Do You Sea What I See: Exploring the Representation of Place-Based Knowledge in Spatial Planning in Coastal Nova Scotia, Canada

By

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Submitted in partial fulfillment of the requirements for the degree
of
Masters of Marine Management
at

Dalhousie University
Halifax, Nova Scotia

December 2023

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List of Abbreviations

BEcoME	Benthic Ecosystem Mapping and Engagement
OFI	Ocean Frontier Institute
MSP	Marine Spatial Planning
DR	Data Representation
ArcGIS	“Arc” Geographical Information System
Esri	Environmental Systems Research Institute, Inc.
VR	Virtual Reality

Terminology

The list below describes the meaning of terms used in this research project. The definitions, arising from knowledge holders and scholarly articles, are specific to the context of this research and may differ from other understandings.

Indigenous people (in Turtle Island)**:** First Nations, Inuit, and Métis people in Canada whose ancestors were on this land prior to the arrival of the first colonial settlers (Reconciliation Framework, 2022).

Local people**:** People who live in an area often have multigenerational associations with a given place but do not necessarily self-identify as Indigenous. They are connected to a given place by their livelihoods, cultural identities, and knowledge, but may not necessarily be the earliest inhabitants of an area or inhabitants prior to colonization (Hill et al., 2020; Wheeler & Root-Bernstein, 2020).

Indigenous Knowledge (in Turtle Island): The collective knowledge of traditions defined, contextualized, and used by First Nations, Inuit, and Métis peoples, passed down through generations. This knowledge system is integral to the sustenance and adaptation of First Nations, Inuit, and Métis to their environment over time; and encompasses embodied practices, spirituality, morality, ideologies, modes of artistic expression, and methods of acquiring knowledge (Reconciliation Framework, 2022). This knowledge is built from and continues to contribute to the Indigenous cultures it derives (Onyancha, 2022).

Local Knowledge**:** Knowledge generated over time while engaging in daily life and is thus based on dynamic experiences. Such knowledge is individual and unique to its community as it represents the intricacy, socio-ecological complexity, and cultural connection to a

space (Onyancha, 2022). This knowledge system is not necessarily derived from or contributes to Indigenous traditions, cultural practices and/or beliefs.

Place-based Knowledge**:** A knowledge system generated through long-standing, typically intergenerational, relationships with a place, and often integrates culture, practice, and ways of knowing. Such knowledge is site-specific in terms of its geography and the unique, dynamic social connection of the space(s) people live and engage with on a regular basis (Silver et al., 2022; Todd, 2020). Place-based knowledge describes related characteristics of otherwise diverse and separate Indigenous and local knowledge systems.

Community**:** A group of people that share geographic space, resource interests, cultural understandings, and/or social practices (Helden, 2004). In this research, when referring to a specific geographical area, the term community may be interchangeable with the term local people.

Place-meaning**:** 'Place' differs from related concepts such as 'space' or 'environment' in describing physical aspects of a specific location as well as the variety of meanings and emotions associated with that location by individuals or groups. The meaning, of significance, one or more assign to a given place may result from individual connection or as an outcome of social influence (Devine-Wright, 2009).

Rightsholders**:** People or groups with rights to land or resources (e.g., Indigenous people); these can either be formulated in law or governed by local customs (Hill et al., 2020; Wheeler & Root-Bernstein, 2020)

Stakeholders: People or groups with interests or concerns related to land or resources (Hill et al., 2020; Wheeler & Root-Bernstein, 2020).

Decolonizing: The process of identifying, deconstructing, and removing (or replacing) Eurocentric control, dominance, influences, perspectives, definitions, understandings, interpretations, and ways of knowing, being, and doing from archival higher education and professional practice (Reconciliation Framework, 2022).

Spatial planning*:* recognized as a process undertaken by the public sector, spatial planning is the iterative approach to influencing spatial distribution of activities. The aim is to organize land, and coastal use in some areas, as well as the linkages between them in a way that balances structural, environmental, and socio-economic needs of an area (Yoshida et al., 2020).

Citation

Khan, J., 2023. Do you sea what I see: Exploring the representation of place-based knowledge in spatial planning in coastal Nova Scotia, Canada. [graduate project]. Halifax, NS: Dalhousie University.

Abstract

Spatial planning is essential in the interdisciplinary management of dynamic coastal environments. However, conventional approaches to spatial planning do not focus on the comprehensive representation and visual communication of place-based knowledge. This oversight limits the contextual applicability of planning decisions. To understand this issue's relevance in Nova Scotia, the suitability of six data representation (DR) tools used in spatial planning for representing local perspectives was explored. Through a scoping review and semi-structured interviews with spatial planners, researchers, and users of coastal environments in Nova Scotia, key characteristics that make each DR tool useful in representing place-based knowledge, as well as certain tool design limitations, were identified. Also identified were the generalized stages of the spatial planning process at which each of the selected DR tools was most effective. The Results are meant to inform the use and design of DR tools in a way that better serves coastal users throughout different stages of the spatial planning process – thereby supporting decision-making that is informed, and equitable.

Keywords: Spatial Planning, Nova Scotia, Place-based Knowledge, Data Communication, Data Representation Tools, Informed Decision-making

Positionality

I am a settler to Turtle Island, raised and educated in the Great Lakes region in Ontario, Canada. My academic journey has been based in a Western scientific ideology. In preparation and while conducting this study, I sought to examine my approach and recognize the influence of my personal identity, academic background, and life experiences on this research. I am committed to upholding the principles of reflexivity. Engaging with knowledge holders, researchers and community members within the province have supported my seeking, inclusion and emphasis of Indigenous knowledge and local perspectives.

Acknowledgements

We are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People. We are all Treaty people.

This work could not have been completed without the input from my supervisor, Dr. Floris Goerlandt, and the rest of the *Work Package 1.1 BEcoME* team – namely, Dr. Claudio Aporta, Fes Simmons, Leah Fulton, Dr. Patricia Manuel, and Dr. Sara Spike – and the generosity of those who participated in this study. I appreciate your time and willingness to share with me and hope to maintain the connections I have made with each of you. I also want to acknowledge the time, resources, and support from the Marine Affairs Program faculty, especially Cali Goud, Dr. Hannah Harrison (who generously acted as my second reader), Maxine Westhead, Dr. Megan Bailey, Dr. Ramon Filgueira, and Dr. Wilf Swartz who enriched my learning experience and taught me the importance of seeking multiple perspectives, valuing introspective reflection and questioning underlying assumptions. Of course, to the 2022-2023 cohort, I am so very privileged to have worked with and learned from you all – you are an inspiring group and I look forward to seeing where your important work takes you. As always, I'd also like to recognize the efforts of my family and friends who's continued support is invaluable.

1 Introduction

Coastal areas are a critical interface in which human activity, ecological diversity, socioeconomic influence, and topographical conditions interact (Globe et al., 2014; Dale et al., 2019). Such environments, and the people who live and work in these areas, are facing unprecedented pressures as a result of climate change and the multiple competing, and at times conflicting, uses of the coasts (Jouffray et al., 2020; Morrissey, 2023). The demand for space – be it for accessing cultural spaces, optimizing industrial functionality, protecting from anthropogenic pressures, or creating recreational opportunities – exacerbates these experienced pressures (Enqvist et al., 2019). The allocation of space is evidently a significant factor in coastal management; and with multiple typologies of activities existing at various geographic and temporal scales there is a need for informed, site-specific spatial planning (Bell & Orozco, 2023; Said & Trouillet, 2020).

Spatial planning methods, encompassing strategies like coastal management and marine spatial planning (MSP) (Box 1), are vital for the interdisciplinary management of dynamic coastal environments. The dynamism of coastal areas emphasizes the need for social-scientific scholarship, focusing on how local experiences influence spatial planning and the consequences of spatial plans on ocean users' livelihoods (Bennett et al., 2017). This understanding is crucial for planners, providing them with detailed insights necessary to manage conflicts between existing activities and plan for potential uses in populated coastal zones (Said & Trouillet, 2020).

Lack of integration is primarily attributed to knowledge gaps, communication challenges, and varying cultural factors. Knowledge gaps arise from communication

issues, differences in evaluating ecosystem impacts, and mismatches between policymakers' broad questions and reductive natural scientific approaches (Karcher et al., 2021). To address this, coastal management initiatives should integrate natural and social sciences with political decision-making processes and should be informed by the best available knowledge (Globe et al., 2014). Coastal systems management involves diverse rights- and stake-holders with conflicting priorities and values, complicated further by population expansion and environmental pressures, including issues like rising sea levels due to changing climatic conditions (Dale et al., 2019). Additionally, environmental problems often exist at multiple scales, making it challenging to transfer solutions from one scale to another. Effective communication necessitates clear problem framing, hindered by language disparities, discipline-specific jargon and uninformed ways in representing complex knowledge and data (Said & Trouillet, 2020; Franconeri et al., 2021). Cultural variations in viewing and understanding environmental issues further impact integration efforts (Smith et al., 2017; Aporta et al, 2020). Developing partnerships with rightsholders and stakeholders that emphasize knowledge-sharing reciprocity becomes crucial in addressing the intricacies of how coastal use and conditions are understood and communicated (Pınarbaşı, et al., 2017). This integrated approach is particularly significant given the initiation of marine spatial planning and other spatial planning initiatives focused on the coastal environment in Nova Scotia (Artelle et al., 2021; Martinez Caledron, 2022). While spatial planning works to facilitate collaboration in decision-making, there are challenges in the way in which planning processes and data are communicated (Globe et al., 2014). Specifically, there is a lack of comprehensive

representation and visual communication of place-based knowledge in conventional spatial planning approaches, limiting the contextual relevance of planning decisions (Bludau et al., 2023).

Box 1: What is Marine Spatial Planning (MSP)?

Marine Spatial Planning (MSP) is an example of spatial planning that takes an integrated approach that combines static protection measures with dynamic strategies to address the constantly changing nature of the ocean, societal concerns, and technological advancements. It requires adaptive planning policies for successful implementation, often initiated by drivers (e.g., climate change impacts, the establishment of offshore industry, etc.) (Westhead, 2022).

This planning method operates on several principles:

- Participatory governance
- Area-based regulations
- Precautionary principle
- Integrated and Adaptive management
- Ecosystem-based management
- Co-management

Overall, MSP aims to improve coordination between sectors and governments, allocating the spatial and temporal distribution of human activities in marine areas through transparency, and collaborative relationships. The process involves adaptive management, which enables the output of informed maps, and incorporates co-management – wherein power is shared between from rightsholders and stakeholders in decision-making (Garben, 2011; Pınarbaşı, et al., 2017).

Place-based knowledge evolves from long-established, often intergenerational connections people have with the areas they inhabit, engage with, and call home (Todd, 2022). This system of knowledge combines the unique ontologies or ways of knowing, cultures, and practices that are specific to a particular geographical region (Silver et al., 2022). However, without proper design, decision-support or data representation tools may be limited in their ability to effectively capture and convey the richness of place-based insights (Bludau et al., 2023). Integrating contextual knowledge and principles of

visual perception into these data representation tools becomes essential to support the adequate communication place-based knowledge systems.

The success of deepening meaning and expanding understanding in coastal spatial planning is ultimately impacted by the ability of tools used to support decision-making to be representative of the dynamics that exist with a planning area (Bludau et al., 2023). Without the adequate inclusion and representation of place-based knowledge, the context essential for effective decision-making is limited. It is thereby necessary to review data representation tools' ability to communicate place-based knowledge systems and explore how site-specific insights can be better integrated into the spatial planning process.

1.1 Management Focus

Spatial planning is an essential tool in managing the province's coastal environments. However, conventional approaches to spatial planning in Nova Scotia are limited without the comprehensive representation of place-based knowledge. To address this limitation, it is necessary to build and amplify the perspectives and understandings of rightsholders and stakeholders in decision-making. A scoping review of available literature and gathering of insights from spatial planners, researchers, and users of coastal areas in Nova Scotia can identify the characteristics of a tool that make it suitable in representing place-based knowledge, as well as the risks of attempting to showcase aspects of place-based knowledge via data representation tools. Such information will inform the use and design of tools in the spatial planning decision-making of Nova Scotia's coasts.

