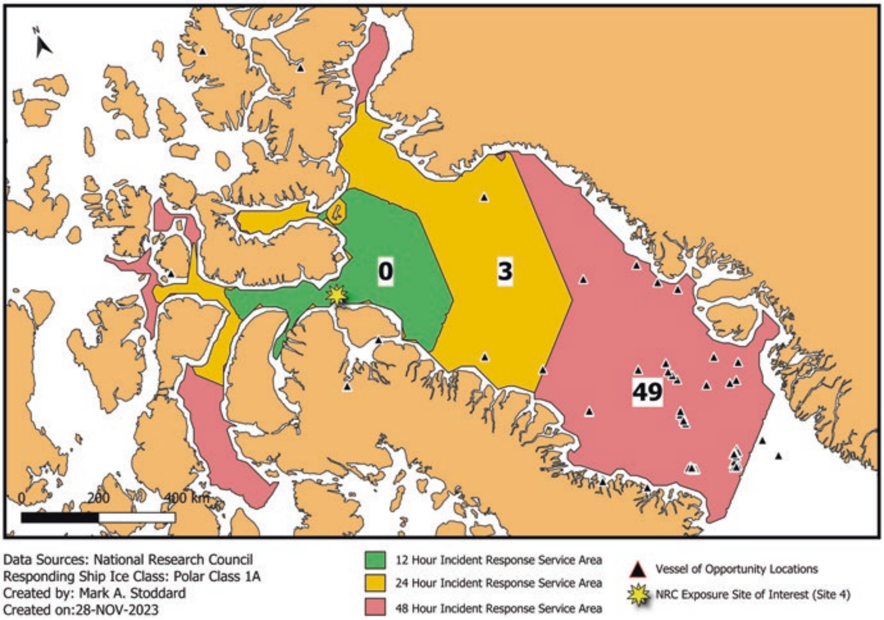


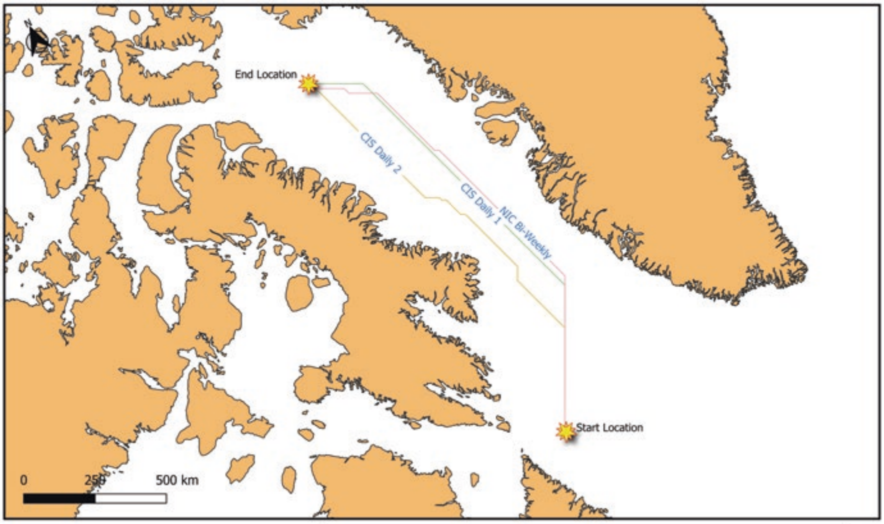
Fig. 12.16 12-hour, 24-hour, and 48-hour IRSA for a Polar Class 1A vessel operating in week 33, with an example overlay of vessel of opportunity locations and total vessel counts in each IRSA

Two major limitations of our approach to analysing incident response using IRSA and IRI are (1) the temporal resolution of sea ice analysis and (2) the use of bi-weekly median RIO values over the 1991–2020 climatological period for route generation and transit time estimation. Our method relies on the use of bi-weekly sea ice analysis from the USNIC to assess navigational risk. The consequence of relying on bi-weekly sea ice analysis is that all subsequent analysis products derived from this sea ice analysis must also be produced on a bi-weekly basis to avoid over-resolving the data. It also means that our network optimization model assumes that sea ice conditions do not change over a 2-week period. For short voyages this should not create much concern, but when examining trans-Arctic routes that could exceed 10+ days, it may seem unreasonable to assume sea ice condition will remain static during voyage execution. Special consideration should also be given to voyages planned during the periods of seasonal break-up and freeze-up, when ice conditions can change dramatically over even a few weeks. This issue is less of a concern when conducting strategic planning but is of greater concern at the tactical ship operations level. Secondly, the use of the climatological median RIO value in our analysis will limit the usefulness of our results for tactical applications.

12.5.1 Temporal Resolution of Sea Ice Analysis

Currently, the USNIC is the only authoritative source of detailed characterizations of sea ice that provide circumpolar coverage of the Arctic and Antarctic regions. The USNIC takes imagery and ancillary data from a variety of space-based and terrestrial sensor systems, such as synthetic aperture radar and passive microwave, to produce detailed characterizations of ice concentration, ice type, and general ice thickness. Once the ice analysis is complete, numerous products are created and provided open access to a very broad user community. USNIC sea ice analysis products are grouped by region and produced for different time periods, depending on the nature of analysis contained in the product. The USNIC product relied on for this study is the Arctic Sea Ice GIS shapefile, which is produced bi-weekly. This product has the desired coverage area and sea ice analysis attribute data to compute POLARIS RIO values throughout the Arctic.

While suitable for strategic navigation assessment, it may be more desirable to assess navigational risk using a daily product for tactical navigation assessment. The use of daily sea ice analysis products in our network analysis would make the fastest path optimization and transit time estimation results more applicable at the tactical level. Figure 12.17 compares the fastest path and transit time results using USNIC bi-weekly sea ice analysis and CIS daily sea ice analysis produced at the start and end of the bi-weekly analysis period. There is good agreement between the



POLARIS RIO Source	US NIC Bi-Weekly - 2020-07-09	CIS Daily 1 - 2020-07-09	CIS Daily 2 - 2020-07-23
Transit Time (hrs)	67.5	67.1	64.9

Fig. 12.17 Comparison of fastest route and transit time using the USNIC bi-weekly ice chart issued on 9 July 2020 and the CIS daily ice chart issued at the start and end of the USNIC bi-weekly analysis period (9 and 23 July 2020)

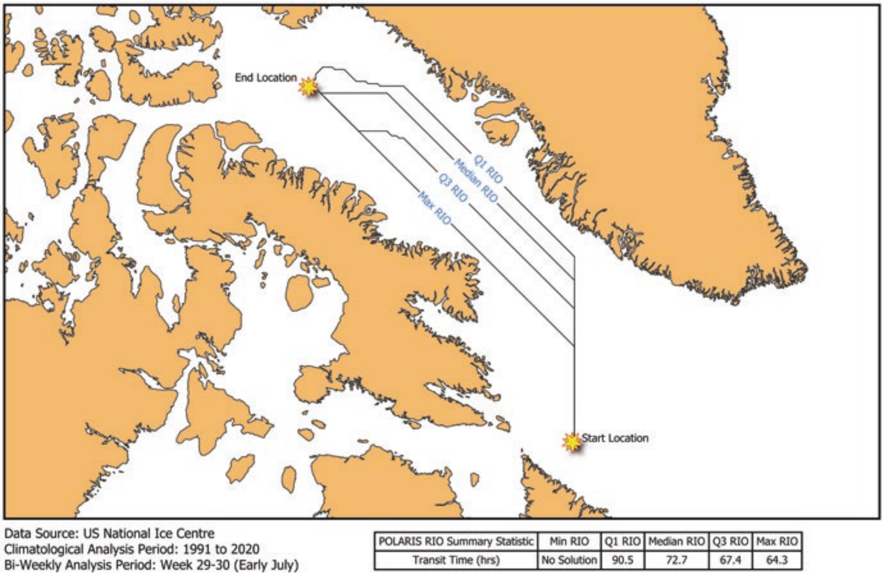
fastest route and transit time produced from the USNIC and CIS sea ice analysis products at the beginning of the bi-weekly analysis period. When we compare the results using the same USNIC bi-weekly chart and a CIS daily product issued towards the end of the USNIC bi-weekly period, we start to observe significant differences between the fastest route and transit time. It should be noted that ice conditions are known to change rapidly in the June/July timeframe, so we would expect the greatest differences between the use of bi-weekly and daily products to be observed during the yearly sea ice break-up and freeze-up periods.

12.5.2 Use of Climatological Period Summary Statistics

For strategic planning, it is often necessary to plan voyages based on the ice conditions expected to be encountered during a planned voyage. The selection of the appropriate sea ice analysis to use for strategic planning is a difficult task and often relies on expert judgement and the selection of sea ice analysis from similar years. Our analysis has so far relied on the use of summary statistics of historical POLARIS RIO values over a given climatological period to support strategic planning. There are two commonly used 30-year climatology periods used for strategic sea ice analysis, namely, 1981–2010 and 1991–2020. The USNIC moved to a baseline period of 1981–2010 starting 1 July 2013 (NSIDC, 2013). The CIS have adopted a different approach, updating their 30-year ice climate normal every 10 years, with the current period being 1991–2020.

In this study we have chosen to use the 1991–2020 climatological period when examining historical sea ice conditions and their expected impact on polar ship operations. The results focus on the 1991–2020 median RIO value when assessing sea ice risk and its impact on ship routing, transit time, and incident response service areas. The other statistical aggregations that have been computed for our study area include (1) minimum RIO value, (2) first quartile RIO value, (3) mean RIO value, (4) third quartile RIO value, and (5) maximum RIO value. Future studies could compare ship routing and transit time results using different statistical aggregations of POLARIS RIO values to better understand the impact this has on route generation and transit time.

The selection of RIO value affects both the fastest route optimization and expected transit time. When selecting the maximum RIO value (most positive), the resulting optimal route is expected to be the most direct route possible between the start and end location, achieving the minimum expected transit time. One would also expect this voyage to also have the highest average ship speed. Figure 12.18 shows the fastest route and transit time computed using different statistical aggregations of historical RIO values observed over the climatological period from 1991 to 2020. Figure 12.18 shows the spatial variability in the fastest route and transit time based on the selected RIO value statistic. The maximum RIO corresponds to the highest RIO value observed during the climatological period, representing the most favourable operating conditions observed.