1.2 Research Objectives

With approximately 7500 km of coastline in Nova Scotia and expressed concern for the socio-economic wellbeing outcomes of spatial decision-making, the province is amidst a paradigm shift in its approach to spatial planning (Waldron, 2018; Waldron, 2021). With an established understanding of the need for spatial planning in coastal areas and discussions around the implementation of an MSP in the province (DFO, n.d.), there is a great opportunity to reimagine the approach to planning with an informed, place-based lens and acknowledge the data used as co-created (Tremblay & de Oliveira Jayme, 2015). The inclusion of such knowledge can provide the necessary socio-economic context to inform decision-making and foster relationship-building, which is crucial for the acceptance of decisions among the wider community (Ainsworth et al., 2020).

To understand relevance of place-based data representation in Nova Scotia, I will be exploring how data representation (DR) tools used in spatial planning account for and represent local perspectives. Insights from community members, spatial planners and researchers will inform the use and design of DR tools in a way that better serves coastal users throughout different stages of the spatial planning process. The objectives of this study encompass several key aspects. Firstly, it emphasizes that rightsholder and stakeholder participation in the design and use of DR tools. This approach recognizes the significance of those whose futures are intertwined with the plans resulting from these tools' utilization (Said & Trouillet, 2020). It is crucial to note that the study does not seek to appropriate or extract knowledge; rather, it aims to facilitate knowledge sharing and ensure the return of data to the community. This involves creating space for place-based

knowledge systems and scholarship (Artelle et al., 2021). Finally, the study seizes the opportunity to contribute valuable insights that can inform the ongoing development of the marine spatial planning presence in the province, aligning with the broader goals of informed decision-making.

These objectives of this research reflect those of Work Package 1.1 (Societal Engagement) of the Benthic Ecosystem Mapping and Engagement (BEcoME) Project. BEcoME is a multidisciplinary project funded by the Ocean Frontier Institute (OFI) that seeks to understand the role that benthic and adjacent coastal habitat play in changing species diversity and distributions due to climate change in the Northwest Atlantic Ocean (BEcoME, 2020). Research teams are using broad and fine scale mapping technologies to identify how seafloor map data can be created, used and presented to develop a deeper understanding of the benthic-related environment (BEcoME, 2020). The findings of this research project are meant to inform the approach Work Package 1.1 takes to societal engagement and data representation, and to contribute to the wholisic understanding of benthic and coastal habitats in coastal Nova Scotia.

1.3 Research Question

As perceived by users, planners, and researchers in coastal areas of Nova Scotia, what are the characteristics of six DR tools used in spatial planning that make them useful to represent place-based knowledge?

1.3.1 Research Sub-question

What spatial planning stages do users, researchers, planners in Nova Scotia consider DR tools to be most useful in supporting communication and informed decision-making?

1.3.2 Research Sub-question

Do users, planners and researchers of coastal Nova Scotia recognize risks associated with using DR tools to represent place-based knowledge?

2 Background

2.1 Spatial Planning in Nova Scotia

Spatial planning is a systematic process used to organize land and/or marine activities and development within a defined area (Yoshida et al., 2020). The generalized stages of this process can be found in Figure 1. Spatial planning involves working within exiting legislations and policy to make decisions based on documented spatial patterns, predicted future development scenarios, and rightsholder and stakeholder input to optimize the use of available space (Said & Trouillet, 2020).

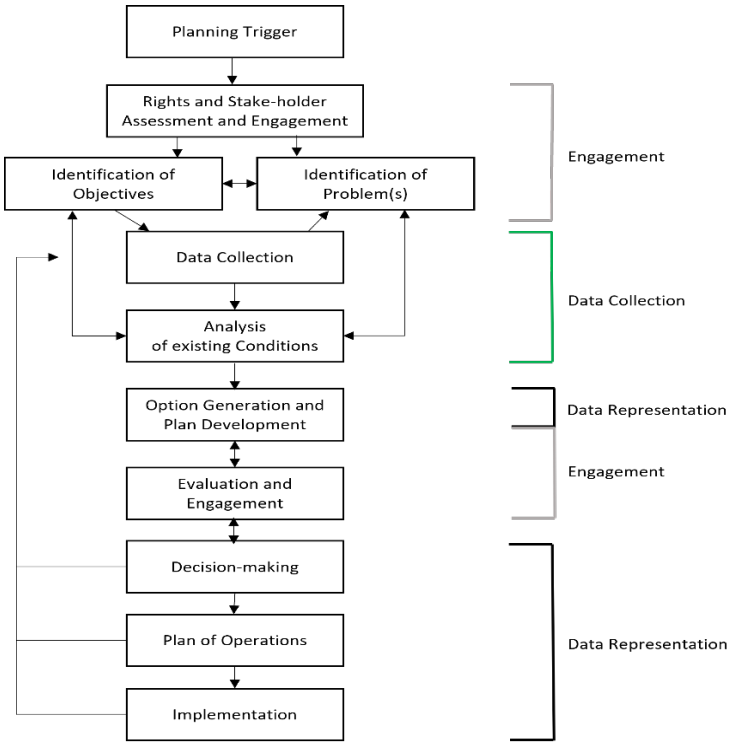


Figure 1 Generalized process of spatial planning and the generalized stages (e.g., Engagement, Data Collection, Data Representation) indicated by brackets to the right of the procedural diagram. Figure adapted from the works of Le Tisser et al., 2004 and Greiving, and Fleischhauer, 2006.

In Nova Scotia, spatial planning is described as a collaborative process involving both provincial and municipal levels of government (Nova Scotia, 2021). At the provincial level, the Department of Municipal Affairs and Housing plays a central role, providing strategic guidance and frameworks for regional and municipal planning efforts (Table 1) (Kraft, 2012). Municipalities within the province are responsible for developing and implementing their own land-use plans, aligning them with provincial policies and regulations (Kraft, 2012). Spatial planning is exemplified through initiatives like the Municipal Planning Strategy and Land Use Bylaw, a framework employed by municipalities such as Halifax Regional Municipality (Nova Scotia, 2022). Under this strategy, specific land use zones are designated, each with distinct regulations guiding residential, commercial, and industrial development. Additionally, initiatives like the Coastal Protection Act emphasize spatial planning by delineating coastal zones critical for biodiversity and community resilience (Nova Scotia, 2021; Nova Scotia, 2022).

Table 1 Examples of provincial legislative acts and tools for coastal area management in Nova Scotia (adapted from Kraft, 2012).

Act	**Tools**
Environment Act	• The province has the power to designate an area surrounding a source of water supply for a water works as a protected water area and to regulate the activities within that area in order to maintain water quality [ss. 106(1), 106(6)]. • The province may [ss. 3(be)(i), (ii), 110(1)(a), 3(bf), 105(3)(k)]: ○ make regulations as to how watercourses – that is, the bed or shore of every natural body of water within Nova Scotia – may be used.

	○ adopt strategies to protect watersheds – the area drained by or contributing to a body of water – for specific uses.
Fisheries and Coastal Resources Act	The province has the power to designate sub-aquatic land as an aquaculture development area or as a closed area where aquaculture development is not suitable [ss. 56(1)(a), 56(1) (e)].
Municipal Government Act	Enables municipalities to assume the primary authority for planning within their respective jurisdictions, consistent with their urban or rural character, through the adoption of municipal planning strategies and land-use by-laws consistent with interests and regulations of the Province [s. 190(b)].

1.2 Contextualizing Data with Place-based Knowledge

Ensuring place-based knowledge is comprehensively contextualized in coastal spatial planning is crucial for site-specificity and the active involvement of local communities and users in the planning processes (Aporta et al., 2020). Place-based knowledge supports the provision of local context that may otherwise be missing in some spatial decision-making. Although acknowledged as a valuable source of information, place-based knowledge often remains inadequately integrated into spatial planning initiatives due to its ontological complexity being challenging to frame in conventional Western approaches in spatial management (Sullivan-Wiley et al., 2019; Fagerholm et al., 2021). This is evident in the absence of place-based context in initial zoning and area-usage maps, resulting in a limited understanding of local use dynamics, which vary significantly from one community to another (Aporta et al., 2020). The limited comprehension of the interactions of existing

social, cultural, economic, and environmental dynamics in a space may result in the unrealized potential of spatial allocation of activities in planning (Helden, 2004; Fagerholm et al., 2021).

In efforts to include place-based knowledge systems, like Indigenous and local knowledge, there is evidence of decontextualization of place-related data whereby there is a removal from its original context (e.g., understanding of coastal habitat); and, with the placement in other contexts, may have its meaning recontextualized and redefined (e.g., (Aporta et al., 2020). This process is depicted in the knowledge-information-data continuum (Figure 2).

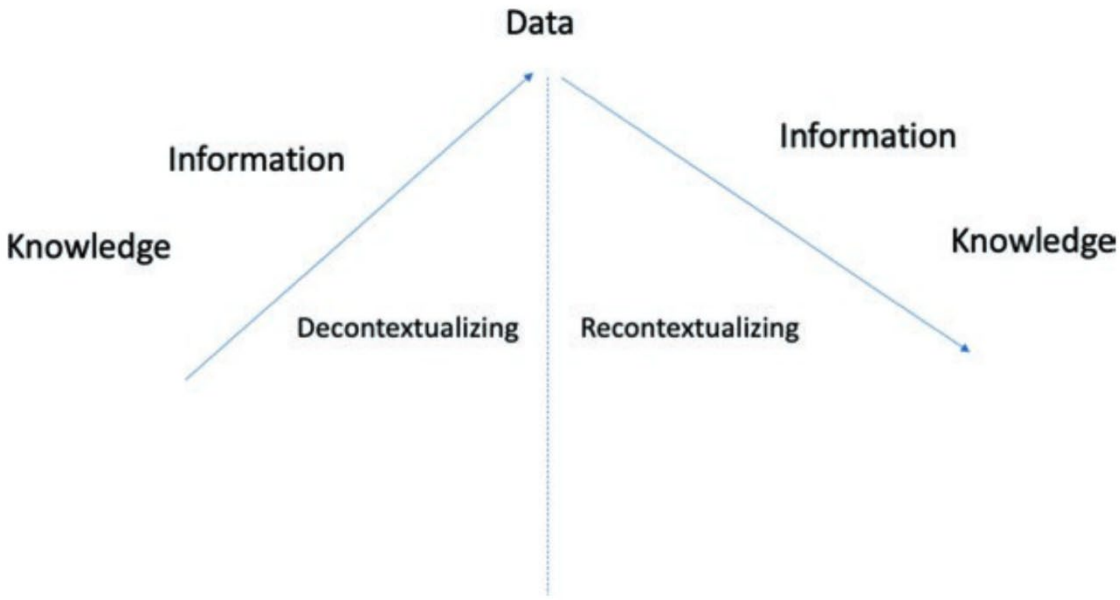


Figure 2. The process of de- and recontextualization in the knowledge-information-data continuum (Aporta et al., 2020).

However, it is crucial to acknowledge that not all aspects of place-based knowledge can or should be translated and shared. For instance, attempting to translate sacred knowledge deeply rooted in the language of the people and environment they derive, into another language is not only impractical but also risks diluting its essence (Bartlett et al., 2012). Also important to note is that experiential knowledge (e.g., place-based knowledge) can not be seamlessly converted into data and communicated, as the process involves various levels of transformation and interpretation (Aporta et al., 2020). Recognizing these nuances in the transferability of knowledge is pivotal for fostering effective collaboration and understanding between local communities and planning practitioners.

2.2 Individual Perception and Data Communication

The way people perceive and understand scientific data influences how they interpret and respond to that information (Franconeri et al., 2021). When individuals encounter scientific data, their personal experiences shape how they make sense of it. The availability heuristic describes how people often rely on easily accessible information, like familiar facts or vivid images, to make decisions rather than seeking a deeper understanding (Slovic et al., 2017). This tendency extends to spatial planning, where the limited representation of place-based knowledge in decision-making data perpetuates this reliance on easily available information (Fagerholm et al., 2021; Martinez Caledron, 2022).

The challenge lies in effectively communicating the complexity of complex knowledge within conventional methods. The availability or lack thereof of critical information, such

as place-based knowledge systems, can significantly impact the trustworthiness of decision-making processes (Fagerholm et al., 2021; Dijkstra et al., 2023). If data communication triggers feelings of uncertainty about the reasoning behind decisions or potential outcomes, it can lead to distrust among those using this data (Franconeri et al., 2021). Trust, therefore, becomes integral in how the quality and reliability of data used in spatial planning are perceived.

Data communication is subjective, and effective communication of place-related data requires an understanding of how individuals perceive and interpret information differently (Dijkstra et al., 2023). Employing tools that emphasize clear visuals, concise language, and relatable examples helps bridge the gap between intricate planning concepts and data comprehension (Franconeri et al., 2021). This approach not only enhances understanding but also minimizes misrepresentation. By acknowledging and addressing individual perceptions, we can maintain the integrity of knowledge without distorting its meaning and ensure that accurate information reaches diverse planners. This, in turn, fosters informed decision-making in spatial planning (Aporta et al., 2020; Dijkstra et al., 2023).

2.4 Data Representation Tools

Data representation tools are software applications or activities used to convey complex scientific or statistical information in a comprehensible and informative manner (Bludau et al., 2023). These tools serve the purpose of making data more accessible and understandable to a wider audience, including researchers, decision-makers, and the public (Pınarbaşı et al., 2017). In their design and functionality, data representation tools aim to integrate contextual knowledge and principles of visual perception to enhance the communication of scientific data. These tools integrate contextual knowledge by incorporating background information, metadata, and domain-specific expertise to provide meaning and relevance to the data. This contextual information can include data sources, units of measurement, temporal or spatial aspects, and any specific domain-related terminology. By presenting data in a context-rich manner, users can better understand the significance and implications of the information being communicated and can support decision-making.

This study evaluates six DR tools in their effectiveness or usefulness in representing place-based knowledge. These six tools are described in the sections below. A summary of each tool's advantages and limitation, as described in the literature, can be found in Table 2.

2.4.1 Marine Atlas (e.g., Canada Marine Planning Atlas)

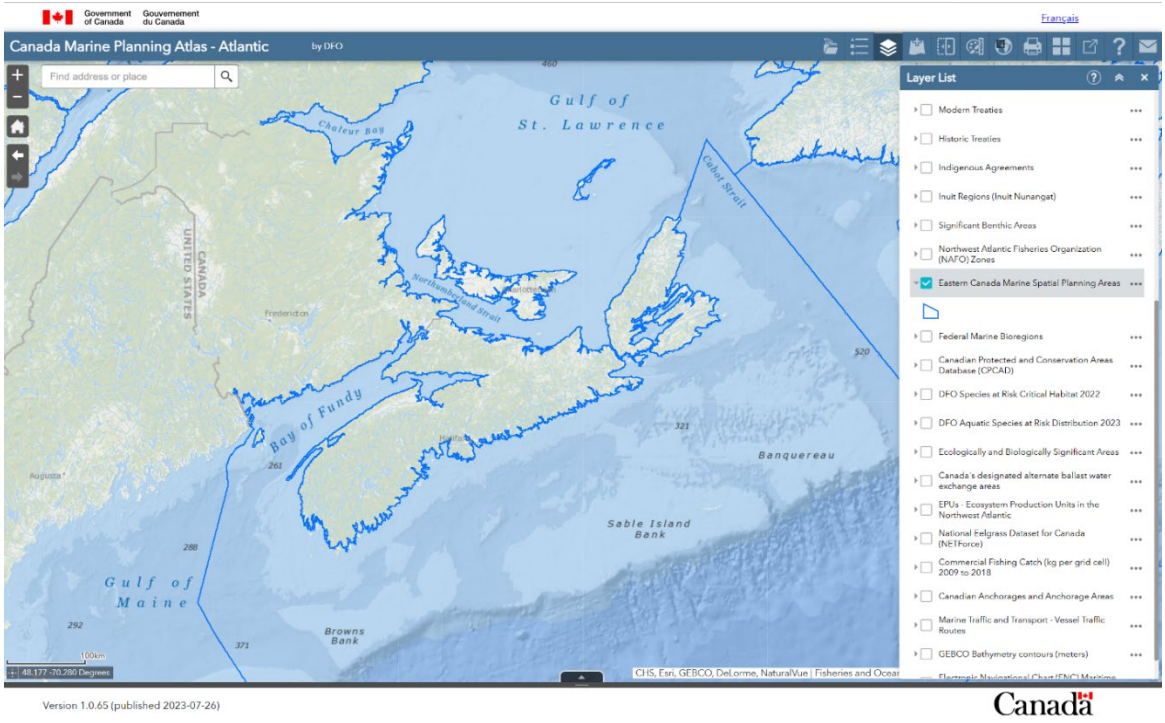


Figure 3. Display of the Canada Marine Planning Atlas interface for the Atlantic region dataset (DFO, 2023).

Marine atlases are interactive mapping tools for decision-makers and end users to access information about ecological processes, bioregion features, and human activities (DFO Maritimes Region, 2023). The Canada Marine Planning Atas is an example of such a tool (Figure 3). The atlas allows users to discover, view, interact with, and download geospatial data relevant to marine spatial planning (Department of Fisheries and Oceans, 2023). The DFO explains that the Canada Marine Planning Atlas tool supports planners in Canada manage conservation work and human activities and industries supporting the livelihoods of many coastal communities (2023b).

Marine atlases, while valuable resources in understanding and visualizing oceanic spaces, encounter limitations in their application to spatial planning. For examples, there is potential for such tools to be slow in the incorporation of real-time data; thus, there

may be challenge in keeping pace with rapidly evolving marine ecosystems due to the dynamic nature of oceans and coasts (O'Dea et al., 2011). Additionally, the scale and scope of marine atlases might not align perfectly with the intricate and localized needs of spatial planning initiatives which may be a result of a lack fine-grained, localized knowledge crucial for effective decision-making in certain areas (Write et al., 2011). Additionally, this tool requires familiarity with this technology to be used – this may subject users unfamiliar with map layers, etc. to find this tool's interface inaccessible (O'Dea et al., 2011; Write et al., 2011).

2.4.2 Participatory Mapping

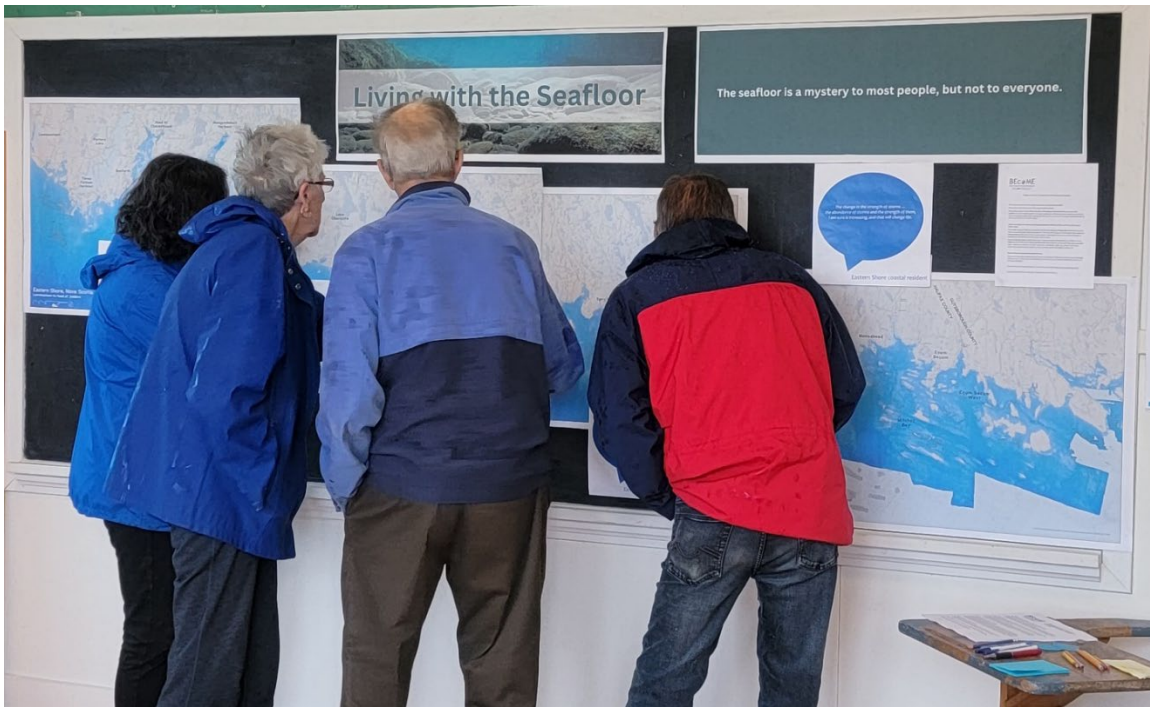


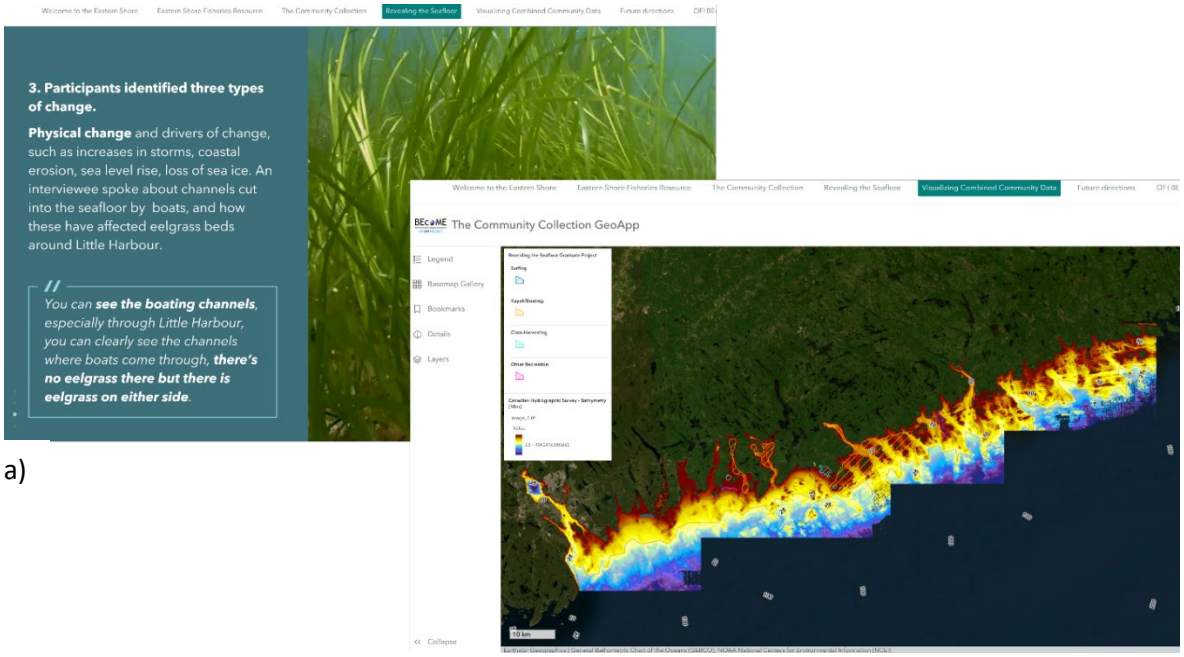
Figure 4 Members of Easter Shore community in Nova Scotia take part in a participatory mapping activity in June 2023.

Participatory mapping is a collaborative method of spatial knowledge generation that involves engaging local communities in the spatial planning processes (Smith et al., 2017). Participatory mapping enables active community involvement in decision-making

processes to represent their spatial knowledge, perspectives, and experiences. It empowers residents to identify and map important features such as cultural sites, natural resources, and land use patterns, providing planners with valuable local insights. By integrating this local and place-based knowledge with scientific data, spatial planners can create more accurate, culturally sensitive, and inclusive development plans. Participatory mapping can enhance community engagement, foster sense of ownership, resolves conflicts, and ensures that spatial plans align with the actual needs and aspirations of the people living in the area, leading to more effective and sustainable outcomes in spatial planning initiatives.

Place base-related activities and experiences have been found to be less challenging to map as compared to place-related values and concepts such as ecosystem services (Fagerholm et al., 2021). An example of such limitations was experienced in the participatory mapping effort undertaken by Aporta et al. (2020) whereby seasonal dynamics of Indigenous and local knowledge, coastal use patterns, and the changing environment related to climate change were difficult to represent and analyze cartographically. Additionally, Sullivan-Willey et al. (2019) contributes to the critique that participatory mapping approaches have a lack of generalizability and difficulty in integrating with scientific approaches at larger scale.