POLARIS RIO Summary Statistic	Min RIO	Q1 RIO	Median RIO	Q3 RIO	Max RIO
Transit Time (hrs)	No Solution	90.5	72.7	67.4	64.3

Fig. 12.18 Comparison of fastest route and transit time using different statistical aggregations of historical RIO values observed over the climatological period from 1991 to 2020

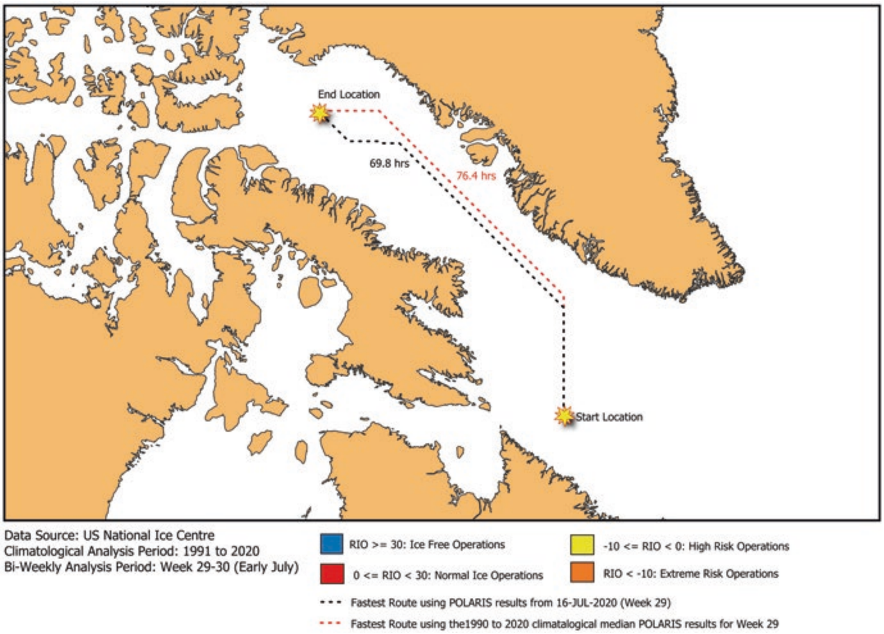


Fig. 12.19 Comparison of risk-adjusted transit time between two points in the eastern Arctic using the 1991–2020 climatological median POLARIS RIO and the POLARIS RIO from a single USNIC sea ice chart for the same bi-weekly period

Figure 12.19 compares the fastest route between the same two points using (1) a single USNIC sea ice chart produced on 16 July 2020 and (2) the 1991–2020 median RIO value. In this case, we see that the fastest route and transit time using the sea ice chart from 16 July 2020 are faster, arriving at the end location 6.4 hours earlier. This would indicate that the RIO values derived from the sea ice chart from 16 July 2020 are more favourable than the 1991–2020 median RIO.

12.6 Conclusion

In this chapter, we have demonstrated how network analysis techniques can be used to determine the fastest route between two locations in the Arctic and to compute IRSA and IRI. The results provide several valuable insights into the spatiotemporal variability of marine-based transit time and ship routing in polar waters. The use of IRSA and IRI to determine the expected response time for marine-based SAR assets was discussed as a possible extension to a 2013 study of maximum exposure time in the Canadian Arctic completed by the NRC. The use of IRSA and IRI to support ABM tools that aim to formally incorporate historical observations of shipping activity into quantitative assessments was also discussed. Incorporating IRSA and IRI results into area-based management tools would provide decision-makers with a useful tool to possibly help plan and coordinate incident response in polar waters and support ABM of commercial vessel operation and SAR provision.

Future technical work should concentrate on examining the use of different sources of sea ice analysis to better understand how change to the source data can impact the fastest route and expected transit time results. The use of modelled sea ice data from ice forecasting and GCM systems also offers a particularly interesting opportunity to compare expected RIO values derived from the statistical analysis of historical observations and from the model results. Computing IRSA and IRI using the RIO values derived from forecasted and/or modelled sea ice conditions may give decision-makers a better understanding of the future navigability of the Canadian Arctic and its impact on ship routing and expected transit times. These insights could be used to update policies, industry practices, and regulations that aim to improve shipping safety and SAR response or even assist the rationalization of SAR service delivery and also indicate where infrastructure development would be most beneficial.

The presented methodology and results in this chapter are not intended to provide a ready solution to the challenge of marine-based SAR response in polar waters. It is, however, hoped that the results, especially the data analysis and visualizations throughout this chapter, will stimulate new discussions and insights on the quantitative performance aspects of maritime SAR and Arctic navigation more generally. It is also hoped that these discussions can assist in improving ABM of shipping risks in the Canadian Arctic and beyond.

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Chapter 13
The Impact of COVID-19 on Arctic Shipping: An Area-Based Public/Occupational Health Perspective

Desai Shan and Om Prakash Yadav

Abstract Maritime activities are increasing in the Arctic and near Arctic areas, including domestic shipping and international transit traffic. Arctic shipping has created opportunities for cruise tourism, resource transportation, community supply transportation, research, and government services. However, hazards and challenges inherent to maritime operations in the Canadian Arctic cannot be ignored, including extreme Arctic weather conditions, limited port infrastructure, extensive distances from search and rescue services, and restricted access to medical care in Northern communities. The onset of the COVID-19 pandemic has compounded these challenges, posing a threat to the well-being and safety of seafarers.

This chapter explores the occupational health and safety challenges confronted by Canadian Arctic seafarers during the COVID-19 pandemic through qualitative interviews with 20 industry stakeholders, including seafarers, union representatives, managers, and maritime consultants. The findings revealed seafarers' concerns of increased risks due to pandemic-induced public health measures including lockdowns, travel restrictions, and controls. The deprivation of shore leaves and prolonged isolation from families substantially impacted the mental health of seafarers, amplifying the risks of depression and anxiety. A comprehensive Arctic occupational health and safety (OHS) policy framework is recommended to support seafarers in addressing the above challenges.

Keywords Canadian Arctic navigation · Seafarers · Occupational health and safety · COVID-19 pandemic · Public health measures · Lockdowns · Mental health · Search and rescue · Human-related factors · Organizational risk · Infrastructure · Environmental hazards

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13.1 Introduction

The increasing sea ice loss in the Canadian Arctic[1] and near Arctic areas is expected to lead to significant growth of maritime activities in these areas (Eguíluz et al., 2016). However, limited infrastructure, remote distances from communities, and extreme weather conditions pose challenges to maritime operational safety. In addition, between 2020 and 2023, the COVID-19 pandemic increased the severity of health hazards related to Arctic shipping in Canada, due to the infection risks among crew on board ships and between crew and members of northern communities. To protect the northern communities from infection risks, strict public health measures were imposed upon Arctic seafarers' mobility, such as shore leave bans, which further complicated the occupational health challenges faced by the Arctic seafarers.

Safe and sustainable development of Arctic shipping requires a comprehensive understanding of risk factors, the advancement of risk mitigation strategies, and enhanced search and rescue capacities. Following the *Akademik Ioffe* grounding accident in the Arctic (69°43.043′ N091°20.951′ W) in 2018, the Transportation Safety Board of Canada (2021) identified environmental, human-related, and organizational risk factors as key challenges to Canadian Arctic shipping that warrant enhanced focus.

13.1.1 Environment-Related Risk Factors

In the Canadian Arctic archipelago, harsh environmental conditions, such as strong swells and winds, can create unexpected risks for vessel operations. Inadequate charting of the Canadian Arctic Waters poses further risks to shipping, such as vessels running aground, potentially damaging the ship, and stranding all crew members (Transportation Safety Board of Canada, 2021; Oceans North, 2023). Harsh environmental conditions contributed to the grounding of the *Akademik Ioffe*, where quarterly swells and winds deviated the vessel's course and rendered the autopilot ineffective (Transportation Safety Board, 2021). The incomplete bathymetric data contained within the Canadian sea charts on board led to the misjudged ocean depth of the alternative voyage route by the master. The vessel ran aground

[1] According to the *Arctic Waters Pollution Prevention Act*, Arctic Waters refer to internal waters of Canada, the waters of territorial sea of Canada, and the exclusive economic zone of Canada, within the area enclosed by 60°N and 141°W, and the out limit of the exclusive economic zone; however, where the international boundary between Canada and Greenland is less than 200 nautical miles from the baselines of the territorial sea of Canada, the international boundary shall be substituted for that outer limit (AWPPA, 1970). According to the *Northern Canada Vessel Traffic Services Zone Regulations*, even though partially south of 60°N, the waters of Hudson Bay are covered by the Northern Canada Vessel Traffic Services Zone. In this chapter, considering the mobility nature of vessel and seafarers, we will discuss health and safety risks and infrastructures existing in the Canadian Arctic and Near Arctic areas (NORDREG, 2010).

north-northwest of Kugaaruk, Nunavut. Abandoning a vessel in the Arctic can increase risks of rapid onset of hypothermia and frostbite due to extreme cold (Ikäheimo & Hassi, 2011). Luckily, this vessel self-refloated with the flooding tide later that day, and passengers were evacuated and transferred to another vessel the next day (Transportation Safety Board, 2021).

Existing and floating sea ice create navigational hazards (CCG, 2019a). Floating sea ice is mobile and can quickly be affected by powerful currents and waves, putting the vessel at risk of collision with adjacent islands, injuring workers during cargo loading and unloading (Fontaine & Hardy, 2022), or damaging the ship (Lasserre, 2022). Changing ice conditions yearly leads to unexpected navigation issues, including the possibility of earlier and prolonged ice presence (Hardy & Fontaine, 2020). Submerged ice chunks (growlers) are difficult to detect with radar imaging (Lasserre, 2022; Hardy & Fontaine, 2020). Reduced daylight hours in the Canadian Arctic amplify risks, leading to greater chances of worker injury (Fontaine & Hardy, 2020b).

13.1.2 Human-Related Risk Factors

The shiftwork typically undertaken by seafarers, in combination with the harsh Arctic navigation environment, can increase workloads and stress, especially if a vessel is understaffed (Fontaine & Hardy, 2020a). This scenario often leads to acute and chronic fatigue, further exacerbated by chronic exposures to vessel noise and vibration. All these occupational hazards increase the likelihood of human errors and potential harm to crew members (Transportation Safety Board of Canada, 2021). Psycho-social welfare, moreover, can be compromised by the remote nature of the Canadian Arctic, leading to loneliness and isolation among seafarers who spend extended periods away from family and friends (Fontaine & Hardy, 2020a).

13.1.3 Organizational Risk Factors

Strategic navigation is an essential component of Canadian Arctic shipping operations. Delays can incentivize vessel masters to navigate through irregularly mapped corridors as a time-saving measure, which could cause the vessel to become stranded in the ice or capsize. Tight schedules might prioritize deadlines over crew safety, which could occur if the captain orders the unloading of too many shipping containers or pallets onto the barges (Fontaine & Hardy, 2020b). This could cause the barge to take on too much weight and take on more water, resulting in the sinking of the barge and jeopardizing crew safety on board.

Management strategies are vital for preventing overwork and inadequate supervision of crew members (Zhang et al., 2019). A deficient safety culture hinders open discussions between the captain, officers, and crew (Guy & Lasserre, 2016), whereas inadequate organizational structure may encourage risky individual behaviours, putting other crew members or the vessel at risk (Zhang et al., 2019). It is also worth noting that the complex interactions between economic, political, and other societal factors influence organizational decisions that may increase the risk of adverse effects in Arctic waters (Stephen, 2018).

13.1.4 Lack of Arctic Infrastructure

Limited port infrastructure in the Canadian Arctic imposes logistical challenges for cargo vessels requiring community resupply (Eguíluz et al., 2016; Transportation Safety Board of Canada, 2021). In the near Arctic area, there are only one deep-water port in Churchill, Manitoba (Lasserre, 2022), and one small craft harbour for large vessels in Pangnirtung, Nunavut (Government of Nunavut, 2013). Consequently, large shipping vessels in the Canadian Arctic must conduct multiple sea lifts—a maritime transportation method for delivering essentials to northern communities—using barges and tugboats to carry containers or pallets ashore (Hardy & Fontaine, 2020). Large ships carry many containers, serving multiple northern communities on one trip before returning to a main harbour for restocking. Recent Government of Canada's initiatives include developing deep-water seaports in Iqaluit and Qikiqtarjuaq, Nunavut, and new small craft harbours in Clyde River and Arctic Bay (Nunavut Impact Review Board, 2017; Transport Canada, 2021; Fisheries and Oceans Canada, 2021).

The Canadian Coast Guard (CCG) faces challenges in search and rescue due to its vast coverage area and limited northern services, operating with nine icebreakers (Lasserre, 2022). Reaching a stranded vessel may take up to a day or longer (Hardy & Fontaine, 2020). Air ambulances from the CCG or Canadian Armed Forces (CAF) can take hours to reach an injured worker. There is currently an inshore rescue boat station in Rankin Inlet, Nunavut, as well as three northern communities that received funding from the CCG Auxiliary Indigenous Community Boat Volunteer Pilot Program to aid in Arctic SAR (Sheehan et al., 2021). The Government of Canada is developing a CAF naval facility in Nanisivik, Nunavut, that includes Arctic offshore patrol ships with icebreaker capabilities and cargo space for the CCG during resupply operations (Government of Canada, 2015). Three search and rescue regions (SRRs) are responsible for SAR operations in oceanic and coastal waters in Canada. Two SRRs (the Halifax SRR and Toronto SRR) are assigned responsibilities to service Canadian Arctic waters (see Fig. 13.1) (Transportation Safety Board of Canada, 2021).

Fig. 13.1 Designated search and rescue regions in Canada (CCG, 2019b) © Canada Coast Guard

13.1.5 COVID-19 and Arctic Shipping

The evaluation of impacts of the COVID-19 pandemic on Arctic maritime occupational health and safety reveals important shortcomings that can inform future crisis management strategies. Seafarers experienced an increased risk of mental health challenges due to long-term isolation from family and friends, concerns about family members' health, and limited access to medical care ashore as a result of strict port restrictions (Baygi et al., 2022). Seafarers reported higher levels of depression and anxiety during the pandemic than during the pre-pandemic period (Pauksztat et al., 2022). Crew mobility, including crew exchanges and shore leaves, was largely restricted during the pandemic due to company and port regulations, prolonging the duration aboard the vessel and, consequently, reducing time with family (Neis et al., 2021).

While several studies have explored the impacts of COVID-19 on seafarers globally, there is a lack of research focus on Arctic seafarers. To address this critical research gap, this chapter delves into the occupational health and safety challenges Arctic seafarers faced during the COVID-19 pandemic. Utilizing insights gained from semi-structured interviews with Arctic seafarers and key informants (e.g. union representatives, ship managers, marine consultants, and human resource managers), the research aims to provide a novel understanding of how the inherent

Arctic conditions exacerbate the effects of a pandemic on seafarers, offering valuable insights for the protection and well-being of people working at sea.

In the following section, we will explain the research methods and qualitative semi-structured interview data collection strategies. In the third section, inherent Arctic maritime occupational health and safety challenges are discussed, as well as how COVID-19 has exacerbated seafarers' health and safety challenges. Fourth, following a discussion synthesizing the complexity of the impact of COVID-19 on Arctic occupational health and safety, we propose some policy recommendations.

13.2 Research Methods

This study examines seafarers' perspectives on COVID-19-related public health regulations, OHS challenges during the pandemic, and regulatory gaps in maritime OHS law. The participants were invited to participate in a semi-structured interview between 2020 and 2021. The participants included (1) seafarers with working experience in the Arctic or near Arctic waters; (2) union representatives of seafarers; (3) health and safety/human resource managers of shipping companies; and (4) key informants from maritime authorities. Due to the outbreak of COVID-19 and the universal ban on in-person research activities, data collection was conducted online. Participants were recruited through LinkedIn or email, and the interviews were conducted by phone, Skype, or Zoom. Invitations to interview included the lead researcher's contact information and were distributed through LinkedIn, Facebook, and email. The first author invited representatives from companies, unions, maritime charities, training institutions, and safety authorities through their contact information available online and at public conferences. A total of 20 participants completed the interviews (see Table 13.1).

The interviews were audio-recorded for the analysis. The interviews were transcribed verbatim. The transcripts were processed by computer-assisted qualitative data analysis software (Nvivo 11). Thematic analysis was used to understand the different challenges seafarers confront in Arctic maritime activities. The thematic analysis method was employed to identify recurring patterns of occupational health

Table 13.1 Research participants

N = 9	Seafarers, including captains, chief engineers, officers, and ratings.
N = 4	Union representatives (two are ex-Arctic ratings)
N = 6	Five managers from shipping companies and one maritime consultant
N = 1	Key informant from maritime accident investigation authorities

challenges and insights shared by participants during the interviews. The text presented in the next section of findings carefully rephrases the original interviews, allowing for a condensed and coherent representation of the participants' perspectives. This approach ensures the faithful reflection of their experiences and perspectives within the context of Arctic maritime activities.

13.3 Findings

13.3.1 Environment-Related Health and Safety Hazards Faced by Arctic Seafarers

13.3.1.1 Cold Temperatures

The domestic Arctic shipping season usually starts in June and ends in November. During this period, ships operating domestic Arctic transportation each undertake three voyages scheduled from Canadian southern ports, such as Montreal, to the northern communities in the Arctic or near Arctic. During the returning part of the first and second voyages between July and September, some Arctic communities can experience temperatures of approximately 20 degrees (SF-13, Captain). Coldness is more concerning for seafarers during the third voyage, usually in November.

There was a consensus that extremely cold temperatures in the Arctic present potential hazards for the crew and the vessel. In October and November, a common task that requires prolonged exposure to cold Arctic conditions is chipping ice off the vessel that accumulated due to sea spray. Ice build-up on board compromises vessel stability (SF-1, Captain). Prolonged exposure to cold temperatures can result in hypothermia and frostbite in seafarers (SF-1, Captain; SF-12 maritime health and safety consultant). When the shipping season is delayed due to unforeseen circumstances, seafarers may be required to work later (i.e. late fall), exacerbating the frostbite risk.

13.3.1.2 Collision Risks with Growlers

Collision with growlers can cause serious damage to a vessel (SF-13, Captain). Impacted by global warming, glaciers and icebergs are more rapidly calving ice and growlers into the ocean, which present as obstacles along navigational routes (SF-3, Chief Engineer). Growlers are often difficult to detect on radar. They are usually old and thick ice that can severely damage a vessel if struck and may not always be detected in time, as most growlers are submerged (SF-7, Chief Officer; SF-12, union representative; SF-14, maritime consultant). When ice accumulates and blocks a vessel's passage in the Arctic, shipping delays can occur by trapping the vessel in the ice and requiring assistance from a Coast Guard icebreaker (SF-15, Manager; SF-16, Captain).

13.3.1.3 Strong Winds and Lack of Daylight

Strong winds in the Arctic can prevent the offloading of supplies from vessels to barges and delay communities receiving supplies (SF-17, Bosun). Crane workers are also ordered to stop if a strong wind is considered to create dangerous working conditions (SF-17, Bosun).

At the end of the navigation season, extended darkness throughout the day poses additional challenges for navigation and cargo discharge (SF-1, Captain; SF-17, Bosun). The steady decrease in hours between sunrise and sunset in October and November leads to fewer hours of daylight to support safer navigation. Ice navigation in the dark can be very stressful, as the risks of striking icebergs and damaging vessels are greater (SF-3).

13.3.1.4 Landscape and Remoteness

To reach certain communities, Arctic seafarers must navigate through uncharted narrow passageways (SF-3, Chief Engineer). Seafarers were concerned that vessels may run ashore/ground if they travel through uncharted or inaccurately charted waters. Remoteness is another significant health and safety concern for seafarers. Search and rescue resources such as the CCG are not always present or immediately available to assist a damaged or stranded vessel in the Arctic. A maritime consultant shared a case of a vessel stuck for 12 days before an icebreaker could reach it (SF-14). An injured worker on board an Arctic vessel can also experience delays in rescue, for example, through medical evacuation, due to the remote location (SF-14, Maritime Consultant).

As summarized below by participant SF-3, a Chief Engineer, the environment-related health and safety hazards increase the workload for Arctic seafarers:

> Sub-zero temperatures, harsh sun, and complete isolation. No mobile network … like socially, you're cut off basically with[in] the vessel for a while … Yes, those things do make it challenging. In the Arctic, I think the workload increases because you don't have a lot of infrastructure, and you work with the shortage of … terminals. So yes, those things make it a lot more hectic in the Arctic.

Low temperature, collision risks with growlers, strong winds, and lack of daylight during the late navigation season are inherent maritime occupational challenges of Arctic shipping. However, for experienced Arctic seafarers, even though they are familiar with these environment-related hazards, the lack of communication support and extremely limited infrastructure increase workplace stress, and seafarers' ability to manage these hazards effectively is restricted.