2.4.3 ArcGIS StoryMap (e.g., *Living with the Seafloor*)



a)

b)

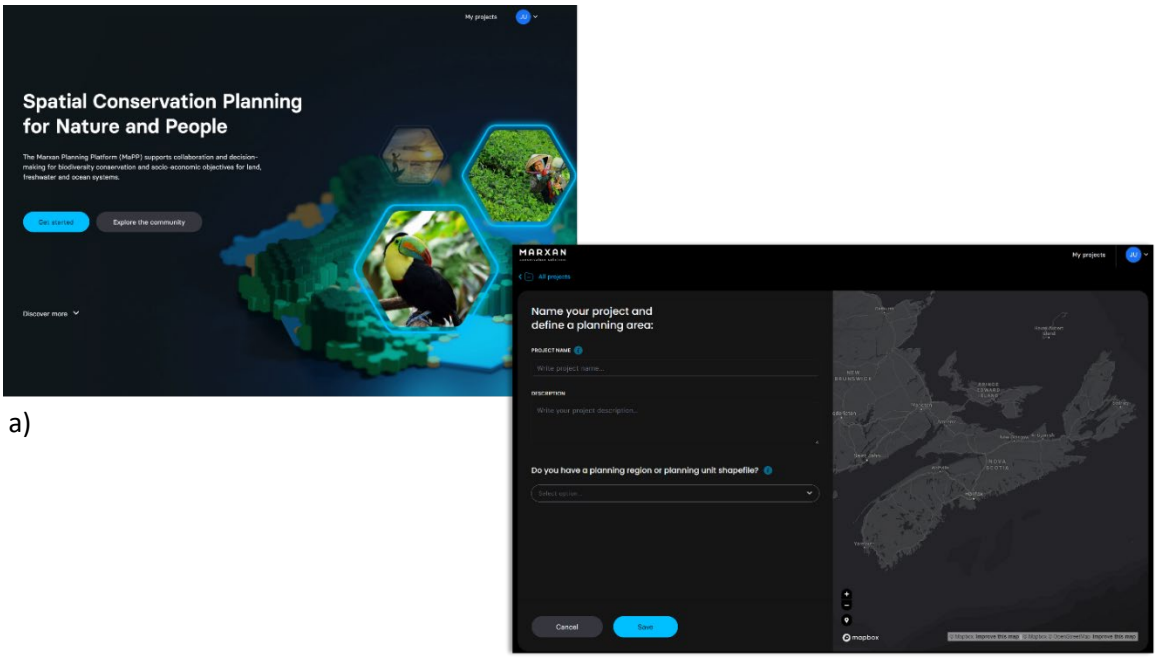
Figure 5 Display of the Living with the Seafloor interface. Two windows are show: a) displays community collected data showing imagery and text, b) displays the community collected information as data points and polygons on ArcGIS map (BEcoME, 2023).

ArcGIS StoryMap is a free, web-based application developed by Esri, a leading provider of geographic information system (GIS) software and solutions (Esri, n.d.). ArcGIS StoryMaps allow users to create interactive and engaging narratives by combining maps, multimedia content, and text. The online platform grants learners access to interactive, models and data by enabling the presentation of complex concepts and substantial information in a user-friendly interface that can be tailored to an intended audience (Kerski, 2017; Cope et al., 2018). Employing story maps has the potential to improve geo- and ocean-literacy, encouraging spatial thinking and comprehension (Cope et al., 2018). An example of the use of this tool to develop an interactive map with multimedia elements to tell the story of the benthic environment in the Eastern Shore, a region in Nova Scotia. *Living with the Seafloor* (Figure 5) offers testimonials, imagery and video

capturing and showcasing local knowledge about significant areas, geographic features and recreational use in coincidence with map data (BEcoME, 2023). The online web-page-like platform allows access to local accounts and the results of research that may otherwise not have been shared with the public or the community from which is derived. This example of a story map has shown its capacity to facilitate a deeper understanding of a place and to promote public engagement – key characteristics useful to enable feedback mechanisms and the potential for community participate in the spatial planning process. However, there are limitations to this tool.

A disadvantage of StoryMaps are that they rely on the availability of internet access (Kerski, 2017). This means that those who do not have access to reliable internet, perhaps even those who had contributed to the content of the StoryMap, may not be able to learn from, or ensure accurate representation of, the data shared. For example, some areas of the Eastern Shore are not well connected to internet networks and, despite having contributed invaluable data to the development of the *Living with the Seafloor* StoryMap, may not be able to view and benefit from the useful tool without finding a better connectivity which may come at financial costs (e.g., travel expenditures). Additionally, there is not yet the requirement for a peer review process to assess the representative quality of StoryMap content (Cope et al., 2018). This does not mean that such tools are not associated with credible authors, authoring institutions, or reputable agencies, but because of an unestablished standard external review process for published material, planners may not view this tool's validity in the informing of decision-making.

2.4.4 Simulation Software (e.g., Marxan)



a)

b)

Figure 6 The interface of Marxan Planning Platform is shown with two windows: a) home screen and b) data input screen (Marxan, 2022).

Simulation software is a specialized tools used in spatial planning and conservation management. Such software applications, like Marxan, employ advanced algorithms and mathematical models to simulate and analyze complex spatial and environmental scenarios (Figure 6) (Possingham & McGowan, 2020). For example, Marxan can, among other functions, predict species occurrences in an area of interest that is subjected to rapid warming given baseline condition data and projected climatic changes. This kind of scenario simulation are very important for systematic conservation planning (e.g., site selection optimization for an MSP) (Ban et al., 2013). Through Marxan's simulations, it is possible to identify and prioritize areas to conserve and that contribute to site-specific conservation goals (Marxan, 2022). Extending beyond this tool's simulation capabilities, Marxan offers opportunity to facilitate public engagement. The tool's visual

representation of the potential outcomes of proposed spatial planning can support an interactive and participatory processes by enabling the public to see view different planning scenarios (Serra-Sogas et al., 2020). In the context of spatial planning, this visual representation of outcomes may encourage the sharing of critical feedback. By providing accessible, data-driven visualizations, simulation software can enhance public understanding of the planning process and may offer opportunity for public contribution to plans (Watts et al., 2009). Although Marxan may serve as a marine planning support system, limitations related to DR tool design have been identified.

The availability of quality spatial data often limit what conservation features of the software can be uses (Possingham & McGowan, 2020). Thus, at scales with less abundant and/or lower resolution data (e.g., local- or community-scale), the functionality of Marxan may be limited. Marxan users must be aware that incomplete data can impact the analysis of information, given that the algorithm will gravitate towards data-rich areas – thereby introducing sampling bias (Serra-Sogas et al., 2020). Additionally, such technology requires familiarity of use; those that do not have a background understanding in simulation software, data input or do not have access to reliable internet may be subjected to the perpetuation of a digital divide between users and planners (Lucendo-Monedero et al., 2019; Caragliu and Del Bo, 2023).

2.4.5 Gaming (e.g., MSP Challenge board game)

Figure 7 Players gather around the MSP Challenge board game and experience the marine spatial planning process (MSP Challenge, 2023).

A game can be used as a learning, communication and data collection tool for planning and decision-making. In the example of the MSP Challenge board game, an educational game meant to reproduce the complexities of the MSP process through play, planners and stakeholders experientially understand the dynamic interrelations among various subsystems, the interdependencies among the actors and the consequences of actions well into the future (Figure 7) (Abspoel et al., 2021). In this board game, each participant takes on the role of a stakeholder such as an environmentalist, industry member, policymaker, etc. Each role-player is given unique goals and interests related to marine resources and development and players are expected to navigate the challenges of balancing sustainable economic growth, environmental protection, and social well-

being within a limited marine space (MSP Challenge, 2023). Through negotiations and opportunity for collaborative decision-making, the game offers a hands-on and interactive way for players to understand the intricacies of spatial planning in marine environments and experience challenges faced by planners when allocating space for activities.

In the context of spatial planning, the MSP Challenge board game serves as a tool for stakeholder engagement, and decision-making training. By engaging participants in a spatial planning environment, participants are encouraged to think critically, consider multiple perspectives, and work collaboratively to find innovative solutions (Abspoel et al., 2021). Moreover, the game fosters dialogue and cooperation among rightsholders and stakeholders, helping to build context for real-world MSP initiatives.

Despite the advantages of game play, there are limitations. As indicated by Poplin & Vemuri (2015) and Champlin et al. (2022), gameplay is limited by the available archetype of players and parameter assumptions. Depending on the number of players, or the design of the gameplay, representation in terms of rightsholder and stakeholder-related activities may not be included. This may impact the real-world experience of players, their understanding of MSP, and may not comprehensively portray the environment it is attempting to reproduce. Additionally, it is unclear if language communications within a digital or physical platform is impacted my game play. The impact of colloquialisms and cultural dynamics in language used during negotiations is not yet known – especially as it relates to the combating or perpetuating of existing power imbalances (Poplin & Vemuri, 2015).

2.4.6 Virtual Reality

Figure 8 A Nova Scotia resident experiences details of the surrounding waterways through virtual reality in October 2023.

Virtual reality (VR) is a computer-generated, three-dimensional (3D) environment and serves as a means for users to interact complex data using specialized hardware, such as VR headsets and motion sensors (Moloney et al., 2018). By immersing users in a digitally created space, VR provides an immersive experience, allowing individuals to explore and interact with virtual objects and environments as if they were physically present (Figure 8). VR technology engages the senses, primarily sight and sound, creating an illusion of presence in a virtual world. The characteristics of VR have enabled this technology to act as a useful tool in spatial planning and design processes.

Studies conducted, like that by Portman et al. (2015), indicate that VR can support those making spatial plans and those subjected to them in their understanding of proposed projects; provides opportunity for rights- and stakeholder feedback; and increases the quality and diversity of public participation (Meenar & Kitson, 2020). By

providing a realistic and interactive representation of spatial plans, VR can enhance communication, facilitate public engagement, and support data-driven decision-making in the field of spatial planning.

However, limitations for the use of VR exist. Researchers have identified the potential for the distortion of 3D projected information (e.g., development models, biological habitat, etc.) on a two-dimensional plane (e.g., headset screen) (Meenar & Kitson, 2020). This may provide an inaccurate representation of proposed spatial plans, thereby possibly impacting the applicability of feedback. Also identified is the potential exclusion of participants without computers, who are unfamiliar with the technology, or have an inability to use a computer for long periods of time (Moloney et al., 2018). VR may also be found exclusionary as they may be challenging to budget time, labour and/or funding to needed to conduct VR sessions (Meenar & Kitson, 2020).

Table 2 Summary of the advantages and limitations of the selected DR tools, as described in the literature, sourced from the scoping review, that is referenced in section 2.4.

Source	DR Tool	Advantages	Limitations
Scoping Review (references available in above section 2.4)	Marine Atlas (e.g., Canada Marine Atlas)	• Useful for organizing planning efforts • Helpful in identifying knowledge gaps	• May not capture real-time change • May not comprehensively integrate local knowledge as it relates to socio-ecological dynamics • Requires familiarity with technology
	Participatory Mapping	• The data sharing and provision also support social and professional connections and empower a community • May promote the inclusion of static aspects of place-based knowledge in a planning context	• Challenging to map place-related values (e.g., ecosystem services) • Seasonal dynamics of Indigenous and local knowledge, coastal use patterns, and the changing environment related to climate change are difficult to represent and analyze cartographically • Lack of generalizability at a large scale
	ArcGIS StoryMap (e.g., Living with the Seafloor)	• Combines story-telling and mapping, enhancing engagement of the final product • Supports deeper learning of a geography • User-friendly	• Requires learning for new users which may be challenging;

	Simulation Software (e.g., Marxan)	• Support site informed site-selection • Offers a simplified visual representation of the outcomes of planning decisions	• Results may be subject to sampling bias in data-limited situations • Heavily reliant on external expertise
	Gaming (e.g., MSP Challenge Board Game)	• Offers a fun, interactive environment to learn • Supports understanding of spatial plan • Promotes opportunity for negotiation	• Archetypes and parameter assumptions made by gamer designers may not be representative of planning situation • Role of language on existing power dynamics in negotiations is unclear
	Virtual Reality	• Offers three-dimension interaction with spaces • Supports understanding of spatial plans • Promotes participation and public feedback	• Possibility of projection distortion and inaccurate representation of plans • May exclude those unfamiliar with the technology, or cannot access it due to needed time, labour and funding