13.3.2 The Impact of COVID-19 on the OHS of Arctic Seafarers

13.3.2.1 COVID-19-Related Public Health Regulations

In 2020, Transport Canada, territorial governments, and health agencies collaborated with Arctic shipping industry representatives to determine measures to ensure that both northern communities and Arctic seafarers were protected from exposure to COVID-19 (SF-1, Captain). Due to limited medical resources, northern communities implemented stricter COVID-19 public health measures than the rest of Canada. While in southern ports, essential shore leaves were permitted for seafarers during the pandemic, for Arctic seafarers, a complete shore leave ban was imposed in northern communities (Government of Nunavut, 2020).

The frequent changes in public health regulations increased the difficulty of their interpretation among seafarers (SF-12, Union representative). Most companies developed operations directives on COVID-19 to fulfil regulatory standards, which were constantly updated (SF-15, Human resource manager). Some measures included requiring all crew members joining the vessel to be screened and asymptomatic (SF-12). Otherwise, they would have had to isolate and receive a COVID-19 test. Some companies required seafarers to take a COVID-19 test before joining the vessel or to quarantine for 14 days before departure (SF-17). If a crew member was travelling to join the ship, they had to take the most direct route and not stop anywhere, whether driving and/or flying. If they had to stay somewhere overnight, it had to be at a company-approved hotel (SF-1, Captain). One shipping company required seafarers to complete a form that reported close contacts if they had spent time with someone for more than 15 minutes (SF-14). These changes significantly increased the workload for seafarers.

13.3.2.2 Mental Health

The Arctic is a stressful workplace due to minimal communication with families and friends. The reduced ability to see their families, particularly when seafarers cannot attend special celebrations or funerals, can affect a seafarer's mental health (SF-1). The limited gym equipment and facilities on board also restrict the possibility of seafarers performing regular exercise, which can help maintain favourable mental and physical health (SF-3, Chief Engineer; SF-17, Bosun).

Long working hours were reported to be a major contributor to fatigue, which could lead seafarers to become less conscious of the dangers around them (SF-1, Captain; SF-13, Captain). Many Arctic seafarers reported that social isolation could result in mental health issues and increase risk-prone behaviours on board (SF-3, Chief Engineer; SF-12, Union Representative; SF-14, Maritime Consultant; SF-15, Human Resource Manager; SF-16, Captain). Extended sunlight/darkness can cause circadian rhythm disorders among seafarers in the Arctic. When darkness extended during the late season, ice navigation watchkeeping was reported to create extra stress for seafarers (SF-3, Chief Engineer; SF-4, Captain; SF-7, Chief Officer).

During the pandemic, one of the major mental health challenges for Arctic seafarers was the lack of communication with families, leading to concern and anxiety about whether their families were safe or not infected (SF-1, Captain; SF-12, Union Representative). Furthermore, crew members had to work longer rotations. In addition to self-isolation after signing off from the vessel, seafarers had to self-isolate earlier to wait for COVID-19 test results before signing on to the ship. This reduced their family reunion time and made it very mentally exhausting for seafarers (SF-12, Union Representative; SF-14, Maritime Consultant).

Fatigue became a more prominent issue as seafarers spent the entire navigation season on board the vessel. Due to the additional COVID-19 test requirements, some companies cancelled short breaks for seafarers between the three voyages. Before the pandemic, when the ship navigated back to the southern port, such as Montreal, some local seafarers could take two to three nights off and return home at night when cargo loading was conducted in port. The cancellation of these short breaks deprived the limited opportunities for seafarers to reduce the stress caused by separation from families. As one bosun (SF-17) explained:

SF-17	"For me last year (2020), I was not being able to come home, sleep at home and then go back to the ship next day. Last year was different compared to before when I could go back home. I could not get away from it—to get away from it, just a break. It was [pause] I wouldn't say stressful but a little more tiring just because you can't get away from it at all".
Interviewer	"So it's basically no life component but always work"?
SF-17	"Exactly. Yeah exactly. And, like I said, seeing as we stayed onboard all the time, I just put in more hours. I just worked more just to occupy the time that I would have been at home instead of being on board".

The inability to leave the work environment between voyages made the occupation more tiring and stressful (SF-17, Bosun). Being confined on board, the seafarer tended to work more hours just to pass the time, which might exacerbate the fatigue problem.

13.3.2.3 Crew Change

Crew changes were challenging before COVID-19. Small charter planes were hired to transport the crew to sign on/off the vessel in northern communities. Weather conditions could affect flights, and cancellations were normal (SF-15, Human Resource Manager; SF-16, Captain). The joining seafarer needed to arrive 1 day before the vessel left to ensure a handover with the departing crew member (SF-15, SF-16). Hotel accommodation service might not be reliable, because sometimes the hotel owner was not on site and could not be reached (SF-15, SF-16). With limited commercial taxi services available, companies relied on local community citizens to pick crew members up from the airport (SF-15, SF-16).

During the COVID-19 pandemic, the Territory of Nunavut temporarily banned the operation of crew changes for Arctic vessels, except for medical emergency (SF-12, Union Representative). No known crew changes took place in the North during the pandemic. Many shipowners required seafarers to work through the entire Arctic navigation season (June–October/November) (SF-12, Union Representative). Some companies were allowed to make one crew change for the entire season, but the change could only be conducted outside the Arctic (SF-12). If the Arctic vessel returned to Quebec, crew changes could be scheduled (SF-15 Human Resource manager, SF-16 Captain). Some companies offered their crew members the option of a car rental, subject to their provincial public health regulations (SF-15, SF-16). Chartered planes were organized for some companies to get new crew members on board (SF-15, SF-16). Crew members joining the vessel stayed in isolated facilities to avoid contact with the general public, so COVID-19 was not transmitted on board (SF-12). Many crew change restrictions were implemented to ensure that the crew on board and the northern community members were protected from infection risks (SF-12).

With the complexity of crew change restrictions, most companies attempted to extend seafarers' shifts on board to save costs. As the Maritime Consultant SF-14 observed:

> Travel restrictions and isolation are very tough, and very challenging for the crew. … Not so bad once you get on board but then when you return, … because it's so difficult to travel most companies are extending your rotations because it is so difficult to travel. And so to make it more inexpensive for the companies.

Extended stays on board increase the risk of fatigue and mental health problems for seafarers (SF-1, Captain).

13.3.2.4 Shore Leave

Before the pandemic, even when seafarers were confined to the vessel for most of the trip, they could still go ashore occasionally. They could walk around communities, inspect the vessel, and seek medical care (SF-1, Captain; SF-2, Captain; SF-3, Chief Engineer). Some seafarers reported enjoying taking a break from the vessel, getting outside for fresh air, and collecting souvenirs (SF-1, SF-2, SF-12, Union Representative; SF-13, Captain; SF-17, Bosun). Other seafarers reported that they decided to stay on board, because "there was not much to do besides walking" ashore (SF-14, Maritime Consultant). Busy schedules prevented some vessels from providing shore leave, as seafarers had to stay on top of their work and not fall behind. They prioritized dropping off the cargo and moving on to the next community (SF-14).

During the pandemic, shore leave in the Arctic was strictly banned unless absolutely necessary for moving cargo around onshore (SF-1, Captain). This was likely due to northern communities' concerns about their lack of healthcare resources in combating COVID-19, their tight-knit communities, and that they did not want outsiders to come in and potentially spread the virus. Transport Canada communicated that no crew members were allowed to travel ashore for personal reasons, such as exploring communities and buying souvenir items (SF-1). Some seafarers reported no problems with the restricted shore leave, as they typically stayed on the vessel for the entire trip (SF-12, Union representative).

If a crew member was possibly symptomatic, all others on board had to be careful about travelling ashore and ensure they would not be in close contact with anyone from the communities to prevent potential spread (SF-1, Captain). For people who did have to travel onshore, two communities requested that seafarers be tested again (SF-15, Human Resource Manager; SF-16, Captain). As a social distancing measure, some crew members brought a setup container as a beach office to keep them comfortable and isolated from other community members (SF-17, Bosun). Shore leave in a southern port, such as Montreal, was also restricted by some companies due to the risk of contracting the virus in the city and bringing it back to the vessel (SF-13). Shore leave, as a major mitigation measure for seafarers' mental health problems and fatigue, was completely banned for Arctic seafarers. This put the Arctic seafarers in a more vulnerable situation during the pandemic since shore leave was one of the few relief measures for fatigue.

13.3.2.5 COVID-19 Isolation

Isolation requirements were complicated for seafarers to navigate throughout the pandemic. These requirements were constantly evolving as government officials learned more about the virus and its transmissibility. In Canada, officials originally instructed seafarers to isolate for 14 days when they returned home. The policy changed subsequently to include the 14 days spent on board the vessel as part of the isolation period, and as a result, seafarers could return home directly (SF-1, Captain; SF-12, Union Representative). Some companies required crew members to self-isolate for 14 days before departing to the Arctic (SF-14). Symptomatic individuals were required to self-isolate on board away from other crew members, wear a mask, and await their test results (SF-1, Captain). The required isolation period once they returned home was difficult for some seafarers because they had to spend extra time away from their families and had less time to spend with them before leaving for the next trip (SF-14, Maritime Consultant).

13.3.2.6 Onboard COVID-19 Virus Management

Preventive measures to reduce the spread risk included seafarers wearing masks and socially distancing themselves from others on board, especially when off duty and during the first few days of the trip, just in case COVID-19 was present (SF-1, Captain). There were concerns about seafarers contracting the virus onshore and bringing it back to the vessel because that meant heavy restrictions would be reinstated and affect their working schedules (SF-9, Ship Manager; SF-10, Ship Manager; SF-11 Ship Manager). Moreover, ventilation systems on board were a risk factor in the potential spread of the airborne virus that could trigger an outbreak. Several seafarers suggested measures to isolate the ventilation of a seafarer's cabin to reduce the spread (SF-12, Union representative).

Responding to a COVID-19 case in the Arctic was challenging, because of the limited medical resources and the remoteness of proper medical facilities and equipment. Seafarers who were infected with the virus but were asymptomatic presented a challenge to the vessel because they were unaware of their infection and potentially spread it to other crew members (SF-1, Captain).

In 2021, when COVID-19 vaccines were introduced, some companies deployed resources to assist with vaccinating their seafarers before arriving on board to reduce the potential spread of COVID-19 (SF-17, Bosun). The first dose was given before their first trip, and the second one between the first and second voyages when they returned from the Arctic (SF-17). With the increased availability of vaccines, Arctic seafarers were immunized as a group of essential workers.

13.3.2.7 Refusal to Work During the Pandemic

Due to the increased occupational hazards, some seafarers refused to return to sea in 2020 or retired early in fear of COVID-19 infection (SF-15 Human Resource Manager, SF-16 Captain). This was especially the case for older seafarers as they understood there was a higher risk of mortality (SF-15, SF-16). Seafarers with chronic health conditions also decided against returning to sea in the 2020 and 2021 seasons; they understood that their health could be jeopardized if they contracted the virus (SF-15, SF-16).

13.4 Discussion

The COVID-19 pandemic profoundly impacted workplace health and safety at sea (Shan, 2022; IMO, 2019; ILO, 2020). A study by Baygi et al. (2022) revealed a high prevalence of anxiety, depression, and post-traumatic stress disorder among international seafarers during the COVID-19 pandemic. The COVID-19 pandemic triggered a humanitarian and health crisis. In addition, related public health measures implemented by governments, such as travel bans, limits on embarkation and disembarkation, or suspensions in the issue of travel permits, exacerbated health and safety challenges faced by seafarers (ILO et al., 2021). The United Nations urged member states to designate seafarers as "key workers" and to ensure public health restrictions in port States did not interfere with seafarers' fundamental rights, including rights to shore leave and repatriation. Most research on OHS in the maritime industry focuses on international seafarers; however, the exacerbated occupational health challenges faced by domestic Canadian Arctic seafarers during the pandemic present as a gap in the current literature. The present research also revealed that COVID-19-related public health measures created barriers to crew exchanges and shore leave for domestic Arctic seafarers in Canada. During the Arctic 5-month sailing seasons in the pandemic (2020–2023), when public health regulations tightened, few shore leave opportunities were available to seafarers who can temporarily escape from work-related pressures. COVID-19 infection risks and concerns about restrictions on crew exchange increase the difficulty of retaining Arctic seafarers.

Regardless of the pandemic-related health challenges, Arctic shipping still involves inherent health safety challenges, including a lack of maritime infrastructure to support cargo discharging in the northern communities, limited search and rescue capabilities, and limited navigational aids (Brigham, 2008; Larsen et al., 2016). In the Arctic communities, port-based seafarer welfare services do not exist. This gap marginalizes Arctic seafarers from the health and well-being services and health-protective advocacy provided by seafarers' welfare centres in southern Canadian ports, further diminishing the visibility of challenges this cohort encounters.

Unpredictable weather conditions and complex navigational challenges in the Arctic waters lead to regular changes to seafarers' work schedules. Interrupted rest and sleep schedules may increase the likelihood of fatigue-related accidents (Shan, 2022; ILO, 2015). The fatigue of seafarers engaged in watchkeeping seafarers may also be exacerbated by extended hours of navigating through challenging ice conditions (Xu et al., 2021). Subsequently, increases in fatigue and limited opportunities to get restorative sleep on board can compromise the mental health of seafarers. Among the young crew members, work overload, stress, exhaustion, lack of social life, and lack of support are frequently reported (Lucas et al., 2021).

Arctic maritime OHS challenges and restrictions in shore leave and crew change entitlement due to public health measures during the pandemic created considerable harm to Arctic seafarers' health and well-being. Additionally, senior seafarers decided to retire earlier to mitigate exposure risks. These factors point to additive pressures that ultimately compromised the institutional safeguards designed to protect mental health of seafarers and impacted seafarer retention. Participants pointed to the impacts of the reduction in resources and workplace supports on the mental health of active Arctic seafarers who were isolated from family and friends for extended periods and subjected to exacerbated fatigue and workplace stress due to the deprivation of shore leave opportunities. These challenging work conditions reduce the attraction of Arctic navigation careers among young Canadians, which affects the sustainable talent recruitment of the Arctic shipping sector.

Sustainable recruitment and retention in Arctic shipping benefit from Arctic area-based risk management strategies that consider the knowledge and perceptions of the rightsholders of northern communities, seafarers, and other industry stakeholders (Lucas et al., 2021). A dedicated Arctic seafarer welfare service is recommended to ensure Arctic seafarers' interests can be well-represented and considered in any future Arctic shipping policy development process.

The current Canadian maritime occupational health and safety law, including the Canada Labour Code and the *Maritime Occupational Health and Safety Regulations* (2010), has not sufficiently addressed Arctic seafarers' unique occupational hazards. In the current Arctic shipping safety regulatory frameworks, the *Arctic Shipping Safety and Pollution Prevention Regulations* (ASSPPR, 2017), which incorporated the International Code for Ships Operating in Polar Waters (Polar Code, 2014/15) into Canada's domestic legislation, rare attention has been paid to protect seafarers from the unique health and safety challenges in the Arctic area. This research has highlighted this gap, and to bridge this gap, further studies are required to understand the occupational health conditions of Arctic seafarers, particularly their mental health conditions. Occupational health support on board and port-based welfare service opportunities in the near Arctic ports must be explored.

13.5 Conclusion

The Arctic environment presents unique occupational safety and health challenges for seafarers. The Arctic is a hazardous environment for maritime activities due to low temperatures, the danger of multi-year ice, the geographical isolation of the region, and a lack of infrastructural facilities. Even though exposure to COVID-19 was the most apparent danger of the pandemic, the public health measures adopted to restrict the transmission of the virus have led to further health and safety concerns. These measures, such as lockdowns, travel restrictions, and border controls, were implemented to safeguard local populations from the threat of infection. However, the unexpected consequences of these actions on the fundamental rights of seafarers cannot be ignored. Stressful and traumatic life experiences, such as pandemics, may increase the risk of depression and anxiety in those individuals who are already at risk. A comprehensive strategy for dealing with the long-term repercussions of the coronavirus pandemic must include a focus on mental health.

Arctic seafarers face various difficulties while working at sea, including cold weather, ice navigation, wind, extended daylight affecting circadian rhythms, and isolation. The fatigue seafarers experience while working in difficult circumstances may have major ramifications for their health, safety, and navigational safety. To prevent fatigue and related injuries, shipping companies must secure sufficient resources, including appropriate crewing levels, promote a strong safety culture, and facilitate smooth crew changes. With the lift of public health restrictions, more support and resources should be available for ship managers and crew. However, challenges arising from the limited infrastructure must be addressed with long-term plans by federal and territorial governments. In the development process of these Arctic shipping infrastructures, seafarers' health and safety need to be considered, including their access to healthcare and welfare services during the Arctic voyages. Such support can be enhanced through onboard occupational support (e.g. telemedical support) and port-based services in Arctic communities and near Arctic ports. Ports and other Arctic marine infrastructure can potentially improve living conditions in coastal populations, producing employment and assisting with the development of communities (WWF Arctic, 2022). Fostering cooperation and partnership between federal and territorial governments, Indigenous communities, and maritime industry stakeholders can be beneficial for addressing some of the challenges highlighted in this chapter.

Due to the travel restrictions and fieldwork bans imposed by the university during the pandemic, this research also has significant limitations. With the support of online interviews, the authors obtained a preliminary understanding of maritime occupational health and safety challenges during the COVID-19 pandemic. However, future studies are still required, preferably with onboard observation and interviews with Arctic seafarers, and an in-depth understanding of the health and safety challenges can be acquired. An in-depth understanding of Arctic seafarers' occupational health and safety challenges is essential to protect seafarers' health and well-being and ensure the future talent recruitment of the Canadian Arctic shipping sector.

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Chapter 14
Conclusion

Ronald Pelot, Aldo Chircop, Floris Goerlandt, and Claudio Aporta

Abstract This concluding chapter serves to elaborate and extrapolate some of the main points delivered throughout this book's collection of complementary perspectives on area-based management (ABM) applied to maritime shipping. Researchers and practitioners in this continuously developing field of ABM can benefit from the diverse perspectives provided in this text, which are synthesized according to key facets, namely, the purpose of ABM and basic principles that mould its construction and application; the role of risk governance and risk analysis in shaping ABM applications and for determining how shipping-related risks may thus be mitigated; how marine spatial planning (MSP), another rapidly growing tool that systematically advances sustainable management of marine areas, intersects with the suite of ABM tools; and what comprises good practices when implementing ABM processes and tools. The chapter concludes with some remarks on fruitful areas for additional research that may further strengthen ABM.

Keywords ABM risk governance · ABM good practices · ABM principles · ABM terminology · ABM tools · International Maritime Organization · Marine spatial planning

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14.1 Our Goal

This book explored the theory and practice of area-based management (ABM) of shipping at a time of growing demand from decision-makers and the academic community for more effective ocean governance. We focused on shipping because, as observed in Chap. 1, the ship is a critical platform for human use of ocean space. It is an instrument of industrialization, and therefore control over its mobility and performance standards is critical to ocean management, as well as the management of port areas and coastal zones, as explained in Chaps. 2, 3, 5, and 11. At the core of the contemporary ABM discourse is the spatial management and regulation of ocean uses to enhance maritime safety, mitigate environmental impacts, facilitate the decarbonization of economies, and ensure good governance of the ocean commons. The contributors to this book explored the relationships between risk, spatial designation, and functions in ABM theory and in the process sought insights into the approach to the use of ABM tools for problem-solving in ocean space and over time and the related costs and expected benefits.

Beyond the conclusions reached by each chapter, we now conclude with what we have learned from this collective endeavour in the big scheme of things. In the introduction we set out questions to guide our explorations and to which we group our reflections under five major themes, namely, ABM terminology, purpose, and scope; the norms and principles that guide ABM; the relationship of ABM to ocean management and marine spatial planning (MSP); the relevance of risk governance and management to ABM in shipping; and ABM good practices. Our reflections are tentative because we also conclude that more research is needed to strengthen our knowledge and skill in using ABM tools. Hence, we identify possible directions for future research.

14.2 What We Have Learned

14.2.1 ABM Terminology, Purpose, and Scope

In the shipping context, ABM comprehends a wide suite of tools that are frequently invoked by practitioners and scholars alike, while not always clarifying what they mean or distinguishing between the different tools. ABM is more than just a buzzword and is a useful and proven approach in managing shipping using multiple tools for specific applications and thereby enhances ocean management, as our observations of ABM shipping practices in Canada suggest in Chaps. 2 and 11. Among others, they are used regularly to ensure safe traffic and manage vessel-source pollution. Most ABM tools in international shipping are adopted in the technocratic meetings of the International Maritime Organization (IMO) according to sound scientific and technical criteria and usually without political fanfare. They may be mandatory or voluntary, and the level of authoritativeness does not necessarily mean less effectiveness.