3 Methodology

3.1 Study Area

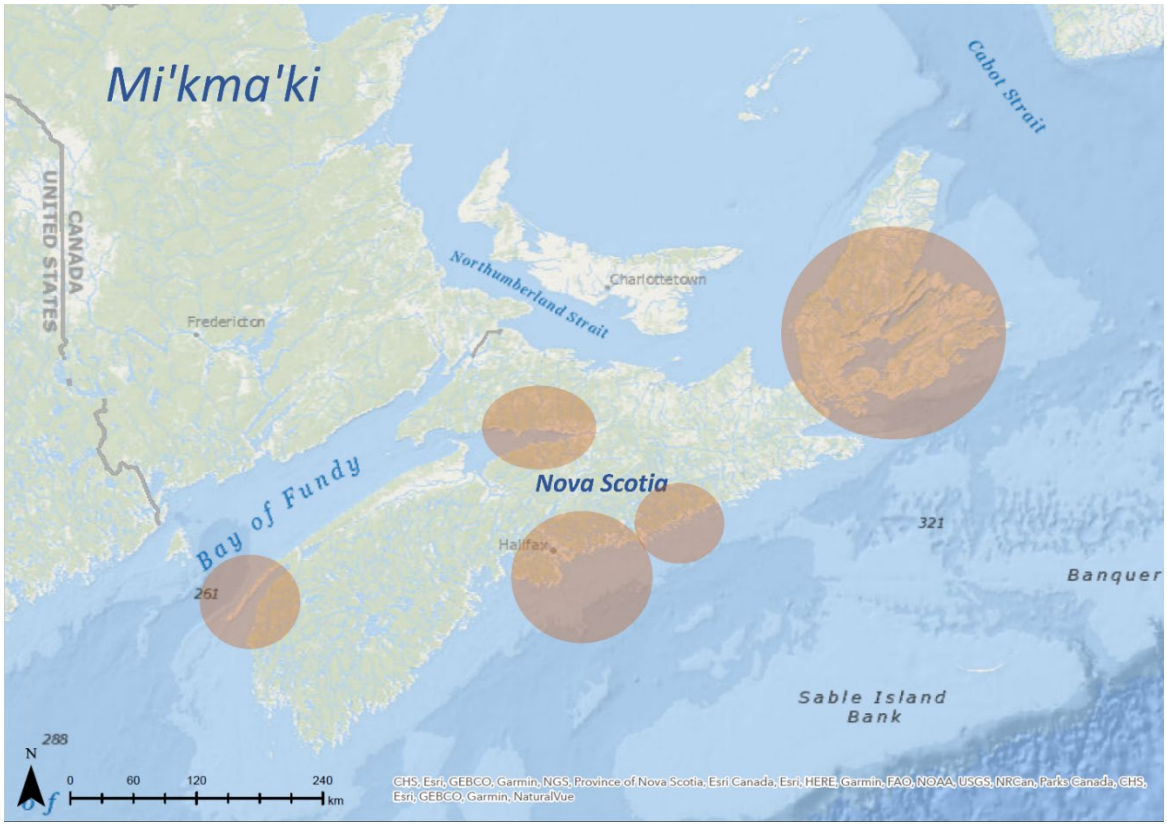


Figure 9 Map of the study area shows, in orange, the source areas of expert input in four general locations across the province.

Nova Scotia, located on the eastern coast of Canada in the ancestral and unceded territory of the Mi'kmaq People, boasts a rich tapestry of coastal communities, economies, and ecosystems – each playing a pivotal role in the region's environmental and socioeconomic dynamics. This study centers its focus on the land-water interface of Nova Scotia's coasts; area subjected to spatial pressures from confounding residential, cultural, economic uses and impacts of climate change (Fanning & Burbridge, 2010; Nova Scotia, 2014; Nova Scotia, 2023). The geographic scope of this research, as highlighted in orange in Figure 6, is specific to the place-based areas of expertise of those who

participated in this study. These areas include parts of Bras d'or Lakes Watershed, Digby County, Eastern Shore, Eskasoni First Nation, Halifax Regional Municipality, Inner Bay of Fundy, and Millbrook First Nation (Government of Canada, n.d.).

3.2 Study Design

To begin, a clear intention was made to ensure a respectful approach to a scoping review and qualitative research and analysis of knowledge. Recognizing the role of positionality, resources were gathered to guide research methodology done in a good way. Social science research methods, as described in the SAGE encyclopedia and Dalhousie University lectures (Goerlandt, 2023), Elder Albert Marshal's definition of Two-Eyed Seeing as

> "…learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing, and to using both these eyes together, for the benefit of all" (Bartlett et al., 2012).

and the Decolonial Model of Environmental Management and Conservation developed by Artelle et al. (2021) were used to inform the methodology. Three tenets of the Decolonial Model (Appendix I), found relevant for their relation to data representation and place-based knowledge, were used to support the study design (Artelle et al., 2021).

Research was undertaken with an understanding of the importance of fostering collaborative knowledge production and meaningful relationships. Due to its collaborative nature, semi-structured interviews were chosen to explore the use of DR tools in spatial planning (Lewis-Beck et al., 2004). The questions asked of experts, which can be found in

Appendix II, were open-ended and focused on understanding individual perspectives of spatial planning and place-based knowledge, the use of data representation tools in conveying knowledge systems, and opportunities for the design of these tools. Each interview was held in-person when possible or virtually over Microsoft Teams and were approximately one-hour in length but did not have a strict timeframe in order to allow each participant to share their complete thoughts in the time they were able to give. With intention to gain insights from particular groups of people (e.g., researchers, planners and users) who have experience with or knowledge of spatial planning in Nova Scotia, a purposive sampling technique was then used in order to attempt to capture diverse interactions and experiences, in terms of location and connection, in the spatial planning across the province (Lewis-Beck et al., 2004; Goerlandt, 2023). A total of 10 participants were selected for an interview. A small sample size was used as a result of time limitations and participant availability related to this exploratory research; however, the participants of the study provide both range and depth of experience in terms of their professional and geographical areas of expertise, their relationship to the coast, and engagement with the spatial planning process. Details of group categorizations are found in the Results sections.

The collection of data followed that of Dalhousie University ethics for qualitative research and the Ownership, Control, Access and Possession (OCAP®) principles for data collection and information governance (2023). The OCAP® approach to this research project is summarized in Box 2. These principles were shared in a participant guide which

was created to summarize the purpose of the research, how the data would be used and outlined the form.

at of this research. Also included in this guide were the guiding questions that were to be used in each interview (Appendix I). This guide, as suggested in the qualitative data methods sourcebook, was developed to ensure consistency in the interview process and to support the reliability, authenticity, transparency and validity of interview data (Miles et al., 2020).

In addition to interviews, a scoping review was used to assess the availability and extent of evidence of relevant research to support a boarder understanding of the knowledge representation in spatial planning (Goerlandt, 2023). Keywords or phrases, such as place-based knowledge, spatial planning, data support tools, data representation, data communication and data visualisations, were used to search for relevant documents in databases and governmental websites. The Novanet Catalogue and Google Scholar provide access to online resources such as articles, e-Journals and books published in hundreds of credible databases (Cucinelli et al., 2023). The abstracts and titles of the resulting document were then reviewed for relevance and sources to inform the study were selected. For example, Resulting governmental documents (e.g., research studies, media releases), like those sourced from the Nova Scotia's departments of Environment and Natural Resources and Renewables, showcased province-specific information related to climate change and land-use planning. Other governmental documents like those from the Department of Fisheries and Oceans Canada, provided data around tools used in spatial planning and the contextual applicability. Academic literature such as articles and

book chapters that presented research undertaken over, approximately, these last 10-years around the tools used in spatial planning, and provided insights into existing advantages and limitations for their use.

Box 2: What is OCAP®, and how was it used in this study?

What is it?

OCAP® is an acronym for Ownership, Control, Access, and Possession – principles that establish guidelines for how First Nations' data is collected, protected, and used (2023). The guidelines ensure that data sovereignty aligns with each Nation's worldview and traditions. OCAP® emphasizes that First Nations have (2023):

- Ownership: The community or group owns cultural knowledge collectively, akin to an individual's ownership of personal information.
- Control: Representatives are within their rights to have tenure over all aspects of governing research processes, resource management, and information review.
- Access: The right of First Nations communities and organizations to manage and access their collective data, through standardized protocols.
- Possession: The physical control of data is done so to allow the protection of ownership.

How was it used?

Below are the steps this research took to abide by the OCAP® principles:

- Ownership**:** Dalhousie University's Marine Affairs Program will act as the governance body for the data, which will ultimately be owned by those participants who agree to engage in this research process.
- Control: Any participant in the research can rescind their permission for their data to be used at any time, and it will be removed from the data set. Any participant can ask questions about the process, the data, and the conclusions at any time. All information will be kept confidential upon request.
- Access: The Marine Affairs Program will hold the research data in its confidential archives, which any research participant can request to view. This may include audio, video, or written recordings of their contributions.
- Possession: The Marine Affairs program will hold the research data in their confidential archives on behalf of the participants they are working with.

3.3 Data Analysis

This section describes the methodology used to analyze data that seeks to explore selected data representation tools' suitability to convey place-based knowledge. Upon conducting interviews virtually via Microsoft Teams, recordings were transcribed verbatim both manually and using the Microsoft Teams function. The qualitative analysis of each transcript was completed through a manual review, supported by NVivo 12 Pro, a computer-assisted qualitative data analysis software that offers data organization, comparison, and consolidation functions (Cucinelli et al., 2023). Analyses aimed to identify core themes, such as those determined by the use of similar terminology and related ideas that indicate desired characteristics of tools, from the perspectives of the three participant groups. The results from interviews were supplemented with findings from a scoping review. The use of this mixed-method approach made it possible to explore how well the six DR tools of interest are suited in representing place-based knowledge in the context of spatial planning in Nova Scotia. A summary of the study design and analysis procedures can be found in Figure 10.

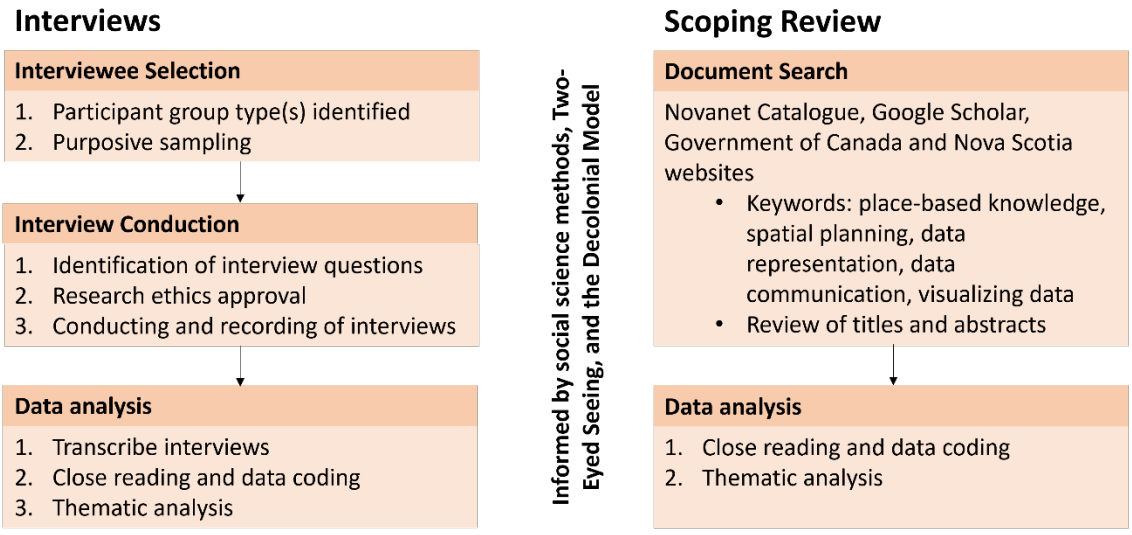


Figure 10 Overview of methods for data collection and analysis. Figure design based on Cucinelli et al. (2023).

4 Results

Ten participants selected characteristics of tools that contribute to comprehensive representation and identify their utility across stages of the spatial planning process. Findings from interviews were compared with information found in available literature, allowing for a more comprehensive understanding of the current landscape of data representation tool usage in spatial planning. It is important to acknowledge that the study's findings are based on the perspectives of the interviewed professionals and existing literature, which may not encompass all aspects of data representation tool usage in spatial planning.

Participants were categorized into one of three groups based on their relationship to the coast and how they wished to identify themselves . Each participants shared insights which are described in the following sections of this chapter. The participant group in which the participants were categorized are described as:

- **User** (coded as participant group A): those who have experience living and working in areas subjected to spatial planning and whose primary perspective is that of a resident, user, or protector of the area. Three interviewees were categorized as part of the user group.
- **Researcher** (coded as participant group B): those who seek to investigate existing relationships within spatial planning and those impacted by spatial plans. Four interviewees were identified as researchers.
- **Planner** (coded as participant group C): those employed to develop or support the development of spatial plans. Three interviewees were identified as planners.

4.1 Ways in Which to Represent Place-based Knowledge

Participants shared sentiments and insights around the ways in which place-based knowledge can be better represented in the context of spatial planning. Some share their personal views on how such data should be communicated. Themes of storytelling and the visualization of broader socio-ecological relationships that exist over time in data representation are discussed. For example, A2 shares the role of storytelling in capturing historical and contemporary context of spatial knowledge with reference to Glooscap's journey through the Bras d'Or lakes:

> "There's a little story that they talked about, but if you talk, if you know this story and if you heard it like the story goes back thousands of years, they talk about markers on the land that if you know the story, you should be able to navigate waters…without a map or anything just by the markers on the land."

A2 spoke about the importance of storytelling, not only for the maintenance and revitalization of cultural value of place, but also for navigation and identification of significant landmarks. A2 describes that such detail is challenging to capture in many data representation tools (e.g., A2 makes reference to the marine atlas), but highlights the role of technology to improve the representation of local knowledge. This desire to adapt current methods of data representation to be able to comprehensively showcase and communicate place-based knowledge is expressed by A1:

> “They've only plucked out the things that they want, but there's a lot more in there and, you know…I'm trying to show people what we see. So how do I show people what we see? Well, the easiest way is to take you with me, and you record it. The problem with it is there's only so much money to go around, for one and two. At first, I didn't understand that I needed to lead the researchers to where they needed to go to see the most. So, they went and picked something out that they wanted to do themselves, like lady crabs or just one little thing for one little year and or you know they just didn't see the Symphony that I see. I mean, for me, I was trying to show them the Symphony, and they're still picking out little pieces to make clear.”

A1 discusses the attempts they have made to share place-based knowledge in a way that they wish for it to be observed. But from their experience, there is a discrepancy between the way in which data is collected and how A1 would like it to be both collected and represented. Also highlighted is the role of finance in the ability to comprehensively represent place-based knowledge. The method of going on site and recording may be a barrier to representing knowledge, in this way.

B2 suggests ways in which place-based knowledge can be told in a more comprehensive way, with the inclusion of images or physical examples of artifacts:

> “I think artifacts also play a really significant role in showing past and presents, especially like how we as a province have been really resilient, having a huge coastline and adapting to that. And those artifacts are things that tell the story of

> the past, but also can still be translated to what is actively going on today. And then seeing how we've changed or moved in different patterns with how we and develop or manage our coastline, our coastal marine environment and the areas around it, those artifacts hold a lot of that history. And I think it's kind of an older side, older-side engagement, definitely not like a youth type of thing, but pictures and I think videos too are also like storytelling."

As indicated by C1, storytelling is not only captured through artifacts, videos or stories themselves, but also through maps:

> "Yeah, I still kind of think maps are the best possible communication tool like they're interesting, they're compelling and they tell the story….And I think, you know, they resonate with a lot of people and especially at the local level, right, when you get down into like ohh this is my area…It's has the potential to really powerfully connect people to the data, right?... So I'm a big fan of maps"

Others describe the need to inquire with the intended audience to determine the methods to use in representing knowledge. For example, B4 expands beyond the physical representation or direct use of a DR tool and discusses the setting in which place-based knowledge is collected and/or shared:

> " [We} need to figure out different ways to engage folks and perhaps in the early stages asking, "how do you want to be engaged?" I think that's a really important question rather than to assume you know Zoom, hybrid or in the boardroom type meetings. And so I think that that's the first thing and from my knowledge."

> “I think we have taken, uh a very Western approach to data collection and to engagement. And so, you know it's presentations in an office setting. Whether that be at DFO's offices or, you know, potentially like [a] boardroom. Uh, which aren't always accessible and are actually very hard to schedule and to plan.”

C2 and A3 also expresses the need for early and effective engagement as the intended audience should determine the methods used and have the opportunity to provide feedback if the tools is in fact representative. C2 states:

> “I don't know if there's anything that's tried and true…. [there] are different approaches for different audiences. And I think some of those [DR tools] are suitable for certain audiences and some are for others.”

A3 reflected on their experience working with rightsholders and stakeholders in decision-making and shares:

> "We ask people to visualize something that they may not know much about... We need creativity which is lacking... Encourage people to come together in groups that are representative and learn and provide feedback."

B2 suggests being “adamant to ask that person or group of people ‘how do you see this information being represented’” and continues to say:

> “Maybe that person wants it to be a video of them actually saying those truthful words. Or maybe someone wants it as just an icon and it just has a couple words associated to it. Maybe it's just a picture that they provide and they're just giving you the background context in the verbal sense, right?... I think really understanding how place-based knowledge, how people that are showing you the place based

knowledge. Umm. Would like it to be representative, I think allows it to be more uniform so that it's brought into the same context as it was delivered in the way that they want it to be. “

There is no one way to represent data, especially in the context of place-based knowledge. Participants suggest using a mixed or an adaptive method approach to tailor how data is represented to the intended audience or intended objective (e.g., storytelling, communication of broader ecological functionality, feedback generation, etc.) and in accordance with available budget. It is important to effectively engage with users of a DR tool, or those subject to a spatial plan, early and approach data representation with creativity.

4.2 Characteristics of a Useful DR Tool

Upon identifying the methods to represent data, participants then reviewed the selection of DR tools and characterised their functionality by offering descriptions of what makes them useful in representing place-based knowledge. The core themes identified contribute to the research question presented in section 1.3 of this paper; these themes are summarized in Table 3. It is important to note that participants did not indicate that the following characteristics belong to all DR tools of which this study focuses. Instead, participants answers suggested that not all tools have the qualities that make them useful and could benefit from a design that is increasingly informed by the tool’s users.

Table 3 Description of the characteristics identified by study participants as being useful in the representation and communication of place-based knowledge in the context of spatial planning in coastal Nova Scotia.

Characteristic	Description
Usable	• The use of the tool is not limited by available technology • The tool accessible in terms of format availability, avoidance of jargon and language(s)
Familiar	• The tool does not require the extension of one's comfortability • Does not require extensive background knowledge or previous experience to navigate
Narrative	• The tool comprehensively captures and shares stories through text, imagery or audio
Collaborative	• Facilitates the involvement of multiple users of the tool • Integrates multiple perspectives and objectives
Interactive	• The tool hosts an interface that promotes visual or physical engagement
Participatory	• Supports learning and a deeper understanding through active participation

There was variance in the characteristics each participant group deemed useful in representing place-based knowledge. For example, the features of a DR tool that users found useful were not completely reflected in the selection of features planners believed would support knowledge representation. The characteristics deemed useful, as it relates to the participant groups, are summarized in Table 4. These differences echo the sentiments shared by C2 in that there is no one-size-fits-all denomination of a useful DR tool.

Table 4 Characteristics deemed useful in the representation and communication of place-based knowledge, as identified by each participant group. The X indicates the characteristic explicitly stated or alluded to by members of each participant group.

	Characteristics Deemed Useful					
Participant Group	Usable	Familiar	Narrative	Collaborative	Interactive	Participatory
User	X		X	X	X	
Researcher	X	X			X	
Planner	X			X		X

These characteristics are associated with the understood advantages and recognized limitation of each of the six DR tools this study focuses on. Participants tended to express the features of a tool the considered useful through stories of their experiences or first impressions. This dialogue included description of the advantages and limitations of each DR tool from their perspectives. Table 5 summarizes these details and provides insights into how perspectives from this participant group compare and contrast to the advantages and limitations of these DR tools found in the scoping review (refer to Table 2). Many themes are reflected in both (e.g., advantages as they relate to their ability to engage the user and story tell, and limitations related to potential for exclusion). Where they differ is in description of in-situ experience (e.g., participatory mapping's ability to offer real-time results and limitation of precision of hand-drawing details). Such insight offers valuable design considerations from a tool-user perspective.

Table 5 Summary of the advantages and limitations of the six DR tools, as described by participants during interviews.

Source	DR Tool	Advantages	Limitations
Participant Interviews	Marine Atlas (e.g., Canada Marine Atlas)	• Serves as a "rich" data source	• The interface designed to serve planners and researchers, potentially excluding users of a space; • May exclude those unfamiliar with the technology, or cannot access due to poor and absent internet connection; • May perpetuate the idea that species and people are limited to a boundary
	Participatory Mapping	• Participants see results in real-time	• Areas indicated by hand-drawing may be limited in accuracy and/or precision; • Participatory mapping events require administrative effort (time, staff, funding) to plan;
	ArcGIS StoryMap (e.g., Living with the Seafloor)	• Allows for the sharing of narratives and storytelling; Promotes visual, and potentially auditory, understanding of space and place; • Enables the communication of multiple ways of knowing	• May exclude those unfamiliar with the technology, or cannot access due to poor and absent internet connection
	Simulation Software (e.g., Marxan)	• Supports a more direct integration of place-based knowledge into spatial planning decision-making as the tool serves as a platform with a "universal" computational language	• May exclude those unfamiliar with the technology, or cannot access it due to poor and absent internet connection; • Technology is not approachable for the wider public (designed for internal use); • Results may be reductive

	Gaming (e.g., MSP Challenge Board Game)	• Offers a fun that encourages exploration; • Promotes participation and public feedback	• Requires space and time to plan and host game play
	Virtual Reality	• Offers a fun that encourages exploration Promotes participation and public feedback	• May exclude those unfamiliar with the technology, or cannot access it due to needed time, labour and funding

4.3 Planning Stages at which DR Tools are Most Useful

Conversations with participants identified a preference for the application of DR tools in the generalized stages of the spatial planning process (refer to Figure 1). These three generalized stages (engagement, data collection and data representation), and the associated DR tool considered suitable for each stage is shown in Figure 12. Each individual participant commented on the use, or lack thereof, of the six DR tools in each stage of the planning process. These results answer the sub-question of this research presented in Section 1.3.1. and indicate that the participants do not consider all the select DR tools best suited to represent data (e.g., no participants identified simulation software as tool best suited to represent place-based knowledge in the context of spatial planning in Nova Scotia). Based on the conversations held in each interview, the decision of each participant may be determined by either their vast experience or limited experience with these tools – both of which are valid as even a first impression of the interface of a tool that is meant to be communicative provide valuable insight from a tool-user perspective.

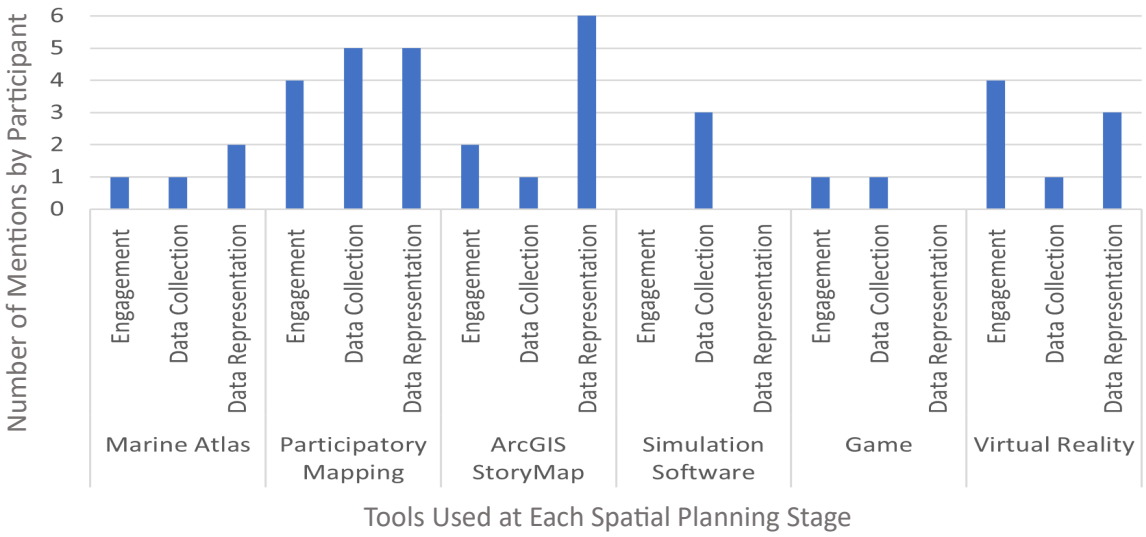


Figure 12 This graph displays the number of times each DR tool was identified to be useful in one of three generalized stages of spatial planning, as defined by participant groups.