Functionally, ABM has been practised long before the coining of the term in the recently adopted *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction*, 2023 (BBNJ Agreement, 2023, art 1(1)).[1] Several existing international agreements, such as the conventions of IMO, provide for a range of tools that today should be considered to be examples of ABM, as discussed in Chap. 2. What the BBNJ Agreement has done is to potentially extend the geographical and functional reach of some ABM tools, such as routeing measures and marine protected areas (MPAs), including MPA networks, to the high seas as explained in Chap. 4. The BBNJ definition is drafted in an inclusive manner so to capture multiple ABM tools, rather than to focus on a single tool to achieve conservation and sustainable use objectives. Accordingly, by itself, the "ABM tool" definition in the BBNJ Agreement is an organizational concept for a "class" of existing tools in ocean management and marine conservation that include MSP and other sectoral tools to manage navigation and shipping and other ocean uses.

In this book we attempted to understand the range and scope of such tools used directly to manage or regulate shipping or to achieve management or conservation goals by addressing human uses including shipping. As part of this exercise, we compiled a comprehensive—but not exhaustive—list of tools employed in shipping and marine conservation (see Chap. 2 appendix). Many of the tools we identified and which we feel can be characterized as "ABM tools" are of old vintage and therefore have their own unique terminology, meaning, and technical scope. Obvious examples are special areas and emission control areas prescribed in the *International Convention for the Prevention of Pollution from Ships 1973/78* (MARPOL) and routeing measures designated by IMO under the authority of the *International Convention for the Safety of Life at Sea* (SOLAS) (MARPOL, 1973/78, Annexes I, II, IV, V, VI; SOLAS, 1974, chap V).

ABM tools in shipping address many purposes, including sustainable ocean use, prevention or mitigation or solution of impacts produced by shipping, conflict management, safety and security of shipping, and the delivery of services to shipping. They consist of standardized and flexible tools, hence their value for ocean governance. Standardized tools are those predetermined in international and domestic legal instruments and accompanying guidelines and whose application is replicable to enable efficiency, consistency, predictability, and clarity, such as in the case of vessel traffic separation schemes for the prevention of collisions between ships (COLREGS, 1972, reg 10). Flexible tools, although enshrined in legal instruments, enable them to be tailored to a particular risk or conservation need in a specific context. This can be done in a nimble manner when time is of the essence. For

[1] Article 1(1): "'Area-based management tool' means a tool, including a marine protected area, for a geographically defined area through which one or several sectors or activities are managed with the aim of achieving particular conservation and sustainable use objectives in accordance with this Agreement".

example, in Canada, speed restrictions in defined areas have been used to address urgent conservation concerns, such as ship strikes of North Atlantic right whales in Atlantic waters and Southern Resident killer whales in Pacific waters (see Chap. 5, this volume). These tools address the impacts of shipping directly through prescribing rules and standards for vessel operations in defined areas. However, other ABM tools having a broader purpose and more general application, such as MPAs, have also addressed shipping among other ocean uses and conservation concerns. Indeed, MPAs are flexible tools designed with the conservation needs of each MPA concerned in mind, and shipping may be only one class of activities that is regulated in such areas (Oceans Act, 1996, s 35(3)(c)). Hence, there is a rich toolbox of ABM tools that can be used or fashioned for common and unique needs, and because of the diversity of purposes, there is no one single formula or procedure applicable to all ABM tools.

The geographical and functional scope of ABM tools in shipping is flexible and can be applied at different levels in ocean governance. At the domestic level, ABM tools may be applied at the national, regional, or local level. At the international level, they may be applied in a transboundary context, that is, between adjacent States, or at the regional level, or even on the high seas. In some regions, for example, in the Baltic and North Sea, multiple ABM tools have been adopted by IMO, and coordinated by the proponent States, to ensure the safety and continuity of routeing measures in transboundary settings, while at the same time safeguarding other marine uses in the vicinity of navigation routes, such as offshore oil and gas installations, offshore renewable energy activities, fishing areas, submarine cables and pipelines, and military use areas. Chapter 8 further illustrated how vessel traffic management is conducted in a coordinated manner in the European Union (EU).

At the regional level, the EU adopted a directive on MSP which member states are in the process of implementing in multiple regional seas (EU 2014). MSP enables them to undertake ABM at the highest level of ocean management through the establishment of "a framework for maritime spatial planning aimed at promoting the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resources" within the Integrated Maritime Policy of the European Union (ibid, art 1). Shipping is one of many ocean uses competing for limited space, producing multiple use interactions and impacts in the marine regions concerned (ibid, preamble, para 1). At yet a different level, and beyond national jurisdiction, the BBNJ Agreement provides for the adoption of ABM tools for application on the high seas, as described in Chap. 4. While this is not totally novel (because some MARPOL special areas, as in the case of the Mediterranean, have included high seas in part), the BBNJ Agreement has broken new ground by *expressly* providing for their designation in the ocean commons.

14.2.2 Norms and Principles Guiding ABM Tools

Several international laws of the sea, maritime law, and environmental law instruments either provide a framework for the adoption of tools or even prescribe specific tools (UNCLOS, 1982, arts 60, 211(6); BBNJ Agreement, 2023, arts 17-26; COLREGs, 1972, reg 10; MARPOL, 1973/78, Annexes I, II, IV, V, VI; SOLAS, 1974, chap V). Those tools are reflected in turn at the domestic level, at least in Canada's case as explained in Chap. 5. The design and application of tools is normally a multidisciplinary scientific exercise to define the problem or risk; weigh environmental, social, safety, economic, and other factors; employ consultative processes; and result in authoritative decisions. In the case of mandatory and recommended routeing measures adopted by IMO, the procedure involves the submission of a technical proposal that must address various traffic and marine environmental considerations and include consultations with affected states and which is reviewed by a technical peer committee within IMO before they are adopted by the Maritime Safety Committee (IMO, 2003).

Accordingly, the use of ABM tools is purposive, not random, and highly rationalized and subject to principles and procedures. Apart from being a lengthy and deliberative technical process (IMO, 2003), the adoption of ABM tools at IMO is frequently an integral part of regulatory measures guided by principles applicable to the development of new and amendment of existing regulations. These include compelling need for the measure, consistency with other measures, proportionality to the risk or problem addressed, fitness for the intended purpose, resilience over time, and clarity for ease of implementation (IMO, 2015).

Moreover, since at least 1992, the use of ABM tools at the international and domestic levels has been influenced by the principles of sustainable development, which include, inter alia, integration, ecosystem-based approach to management, precaution, polluter pays, environmental impact assessment, and inclusive participation (UNCED, 1992, principles 7, 10, 15-17, 22; Oceans Act, 1996, s 30). IMO took early steps to embrace precaution to developing "solutions to problems and consideration of new and existing policies, programmes, guidelines and regulations … in accordance with the precautionary approach" (IMO, 1995). In the era of ocean governance, greater emphasis is placed on inclusive approaches, rather than *dirigisme*, thus involving all interested and affected rightsholders, stakeholders, and the public at large. In this respect, and as explained in Chap. 5, Canada was an early starter in legislating a ministerial duty to lead and facilitate the development of integrated management plans that necessarily involved interdepartmental cooperation and a wide range of societal groups and interests (Oceans Act, 1996, ss 31–33).

14.2.3 ABM Relationship to MSP

In the dynamic interplay between human activities (including shipping), the protection of marine ecosystems, and the well-being of coastal communities, it is relevant to ask whether ABM tools are effective enablers of good governance, or whether more integrated approaches, such as marine spatial planning, should be considered.

The taxonomy of ABM tools presented in Chap. 2 distinguishes those directly linked to shipping (e.g. designation of places of refuge) and others impacting shipping within broader management goals (e.g. national marine conservation areas). Many of these tools require collaboration between government/regulators and stakeholders, including rightsholders, particularly in managing shipping risks in sensitive areas requiring protection.

Arctic Canada, and particularly the development of the governance framework for the Northern Low-Impact Shipping Corridors, will perhaps be a unique opportunity for assessing ABM solutions for shipping and for inquiring whether more comprehensive approaches that address shipping within broader contexts of governance are needed. The vulnerability of Arctic marine ecosystems, the intensity and seasonal use of the marine space by Inuit coastal communities, the lack of accurate charts, the seasonal variations of the environment, and the intrinsic connections of shipping with many other activities (from mining to community supply) make the Canadian Arctic a case of special interest for future research.

The question of whether individual ABM measures should contribute to a broader marine spatial plan that integrates various ABM initiatives within a comprehensive framework is not limited to the Canadian Arctic. MSP, conceived as a "vision for the future" that is general in nature and that defines long-term goals (Ehler & Douvere, 2009), could potentially provide a framework to initiatives like the Corridors. An integrated MSP approach may offer other benefits, including clear guidelines, data-sharing platforms, streamlined decision-making, and coordination in the consultation and engagement process. But it may also present challenges.

Indeed, an inclusive integrated approach is in alignment with Canada's *Oceans Act* (1996), but this book has shown that many ABM tools appear to work and largely achieve their purposes (e.g. enhancing safety, mitigating vessel-source pollution) without an MSP framework in place. Moreover, it is interesting to note that the tools applied tend to have an institutional sectoral driver (e.g. Transport Canada, Fisheries and Oceans Canada, port authorities, Parks Canada). Naturally, this does not necessarily mean that a full-fledged integrated approach is not desirable or indeed needed, but it does suggest that using shipping ABM tools may promote pragmatic coordination of ocean use and management concerns.

The potential framing of specific ABM initiatives within a broader MSP framework poses other challenges, including the resources and time needed to establish partnerships and collaborations, the efforts involved in intergovernmental coordination, and the establishment of complex governance bodies, but in the long term, the benefits of integration may be greater than the short- and medium-term challenges, as shown by the developments of the Marine Plan Partnership for the North Pacific

Coast (Diggon et al., 2022). For a comprehensive MSP framework to work, a critical approach that gives proper respect to local communities and that properly accounts for local knowledge is needed. An uncritical approach to MSP may perpetuate or even reinforce pre-existing conditions of power unbalance among stakeholders (Flannery et al., 2020).