4.4 Potential for the Use of Multiple DR Tools

Acknowledging the advantages, limitations, and suitability of each DR tool to each stage of the spatial planning process, participants described the potential to use multiple tools in conjunction with one another to improve functionality within or across stages of the spatial planning process. For example, B2 shares that:

> "gaming can be combined with participatory mapping to improve a games applicability to data collection stages of the spatial planning process"

Also described were how multiple tools may enhance tools' ability to represent place-based knowledge in planning decision-making in coastal Nova Scotia. For example, B2 states:

> "[D]ifferent tools should be utilized because you know in the future, if let's say, uh participatory mapping and videos; you know, community members can be recorded talking about these spaces that are important to them and pictures of places... If those are presented in a way, it could be really powerful, really moving,

and it could again build that trust, build relationship between government local communities to move forward in a more positive direction than again, in my opinion, where we currently are at."

In addition to the potential combined use of participatory mapping and DR tools involving video, such as ArcGIS StoryMaps, participants suggested combining the Marine Atlas and ArcGIS StoryMap to enhance the Atlas' engagement and broaden the context of the information shared thereby contributing to the improved representation of knowledge. B2 contributes to this sentiment by expressing that ArcGIS StoryMap humanizes data and provides depth of context in mapping but brings forth insights around how such a mixed method use of tools may not fit within the current approach to spatial planning in the province:

"I think it allows to inform the greater process, but I don't think it's specifically fits in with the [planning] process that we have right now… I think it might supplement the process, but I don't know if, umm or even how the government might see the tools that other researchers or universities or communities are developing and how they want those to be incorporated into the plan."

"They know where my we might be developing these things and we might be doing these things, but how do then they see what we're doing in the work behind the scenes of academia and all that stuff? How do they actually see that being brought in? Because if we're doing all this great work like you guys are as well and it and you know, we're trying to make these collaborations and partnerships and really work together i.e. Without getting a real confirmation on how they see, I would

say it would be like a standalone tool really that might supplement the tools or the process that they want."

C3 shares what they believe the impact on resulting spatial policy that is informed by use of multiple DR tools:

> "I think it's a great starting point and that's where kind of like you said like multiple methods are needed to fully engage and fully get the results that you're looking for and use those results in good policy because I think that's some things that again like that we're because we're not engaging properly, we're not getting the results that we need to make good policy."

Informed spatial decision-making, as it relates to place-based knowledge, should not only focus on the representation of this knowledge system; but should also consider the risks of representing place-based knowledge via these DR tools. With understanding of risk, there is better opportunity to mitigate the negative impacts associated with specific risks.

4.5 Risks of Representing Place-based Knowledge, as Identified by Participants

Understanding how users and researchers in coastal Nova Scotia identify risks associated with representing place-based knowledge using the DR tools of focus can help planners adapt how tools can be design and used (Greiving and Fleischhauer, 2006). There exists a challenge, as identified by participants, to collect necessary data for spatial plan development, and capture the values associated with place, in a way that is not intrusive or negatively impactful to the lives of tool-users or those subjected to spatial plans. This

is summarized by B3 who shares that there is risk of “not sharing the whole story and also, without thoughtful logic of the community, [tools] can risk oversharing” of data. Misrepresentation and oversharing of place-based knowledge with the use of DR tools like the Marine Atlas, participatory mapping, ArcGIS StoryMaps, simulations software and VR (if showing the results of mapping exercises) were referred to by most participants – representing all three participant groups. For example, in reference to misrepresentation, A3 cautions tool-users to explore with reason as DR tool:

> “ha[ve] to be always moderated, but that's the biggest risk is you don't want them to have, you know, use a tool that will reinforce information that's incorrect”.

Misrepresentation was mentioned by B1 to be as a result of limited engagement and lack of comprehensive inclusion of through representative methods.

Input from A1, who refers to the risk of threatening privacy through oversharing – which was the most mentioned risk of representing place-based knowledge – highlights the negative implications associated with having certain industry knowledge, (e.g., fishing spots), shared publicly. Participants identified that risks of oversharing lie in the results of a participatory mapping exercise or another mapping platform the are made public. Such oversharing may place harvesting pressure on a site and fishers who frequent the area for their livelihood. It is important to ensure this risk is mitigated, but mitigation should not give allowance for avoidance. As shared by C1:

> “Well, I thought about a lot as practitioner is wanting all the data and including how to best ensure that indigenous information is brought to the table. It's how do you deal with the privacy issue. And I think that is a risk in that you could just overlook

it…Say Oh well it's private information. We don't have it, so therefore we don't have to consider it and ultimately that could create a conflict. Or also the risk it like there is a risk in so not using that information because you don't have it."

It is therefore necessary to balance data collection and privacy, and to develop a privacy protection strategy that does not incentive avoidance for the use of DR tools in spatial planning.

5 Discussion

Harnessing the value of place-based knowledge systems contributes to a deeper, site-specific understanding of an area and informs decision-making as it relates to spatial planning (Martinez Calderon, 2022; Bludau et al., 2023). Without place-based knowledge, there is limited context to decision-making (as strongly referred to A1, A2, B1, B2, B3, B4, and C1). The ways in which to represent data, as identified by participants and the potential for the use of multiple DR tools in conjunction with one anther generate insight and invite attention to complexity of place-based knowledge representation. It is made evident by the results that there is not a single DR tool that can serve as the most suitable selection for knowledge representation, and that the tool may not be suited to representing data at all (refer to section 4.3, Figure 12). It is important to consider the objective for the use of the tools (i.e., at what stage will the tools be used), who will be the main tool-user and what characteristics are significant to have, given the objective and intended audience. The results of the study provide information to support the redesign of a DR tool. It is necessary to acknowledge that place-based knowledge is usually

collected and used, through the use of DR tools, in scientific or Western-centric frames of reference and methods (Aporta et al., 2020). There is possibility to adapt DR methods through the transforming and reimagining of data representation through a decolonized lens. Of course, this is just one way of adapting these tools (non-Indigenous, social-scientific methods can also inform the design of tools).

5.1 Transforming and Reimagining Data Representation through a Decolonization Lens

The complexity of individual (human and non-human) and ecosystem-level contexts, interpreted risk, and histories and livelihoods of rightsholders and stakeholders involved in decision making as it relates to spatial planning is a source of challenge and opportunity. There is opportunity for a transformation in how place-based knowledge is viewed, understood, involved and represented. Silver et al. (2022) outlines urgent and interconnected objectives to decolonize marine resource management and science – the objectives found to be relevant to this study, as they related to the application of diverse ways of knowing and reimagining of data, are referred to below:

> "(a) transform the siloed institutions, practices, and culture of Western science; (b) reimagine and rebuild pathways between information (including diverse values and perspectives) and decision-making…"

In order to a) transform siloed institutions perpetuated by conventional Western Science, effective collaboration is needed; b) reimagine pathways between information and decision-making, the principle of interrelatedness and methods of visual storywork could be adopted where deemed appropriate by knowledge keepers.

5.1.1 Transform Data Representation via Effective Collaboration

Collaboration can mean initiating a discussion/decision with a comprehensive assessment of who should be involved and including them in a way that is respectful, culturally safe, and communicative (Gunton et al., 2010). Ensuring those who need to be a part of, and potentially leading, the discussion is vital to the inclusion and empowerment of diverse ways of knowing. The diversity can enrich conversations, improve knowledge translation, introduce meaningful practices and improve the ways in which communication is conducted. Taking steps to establish effective collaboration can reduce the impact of siloed institutions (which were referred to by A2, A3, C1, C2, and C3 as a limitation of the current ways in which spatial planning is undertaken) and create meaningful relationships while also developing methods in identifying and representing knowledge meant to inform spatial decision-making (Hamelin et al., 2023). Initiation discussion is just one aspect of collaboration. Effective collaboration, when integrated in design can enrich and inform decision-making. With the involvement of multiple users and the integration of multiple perspectives in tool design, functionality can be tailored toward an intended audience and objective. This connection between collaboration (as defined in Table 3) and functionality underlines a tool's *usability* – which was the only characteristic of tool selected by all participant groups to be deemed useful in representing place-based knowledge (refer to Figure 11).

5.2.1 Reimagine Data Representation via Interrelatedness and Visual Storywork

Place-based knowledge systems are context-dependent (Therrien et al., 2022). This may present a challenge to conventional methods of categorizing and representing data

hierarchically (Aporta et al., 2020; Artelle et al., 2021). By reimagining, or reconsidering, what constitutes conventional data sources (e.g., place-based knowledge systems), and the methods used represent results (e.g., tools with place-based-informed design), it is possible to better capture and communicate site-specific context necessary to support informed spatial planning in coastal Nova Scotia. Findings from the scoping review indicate that there have been growing interests in approaches toward more wholistic data collection but limited assessment of knowledge representation in the incorporation of place-based knowledge in spatial planning (Said & Trouillet, 2020; Artelle et al., 2021; Martinez Caledron, 2022; Bludau et al., 2023). This is echoed the concerns expressed by some participants (e.g., A1, A2, B1, B2, B3, C1, C2) around how the spatial planning process and the design of tools currently supporting decision-making around spatial coastal use. To avoid inadequate representation of knowledge whereby data points do not capture “the symphony” or the collective story of the ecological and social interactions in a given area over time, as described by A1 and with sentiments shared by A2, B1, B2, B3, B3 and C2, there should be a reimagining of data representation. Reimaging representation can support the comprehensive illustration of place-based knowledge, and therefore its integration, in spatial planning; and it is through the adapting of decision-support frameworks that this can be done (Lloyd et al., 2013; Ainsworth et al., 2020). By recognizing diverse ways in which information is observed and experienced by rightsholders and stakeholders, the principle of interrelatedness is mobilized, and the methodology of visual story work can be enacted (Christian, 2019).

Through conversations with participants of the study – particularly from the perspectives of planners and users – it was found that for DR tools to be useful in representing place-based knowledge, it was important for the tools to be collaborative, participatory and narrative (Refer to Table 3 for description of these characteristics). The definitions of these characteristics relate to common theme of contextualizing data by comprehensively capturing and communicating the perspectives and stories of rightsholders and stakeholders. To adequately tell the story of place-based information the principle of interrelatedness, which accepts multiple ways of knowing and recognizes that thought can come from human and non-human beings, including the land (Watts, 2017). Todd (2020) describes this understanding as "thought (…) co-constituted by the beings within it, and humans think together with land, water, and other non-human beings within these places". In the context of spatial planning, the principle of interrelatedness can support informed decision-making by recognizing, and incorporating in DR tools, and potentially plans themselves, the specific legalities, stories, histories, or traditions that inform the relationships between Indigenous peoples, coastal communities, and local users to their environments (Johnson, 2012; Watts, 2017; Todd, 2020). Applying this principle into the design of DR tools can take the form of visual storywork (Christian, 2019). Visual storywork is a way of communicating messages, emotions, narratives and information in a way that abides by local land, story and cultural protocols (Chrisitan, 2019). Researching the methods of co-designing a tool with rightsholders and storytellers that communicates and represents place-based knowledge using visual storywork may capture a narrative in an interactive and participatory way that

also ensures cultural congruence, or the action of being aware and inclusive of cultural values, beliefs, and practices in design (Schim & Doorenbos, 2010; Christan, 2019).

Through the reimagining of information and the representation of this information, a more informed design of data representation tools, used in decision-making, can be supported. Being open to seeking and learning pathways of information can facilitate a Two-eyed Seeing approach to management, ensure informed decision-making in spatial planning.

5.2 The Future of Data Representation in Nova Scotia's Coastal Spatial Planning

The exploration of data representation in the context of Nova Scotia's coastal spatial planning highlights opportunities for future use of the selected DR tools and research. As indicated by study participants, users, researcher and planner see potential in the application of multiple DR tools used in conjunction for the purpose of richer representation of place-based knowledge in spatial planning. Perhaps, there is opportunity for the design of a new DR tool, or updating of an existing tool, that incorporates the characteristics identified by participant groups. Such developments contribute to specificity and applicability of DR tools in multiple stages of the spatial planning process (refer to the Figure 1).

Regrettably, the study's timeline prevented the inclusion of certain vital components, such as the nuanced roles of data justice and scale dynamics and methods of quantitative data visualization. In this limitation lies an exciting prospect for developing guidelines that address the complex landscape of multi-scale environmental challenges,

bridging the gap between scientific and place-based insights, and policy implementation across temporal and spatial scales in a non-extractive way that protect knowledge systems and holders (Therrien et al., 2022). This is particularly relevant within the framework of just place-based data representation. A developed framework that outlines a procedural approach to the comprehensive and respectful representation of place-based knowledge offers broader applicability to inform a site-specific approach to decision-making in coastal spatial planning. There is also the opportunity to review and analyze existing perspectives on other DR that were not included in this study. From a forward-looking management perspective, the study prompts critical questions about the implications of employing different data representation tools on planning conclusions. The variability in tool characteristics identified raises concerns about the potential influence of non-representative data on spatial decisions, particularly when using tools lacking the identified characteristics deemed crucial for representing and communicating place-based knowledge in the dynamic context of Nova Scotia's coastal spatial planning. This leads into a question that considers potential management implications of coastal environments: can different planning conclusions be made with the use of different tools? This research showcases the variability in DR tools and their ability, or lack thereof, to be usable, familiar, narrative, collaborative, interactive and participatory. It is important to consider the qualities of a tool used when striving for place-informed spatial decision-making as the contextual applicability of outcomes may be impacted by incomprehensive, or absent, place-based knowledge representation (as expressed in interviews with A1, A2, B1, B2, B3, B4, and C2).

6 Concluding Remarks

Spatial planning is an essential tool in managing the province's coastal environments (Said & Trouillet, 2020; Bell & Orozco, 2023). However, conventional approaches to spatial planning are limited without the comprehensive representation of place-based knowledge (Martinez Calderon, 2022). Empirical studies focused on investigating approaches towards collecting place-based knowledge for the purpose of integrating such knowledge systems into existing operations; though, there are few, at the time of writing this study, that assess how the resulting collection is presented and represents the place-based knowledge. As a result of this oversight into data representation, there are risks of misrepresentation, misinformation, persistence of knowledge gaps and a hinderance of reciprocal knowledge exchange. Through this exploratory research that focuses on six DR tools, the characteristics of what constitutes a useful tool in the representation of place-based knowledge, from the perspectives of users, researchers and planners of coastal Nova Scotia have been found. Of course, this would not have been possible without the contributions of each participant of this study, who shared their time and insight. In the spirit knowledge reciprocity and the reimagination of data representation, the findings of this study are summarized in an infographic and will be shared with those who contributed their knowledge as well as act as another way to view and interpret this study. This infographic can be found in Appendix III.

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Appendix I

Below are the most relevant tenets of Artelle et al.'s (2021) Decolonial Model. These tenets serve as an empirical tool to create a better understanding of decolonized approaches to management and research.

Graphical Representation	Tenet	Description	Relevant reading
	*(3) All available knowledge sources are considered (and respected)*	Diverse disciplines and knowledge systems exist, are often complementary, and can contribute productively to informing environmental interactions. This precludes assumed primacy of one knowledge source over another. For example, although positivist science is valuable for informing management, it is often presumed to be superior to all other knowledge sources, as explicitly reflected in the NAM's tenet 'Science is the proper tool to discharge policy'. Decolonized management instead respects and considers all knowledge sources in decision-making. Notably, knowledge is inextricable from context and the people who hold and create it. Decolonized approaches do not seek to 'integrate' (*i.e.* extract) knowledge from one knowledge system into a dominant one, but instead support meaningful co-governance that includes the people and governance systems tied to knowledge directly into governance processes.	(Jasanoff, 2007, Whyte, 2013, Whyte et al., 2016, Pasternak et al., 2019, Burt et al., 2020, Latulippe & Klenk, 2020, Reid et al., 2021)
	*(4) Environmental stewardship is place-based (centered on communities), with collaborations with other governments as appropriate.*	Decolonized management and stewardship processes match the scale of the social-ecological processes they support. This contrasts with agencies of settler states, which might have region-specific objectives but are often governed centrally by organizational systems not specifically adapted to places of application. In Indigenous contexts, place-based approaches and governance systems have existed for millennia. However, recognizing that fauna, flora, and ecological processes might span large spatial scales – for example, many species are migratory, rivers and the atmosphere flow through territories – highlights that large-scale collaborations or co-governance arrangements might be needed among place-based governance systems to match governance to all relevant ecological scales. Decolonized governance therefore is place-based and interconnected with other governments as appropriate.	(Ostrom, 1990, Berkes et al., 2006, Lee et al., 2019, Burt et al., 2020)

Graphical Representation	Tenet	Description	Relevant reading
	(7) *Governance recognizes, respects, and addresses the cultural importance of species and places*	The ways by which particular species or places are perceived and, hence, what is required in interactions with them might vary substantially based on worldview, an important consideration for cross-cultural collaborations and allyship. Species might have importance beyond their numerical sustainability. For example, keeping 'herds' of wildlife at levels where extinction is unlikely, or ecological or percentage-based targets (*e.g.* of maintain x% of a landscape intact) that might be compatible with conservation paradigms such as ecosystem-based management might not be deemed sufficient for species or places of particular cultural importance. Decolonized approaches recognize species and places of cultural importance and uphold specific additional requirements for them, *e.g.* for place-specific protocols, respectful conduct, and reciprocal interactions.	(Garibaldi & Turner, 2004, Atleo, 2011, Reo & Whyte, 2012, Housty et al., 2014, Cuerrier et al., 2015, Indigenous Circle of Experts, 2018, DeRoy et al., 2019)

Appendix II

Interview Guiding Questions:

1. What does spatial planning mean to you in the ocean/seafloor environment?
2. Are there risks you are concerned about in using or seeking information in the spatial planning process?
3. Do you believe there are limitation to how spatial planning is undertaken or communicated? If so, could you describe what these limitations are?
4. Are there ways to represent information (e.g., pictures, photos, narratives, artifacts, etc.) that would create a better understanding of the coastal environment and its uses in Nova Scotia?
5. What is the role of technology in communication in spatial planning?
6. Does one data representation tool stand out to you as being most useful in representing place-based knowledge in spatial planning?
    a. Participatory Mapping
    b. ArcGIS StoryMap
    c. Marine Atlas
    d. Planning Simulation Software
    e. Virtual Reality
    f. Board/Virtual Gaming
7. What characteristics make this tool useful in communicating and representing place-based knowledge?
8. Are there risks to using this tool to represent place-based knowledge?
9. How well does this tool fit within the spatial planning process in Nova Scotia?

10. Do you think there is an opportunity to use multiple data representation tools together to better represent place-based knowledge in Nova Scotian spatial planning? If so, which tools could you see working together?

Appendix III

The infographic of the following page summarizes key aspects of this research and will be shared with participants to promote knowledge-reciprocity while also acting as another means to view and understand this study.

DO YOU SEA WHAT I SEE?

Exploring the representation of place-based knowledge in spatial planning in Coastal Nova Scotia.

This study sought insights on select spatial planning tools from Planners, Researchers and Users of coastal spaces in Nova Scotia.

Selected Tools

Marine Atlas
Canada Marine Atlas

Participatory Mapping

ArcGIS StoryMap
Living with the Seafloor

Simulation Sotfware
Marxan

Board Game
MSP Challenge Game

Virtual Reality

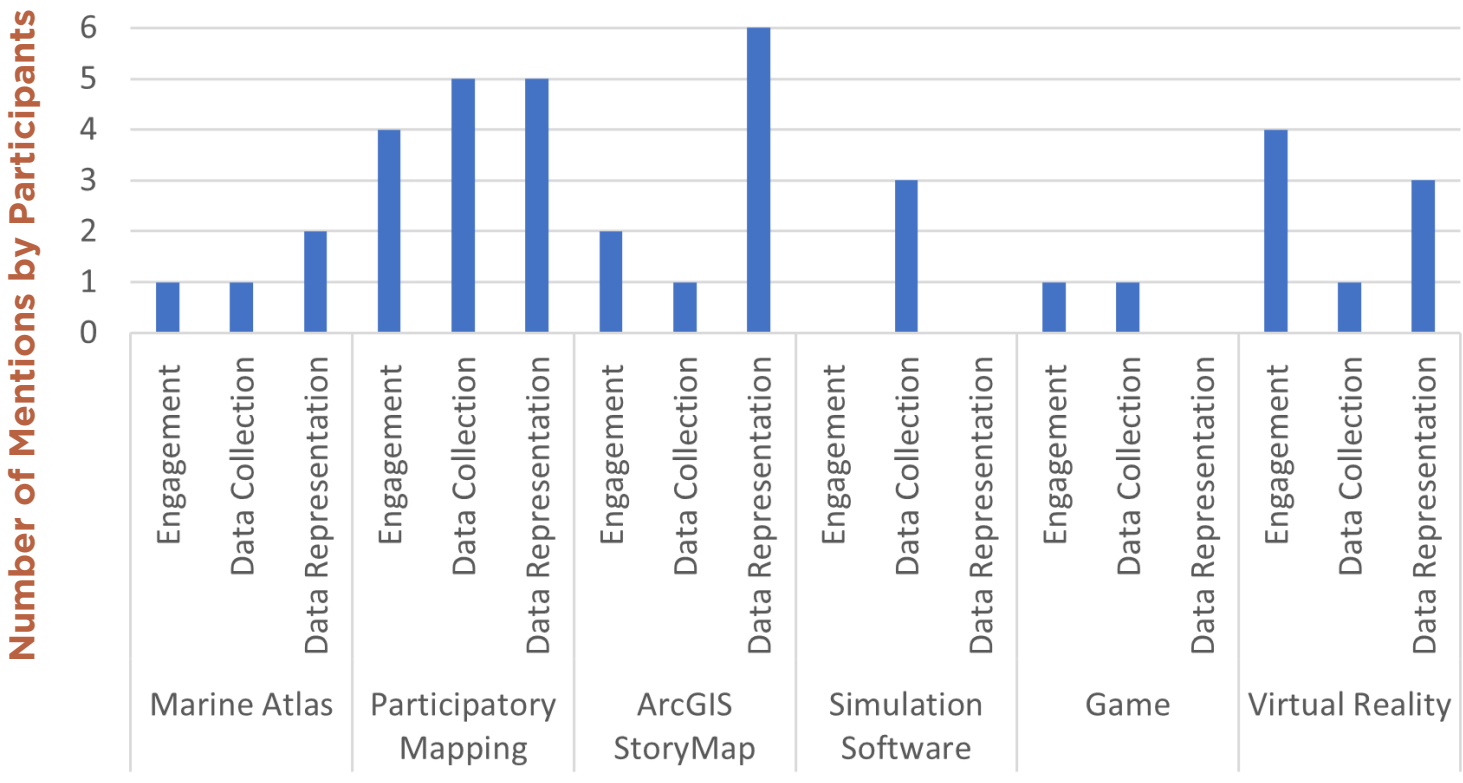
What characteristics should spatial planning tools' possess to make them useful in representing place-based knowledge?

Characteristics Identified as Useful by Participants

Usable	• The use of the tool is not limited by available technology • The tool is accessible in terms of availability of format(s) and languages, and avoids jargon
Familiar	• The tool does not require the extension of one's comfortability in use • Does not require extensive background knowledge or previous experience to navigate
Narrative	• The tool comprehensively captures and shares stories through text, imagery or audio
Collaborative	• Facilitates the involvement of multiple users of the tool and integrates multiple perspectives and objectives
Interactive	• The tool hosts an interface that promotes visual or physical engagement
Participatory	• Supports learning and a deeper understanding through active participation

What stage of the spatial planning process are these tools most useful?

*Participants categorized the spatial planning process into three generalized stages.



Tools Used at Each of the Spatial Planning Stages

Participants of the study brought attention to the advantages and limitations of the selected tools use in conventional spatial planning. Full details of the study can be found in the final report.

This work would not have been possible without the contributions of each participant, and support from Dalhousie University's Marine Affairs Program and the Ocean Frontier Institute.

If you have any questions, or would like a link to the full report, please contact Jumanah at jumanah.khan@dal.ca.