Broader MSP or integrated frameworks may constitute an approach (ecosystem-based, holistic, place-based or area-based, adaptive and capable of learning from experience, strategic and anticipatory, and participatory) that is generally aligned with the expectations of coastal communities and that is ontologically compatible with recognized Indigenous governance principles (Brondízio et al., 2021).

A lesson learned from some of the initiatives discussed in this book, and that remains true for both ABM and MSP, is that the pursuit of synergy across diverse knowledge systems, such as the intersection of Western scientific methodologies and Indigenous knowledge, can present a transformative strategy to develop a more comprehensive and holistic understanding of the multifaceted issues associated with marine shipping activities in a given region (as discussed in Chap. 3). By tapping into the strengths of different knowledge systems, the decision-making process may access a wealth of insights, ensuring a more nuanced and well-informed approach to decision-making.

A culturally inclusive strategy may not only enhance the effectiveness of decision-making processes but also foster processes of engagement with Indigenous communities in alignment with the recommendations of the Truth and Reconciliation Commission (TRC, 2015) and thus result in a more nuanced, culturally sensitive, resilient. and adaptive governance framework (see Chap. 6 for a detailed argument). This inclusivity may also result in management strategies that evolve in response to changing environmental dynamics and societal needs.

14.2.4 Relevance of Risk Governance and Management to ABM

The use of ABM tools and the processes associated with their implementation can be approached through various lenses related to risk governance and management, with several examples of these addressed in various chapters of the book, notably in Chaps. 7, 10, 12, and 13. A first high-level observation is that ABM can be readily understood as a mechanism of modern "risk societies" to cope with a variety of risks to ships and risks from ships to the ocean and coastal environment. In modernity, societies are self-reflexive about the various risks created by scientific, technological, and industrial progress, which produce possible but uncertain impacts on a makeable future. In this sense, ABM tools can be seen as risk mitigation measures devised by modern societies, which project their socio-cultural values and norms on marine areas, for example, by prioritizing marine conservation or enhancing safety of ships and humans at sea over economic exploitation or profit.

A second observation is that ABM tools are devised explicitly to address specific aspects of shipping-related risks, as needed in defined areas, by imposing technical and operational actions and restrictions on ships navigating those areas. These ABM tools can be tailored to a specific risk, such as traffic separation schemes for improving navigational safety or emission control areas for reducing the impacts of harmful air emissions. Other ABM tools can be devised to accommodate and direct different risk-inducing activities across a marine area, for example, MSP processes. Similarly, ABM tools provide flexibility to address one or several of the risk management phases, that is, prevention, mitigation, preparedness, response, and recovery.

Third, the fact that ABM tools aim to achieve desired policy outcomes, typically embedded in higher-order policy goals which reflect the socio-cultural norms and values, implies that their selection and implementation are essentially a political undertaking. There can be different legitimate views among stakeholders and rightsholders related to the importance of and need for protecting or promoting certain values in a given marine area. Significantly, these can be justified based on different value systems of the societal actors with an interest in the human activities in that marine area. Thus, while scientific and technical knowledge is often a key element in supporting decisions on the need for ABM and in deciding on the specific measures in its practical implementation, normative ambiguity and different worldviews among stakeholders and rightsholders must be considered in selecting, constructing, implementing, and monitoring ABM tools as a matter of good governance. Furthermore, as illustrated in case studies in Chap. 9 and elaborated theoretically in Chap. 6, special consideration should be given to Indigenous knowledge systems and their relation to findings based on Western science, when Indigenous rightsholders have legitimate interests in the marine area under consideration. As explained in Chap. 2, this balancing act can be approached through a risk governance lens, with frameworks such as the International Risk Governance Council's Risk Governance Framework (IRGC-RGF) potentially providing a fruitful basis for strengthening the principles and processes associated with selecting, developing, implementing, and monitoring ABM tools, through distinguishing simple, complex, uncertain, and ambiguous risk types. For already implemented ABM measures, the IRGC-RGF can similarly serve to assess and evaluate the performance of the practical risk governance processes and activities and direct decision-makers in making improvements. This is exemplified in Chap. 10, which focuses on risk governance deficits associated with oil spill pollution preparedness and response ABM tools in Canada.

A fourth observation is that to support decisions on and to support the practical implementation of ABM tools, various techniques, models, and computational tools have been developed. For some tools, techniques have been developed to explicitly analyse the shipping-related risks in a given marine area in terms of the probability of occurrence and severity of consequences of unwanted events, as elaborated in Chap. 7, for assessing navigational risks in waterways and to delineating traffic separation schemes. When devising such techniques, the chapter highlights the importance of attention by academics and understanding by decision-makers of the theoretical frameworks on which such techniques build, as this can have important implications for the validity and completeness of the findings. For other ABM tools, techniques exist or are being developed to support strategic or operational decision-making without explicitly determining the risks, such as the maps depicting incident response service areas and incident response isochrones introduced in Chap. 12.

Based on the above, adopting a risk governance and management lens in the context of ABM can be beneficial especially as there are elaborate risk frameworks and techniques available to support the decision-making processes for and the design, implementation, and monitoring of ABM tools. Risk analyses are especially well-suited to gain insights into the complexities underlying the unwanted events and their consequences addressed by ABM tools, including the effects of associated risk mitigation measures. Understanding complexity is particularly important to anticipate undesired side effects of implementing risk mitigations in ABM tools. This is, for instance, highlighted by Hassellöv (2023) by focusing on the increased marine pollution and ecotoxicological risks to marine ecosystems caused by exhaust gas cleaning systems (scrubbers), which are used on board vessels to attain their nitrogen oxide and sulphur oxide emission limits in emission control areas established under MARPOL Annex VI.

An essential aspect of risk analysis and management is consideration of uncertainty in decision-making. When elaborate scientific and technical evidence is available and uncertainties are low, risk-based analytical approaches that explicitly account for complexities (for instance, through quantitative scenario analyses) can be used to make trade-offs between decision alternatives, explicit or qualitative assessments of events, and acceptability of risks and consequences. However, when evidentiary uncertainties are large and/or when societal actors are in alignment on the values to protect, precautionary approaches to managing risks in marine areas can be the preferred routes to risk management. In this respect, established risk management standards such as ISO 31000:2018 (ISO, 2018) and frameworks such as the IRGC-RGF (IRGC, 2017) can form a fruitful basis for elaborating decision-making procedures, implementation and monitoring plans, and stakeholder and rightsholder engagement processes for existing or new ABM tools.

The issue of standardized versus flexible ABM tools (noted in Sect. 14.2.1) can also be viewed through a risk lens. Standardized tools to handle particular risks, such as traffic separation schemes to prevent collisions and grounding accidents, can be recommended when the risks, the risk-reducing effects of ABM tools, and the potential for unintended side effects of risk mitigation measures are well-understood and the associated complexities and uncertainties are relatively low. Other well-established ABM tools balance efficiency, consistency, predictability, and clarity of legal instruments, with the flexibility inherent in the tool to tailor risk mitigations to the specific context of the marine and coastal areas under consideration, accounting for local conditions, stakeholder views, presence of other legal requirements, and anticipated long-term developments of marine activities and marine ecosystems. As described in Sect. 14.2.3, MSP is an example of an ABM tool balancing standardization with flexibility concerns. In the EU, MSP has a clear legal basis in Directive 2014/89/EU establishing a framework for maritime spatial planning for EU member states (EU, 2014). Additionally, elaborate guidelines exist to operationalize the specific nature of an MSP in a given marine area to flexibly consider the local context, for example, the MSP global international guide on marine/maritime spatial planning (UNESCO-IOC/EC, 2021).

Other risks, which are less well scientifically understood, and about which uncertainties are higher, or on which societal actors agree on the values to protect, can be mitigated through precautionary risk management approaches using standardized ABM tools. The establishment of MPAs, such as the Tuvaijuittuq MPA in the Canadian Arctic (Oceans Act Order, 2019), is an illustration of such an ABM use in the context of scientific uncertainties on the effects on marine ecosystems of possible increased shipping and human activity in Arctic areas, which are themselves also uncertain.

Finally, for new and emerging risks for which prohibiting human activities in marine areas is undesirable or infeasible, ABM tools providing a high degree of flexibility in requirements and measures to regulate activities are recommended. While technical risk assessments often play an important role in flexibly setting requirements in such ABM tools, the ability of regulators to adopt resilient strategies to set and adapt requirements as new information becomes available is arguably of key importance. An example of such an ABM tool is the designation of specific marine testbed areas to support the development and testing of new maritime autonomous surface ships (MASS), with accompanying guidance such as the IMO Interim Guidelines for MASS Trials and industry codes of practice, for example, the one produced by Maritime UK (IMO, 2019a; Maritime UK, 2020).

14.2.5 ABM "Good Practices"

Instances of good practices for applying ABM tools are peppered throughout this book, with a sample sprinkled above in this chapter. However, a recap of good practices, and its antithesis, poor practices, must be tempered by the realization that the applicability and application of given ABM tools are very context specific, so generalizations must be viewed cautiously. Traditionally, good/best practices refer to the established techniques, methods, processes, or activities that are recognized as being effective and efficient means of achieving desired outcomes in a given domain. These practices are often identified through experience, research, and analysis and are widely accepted as superior to alternative approaches. Best practices are continually refined and updated based on new knowledge, technological advancements, and changing circumstances. They serve as benchmarks for excellence and are adopted by organizations to improve performance, streamline operations, reduce risks, and enhance outcomes.

Of these approaches to capture and convey good practices for ABM applications, experience is generally the best guide, but given the diversity of methods, scope, and contexts in the diverse cases as reflected in the examples in this book, the identification of fairly similar situations is required to replicate successful preceding applications. For example, the approach taken to mitigate the risk of ship-whale collisions in the Gulf of St. Lawrence (see Chap. 2) through reactive speed reductions and/or route alterations is very different than the ABM planning process used to accommodate potentially harmful impacts on whales in the Canadian Arctic, where the community engagement is much more extensive, the consequences are more varied and diffuse, and the solutions are more persistent (see Chap. 9). Thus, other ABM initiatives elsewhere to deal with this type of problem must examine these and similar cases to see what aspects are translatable to the new situation, and even then, the relevant stakeholders, regulatory regime, environmental conditions, and other factors might differ significantly. This inexorably leads to the observation that a process of drawing upon good practices in ABM would rely on a substantial set of available, successful applications to discover potentially comparable conditions or more realistically that it is the underlying elements of the various tools and approaches which provide the foundation for good practice emulation, and not solely the specific methods.

Key elements for good ABM design revealed throughout this book include the following. Some elements are universally beneficial for any ABM, while the relevance of other elements is context specific and will not apply to all initiatives.

- Methodical process: ABM should be based on a structured, rational approach to achieving the desired goal(s). There is no single approach, or recipe, to ABM, so it needs to be customized to the problem at hand, which is why generally ABM comprises a framework and various tools for effective management in marine spaces.
- Stakeholder engagement and collaboration: The nature and degree of multiple stakeholder involvement depend on many factors, but principally the nature of the problem. Standard shipping lane designs in ports and waterways generally fall into the simple risk category (see Chap. 2) and may rely primarily on data-driven modelling, requiring limited consultation with shipping and port experts. Conversely, as noted in the preceding sections, shipping in the Canadian Arctic may involve complex and/or ambiguous risks which calls for extensive consultation with Indigenous groups, environmentalists, shipping companies, seafarers (see Chap. 13), and multiple levels of government.
- Building trust: When there are competing interests in an ABM problem, better outcomes can be achieved through collaborative solutions, even though they often involve compromise on all sides, but such a joint effort in turn is enabled by building trust between the varied stakeholders and rightsholders. This takes time, patience, and diplomacy, but the end result can benefit greatly, and it also helps to foster sustainability of the ABM implementation.
- Evidence-based decision-making: ABM should be based on the best available scientific information and data. This includes spatial data on the relevant oceanographic conditions, human activities in the area, and socio-economic, and sometimes cultural, factors. Incorporating data does not preclude subjective inputs that may complement or occasionally supersede scientific-based information since, for real-world problems, crucial data may be lacking or sometimes be misleading or erroneous.

- Long-term vision: Some ABM applications that are meant to endure indefinitely should be guided by a long-term vision that considers the implications of decisions over time. This involves setting clear goals and objectives for sustainable development and continuously monitoring progress towards achieving them. Furthermore, projecting into the future allows planners to account for potential significant changes in conditions, such as climate change effects, evolved ship designs and technology, new international regulations, changing global markets, and other elements. Such considerations may affect specific aspects of the proposed ABM plan. Finally, uncertainty should be considered, and while it generally grows with longer time horizons, incorporating it can contribute to hedging strategies which ultimately enhance the success of the ABM plan.
- Adaptive management: As a corollary to the preceding point, since a forward-looking approach does not address all uncertainty, when it is germane, ABM tools should be flexible and adaptive, capable of responding to new information, changing conditions, and emerging challenges. This involves monitoring and evaluation mechanisms to assess the effectiveness of planning decisions and to make adjustments as necessary over time. While the processes in a given ABM tool should be responsive to changing conditions, the concept of "dynamic" should be considered in the short, medium, and long term, where the main emphasis depends on the particular problem.
- Cumulative effects assessment: Depending on the context, the term cumulative can refer to the possibility of impacts of multiple ship-source stressors on various receptors, but also the accumulation of impacts over time (even of a single stressor), which ties into the previous element of trying to predict the aggregate future benefits, and possibly side effects, of an ABM plan.
- Sustainability: The previous points also tie into the concept of sustainability, which may apply to some ABM problems, whereby the plan should aim to meet the needs of the present without compromising the ability of future generations to meet their own needs.
- Equity and social justice: On occasion, ABM must promote equity and social justice, particularly for coastal and/or Indigenous groups that are affected by shipping activity. This may include mitigation of shipping impacts on valued environments or activities, or opportunities for communities to benefit from changes induced through the ABM implementation.
- Environmental protection: Irrespective of all considerations for the needs and values of rightsholders, special interest groups, or industry, ABM should prioritize the protection and conservation of the environment where possible, even if it is not the principal aim of the exercise, including the coast, water, air, and biodiversity.
- Efficiency: By design, many ABM plans place various restrictions on shipping activities, but to the extent possible, economic benefits should be maintained or enhanced, to the benefit of all consumers of the vessels' cargoes or services. In accordance with that, there should be consideration of the increased costs of shipping when ABM tools have the effect of prolonging voyages. This element also applies to multiple, potentially conflicting, uses of ocean spaces, whereby an

ABM application can sometimes accommodate distinct aims in order to provide opportunities to multiple groups and/or lessen the economic burden on any of the players.

- Effectiveness: Ultimately, the implementation of an ABM tool requires a supportive legal, policy, and monitoring framework, which may be at the national, regional, and international levels, as well as mechanisms for coordination and cooperation among relevant authorities and stakeholders. Alternatively, the constraints on shipping behaviour can be applied on a voluntary basis, subject to sufficient monitoring and compliance.
- Periodic review: The design and application of ABM tools should be accompanied by periodic performance review and evaluation to determine overall effectiveness and justification of the continued associated costs. An evaluative framework that investigates the performance and measures the elements set out above should be considered.
- Transparency and accountability: ABM processes should be transparent, inclusive, and accountable to ensure legitimacy and trust by relevant stakeholders and rightsholders. This involves providing access to information (subject to data sovereignty or privacy restrictions), opportunities for public participation, and mechanisms for feedback and grievance redressal.

There are of course challenges to adopting some of these elements in ABM design. Some difficulties may derive from the contradictory nature of certain aspects of ABM. For example, while some ABM plans should be dynamic and nimble, in general they must also be consistent enough to be captured in guidelines and regulations, to be understood by all affected parties, and stable enough to be monitored for continuous improvement. Another hurdle, well appreciated by practitioners, is that effective multi-stakeholder collaboration and compromise are often elusive, especially when the problem is a zero-sum game. Nevertheless, skilled negotiators can often arrive at solutions that distribute the benefits or risks across groups. Another concern is the apparent gap between the theory and practice of ABM. While this dichotomy arises in many domains, it may be particularly acute in ABM given the ongoing development of this management approach and its somewhat amorphous nature.

This brings us to the concluding point. Identifying and adopting good practices for ABM depends largely on the number and availability of past ABM case studies, as well as an approach for comparing, contrasting, and synthesizing the key elements from those processes. This in turn relies on those cases having a mechanism in place for capturing the principal aspects needed to infer best practices: the planning process that was followed from conception to implementation and the outcome that was achieved, which usually requires monitoring the changed activities over a substantial period of time. This information is often not available and constitutes one of the recommendations for future work in the next section, via increased performance evaluations of ABM implementations. Finally, such information, when produced, must be available to interested ABM practitioners, which is also a challenge as only a limited portion of it may be publicly available through academic journals or government publications. Adding more mechanisms for sharing written information, as well as promoting best practices through training courses or open symposia, would be beneficial.

14.3 Directions for Future Research

As we explored the theoretical foundations and practical explanations of ABM tools in shipping, we experienced knowledge gaps and the need for greater general understanding of the opportunities and limitations of ABM tools.

Although the design and adoption of ABM tools at IMO are generally accompanied by impact assessment processes, it appears that at least some tools, such as particularly sensitive sea areas (PSSAs) and MARPOL special areas, are not followed by periodic performance assessments leading to reviews to determine if they need to be adjusted, strengthened, or discontinued. Some ABM tools are kept under constant review (e.g., routeing measures for the periodically updated *Ships' Routeing*), but it is unclear whether these undergo periodic formal performance evaluation. IMO Member States requesting the designation of tools such as PSSAs are supposed to keep IMO informed (IMO, 2019b). Indeed, IMO's own guidelines provide that the organization "should provide a forum for the review and re-evaluation of any associated protective measure adopted, as necessary, taking into account pertinent comments, reports, and observations of the associated protective measures" (IMO, 2005, para 8.4). Even if performance evaluations of PSSAs and special areas were to be undertaken, an appropriate and peer-reviewed framework would need to be developed. In comparison, guidelines for evaluating the effectiveness of MPAs have existed for some time (Hockings et al., 2006). Periodic evaluations or audits are useful to enable the design of better and more effective tools. For this purpose, researchers could help develop a scientifically supported framework for observation, monitoring, data collection, analyses, and reporting. There is an opportunity here because ABM tools adopted under the BBNJ Agreement must be monitored and periodically reviewed by the Scientific and Technical Body, and for this purpose an evaluative framework would have to be developed (BBNJ Agreement, 2023, art 26).

On another front, Canada is joined by other countries around the world in looking at the identification and management of impacts from marine shipping on the ocean environment in a regional or area-based context (Samuel Mansfield, personal communication, 16 February 2024). Regional assessments are extensive studies conducted in areas with existing or anticipated development that can guide land and marine planning efforts. These assessments are characterized by adaptability, as they involve a range of approaches and can encompass various activities, sectors, or specific activities within a region. Moreover, they can enhance impact assessment processes and other ABM approaches (e.g. marine spatial planning) and ultimately provide comprehensive and strategic information for decision-making on how to manage effects. This extensive initiative could benefit from post hoc analysis to produce insights into good (and poor) ABM practices and to monitor outcomes of implementations over time to establish effective methods to measure tangible benefits.

There is also a need for further risk-related research. First, there is value in increasing academic understanding through case studies to show how the need for, and selection, design, and implementation of ABM tools, has been practically achieved in different contexts. While many ABM tools exist and have been used, there is little systematic understanding of these issues, whereas such knowledge could be beneficial to guide decision-makers in improving the practical use of ABM tools.

Second, given the evolving landscape of human activities in marine spaces and the changes to the natural, economic, and socio-cultural environments in which these take place, there is a continued need for developing new risk frameworks, analysis techniques, and models to support decision-makers in operationalizing ABM tools throughout their conception, design, and implementation stages. In this context, the prospects of ongoing developments towards digital twins, which provide a digital representation of physical, chemical, and biological features of ocean, marine, and coastal areas, and of selected human activities within these, can provide new mechanisms to monitor the effects of ABM tools and to support decision-making through predictive analyses. More research is required not only to develop such digital twins for different contexts and shipping risk mitigation purposes but also to embed these in regulatory and policy practices.

Finally, to flexibly respond to new and emerging risks of marine activities, and devise or implement new ABM tools or adapt existing ones to changing conditions, responsible authorities should have the capacity to respond to regular and irregular events, to monitor ongoing conditions, anticipate developments and changes, and learn from experience. Research is recommended to better understand how risk-based versus resilience-based perspectives for ABM tools can be effectively used in the development of new techniques and in decision-making and risk monitoring processes.

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