



An Iterative and Participatory Method for Mapping Inuit Knowledge of the Ice and Ocean in Nunatsiavut

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Abstract

In 2019 and 2021, we held participatory mapping workshops in Nain, Hopedale, Postville, Makkovik, and Rigolet (Nunatsiavut, Canada) to document Labrador Inuit’s knowledge of the sea ice and ocean environment. We provide an overview of the iterative and adaptable methodological approach we used to support collaborative and transcultural marine research, emphasizing participants’ experiences during the process. The participatory mapping method created a space that encouraged participants to recall journeys across different times and places. Sharing these journeys provided essential contextual details connecting social and cultural values to the marine environment, while also conveying information about ice and ocean conditions. This approach resulted in collecting spatial and qualitative narrative data related to the marine environment that reflected local climate patterns and snapshots of unusual events or conditions observed at specific times and locations. We highlight that maps mainly facilitate knowledge-sharing rather than generating knowledge itself. This is evident in how Inuit participants interacted with the maps as objects that evoked memories and prompted movement across land-, sea-, and ice-scapes.

Keywords Indigenous Knowledge · Participatory mapping · Knowledge mobilization · Transcultural research · Participatory research · Ocean science · Nunatsiavut · Canada

Introduction

Western scientific research initiatives still reflect colonial legacies, which openly and subtly influence motivations, methods, and outcomes. When research involving Indigenous communities is conducted through Western academic or other organizations, many obstacles can hinder fair sharing of power and influence during the process. Navigating cultural and disciplinary differences requires awareness of both the visible and hidden effects of colonial legacies, such as unequal power relationships, on research techniques. Participatory approaches have emerged as strategies to empower communities, include diverse perspectives, and address long-standing

power imbalances that have shaped relationships with Indigenous peoples. In Inuit Nunangat (the Inuit homeland in Canada) these approaches often follow guidelines outlined in the National Inuit Strategy on Research (Inuit Tapiriit Kanatami, 2018), which describes how researchers can collaborate with Inuit throughout all research stages to shift from practices of exclusion or exploitation toward those supporting Inuit self-determination. Such methods are increasingly used in Nunatsiavut, a self-governing Inuit land claim region in northern Labrador, where research is progressively involving Labrador Inuit and organizations like the Nunatsiavut Government (NG), Inuit Community Governments (ICG), and co-management boards as research partners and leaders.

Participatory mapping enables groups or individuals to visually share their knowledge, values, experiences, and connections to the land. In Canada, Indigenous peoples have been mapping their land use and resources using what Terry Tobias calls “the geography of oral tradition,” a term he developed through his work with Indigenous communities to improve use-and-occupancy mapping methods and best practices (Tobias, 2000, p. xi).

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Although Western cartography contributed to colonization by helping erase Indigenous homelands, a process called “counter-mapping” has emerged to assert alternative spatial perspectives that oppose those of the state.

In Canada, Indigenous land use and occupancy mapping has made significant progress. For example, the Inuit Land Use and Occupancy Project was conducted in the Canadian Arctic from 1974 to 1977 (Freeman, 1976a, b, c), leading to the creation of Nunavut and the resolution of the Inuvialuit land claim—marking an important milestone in empowering Indigenous peoples through cartography (Aporta, 2016b). Indigenous mapping efforts have also included place name projects aimed at changing perceptions of Indigenous territories. Indigenous mapping played a key role in negotiating and settling the Labrador Inuit Land Claims Agreement (LILCA) and establishing Nunatsiavut in 2005 (Brice-Bennet & Labrador Inuit Association, 1977). Using spatial mapping to represent Labrador Inuit oral histories supported Nunatsiavut by facilitating cross-cultural negotiations and reinforcing Labrador Inuit self-determination and self-governance.

Originating as a highly social and political practice, participatory mapping has increasingly been integrated into Western scientific settings as a widely used method for environmental research that incorporates Indigenous and local knowledge. Although it is used in various social science studies, participatory mapping is now more often formally and informally included in interdisciplinary and natural science research. This includes its application in marine studies focused on mapping local and Indigenous knowledge of benthic habitats, sea ice conditions, and ocean currents (Davies et al., 2020; Laidler et al., 2010; Puniwai et al., 2016; Teixeira et al., 2013). The primary goal of this approach is to connect social and cultural values to marine spaces to support conservation and management efforts (Blake et al., 2017; Davies et al., 2020; Dawson et al., 2020; Gadamus et al., 2015).

In Nunatsiavut, the marine environment has been inhabited and used by Labrador Inuit for thousands of years, making it a crucial part of their homeland. The region is characterized by landfast sea ice—ice anchored to the coast that does not drift with currents or winds—during winter and early spring, with open water dominating the rest of the year. Labrador Inuit knowledge of the environment stems from their extensive movements across land, water, and ice for hunting, gathering, visiting other communities, and reconnecting with ancestral homelands. This knowledge is continually evolving, updated,

and revised through observations, experiences, collective dialogue, and the integration of other knowledge sources (Davidson-Hunt & Berkes, 2003; Ford et al., 2006; Ingold & Kurtilla, 2000). Inuit knowledge is embedded in stories about traveling on the land, including routes, place names, and journeys taken over thousands of years (Aporta, 2005, 2009, 2016b). It reflects an ontological view of territory where the environment is revealed and given meaning through inhabitation and interaction (Ingold, 2011). This approach contrasts with most Western perspectives that tend to fragment humans and environmental systems (Sundberg, 2014), often overlooking or selectively engaging with the holistic Inuit worldview (Pfeifer, 2018). Recognizing this is essential for effectively bridging the gap between Inuit knowledge and scientific understanding in environmental research. The space of this transcultural approach involves ontological tension.

Our goal was to explore how participatory mapping can support transcultural and collaborative marine research involving both Western science and Indigenous Knowledge. This area is important because of the different yet complementary Inuit and Western scientific approaches to understanding the ice and ocean, which offer unique perspectives for collaborative and participatory research practices. Western institutions have traditionally been recognized for generating authoritative information and knowledge about the marine environment. However, considering the redistribution of power resulting from counter-mapping efforts, emphasizing Inuit Knowledge of the marine environment can help promote decolonizing marine research with and for Inuit communities. We draw on a series of participatory mapping workshops conducted in Nain, Hopedale, Postville, Makkovik, and Rigolet in 2019 and 2021 that documented Labrador Inuit Knowledge of the ocean and ice environment in Nunatsiavut, Canada. Participatory mapping of the ice and ocean in Nunatsiavut serves as a case study to explore how collaborative interdisciplinary marine research can be supported through mapping and how research can be shaped by creating flexible, iterative spaces for participation. Next, we present an adaptable, iterative methodological approach and detail the stages of developing and conducting collaborative research. The findings are based on participants’ descriptions of their interactions and engagement with the mapping process, including their motivations and experiences that both emerged from and guided the ongoing development of this research. The discussion highlights the vital role maps play in sharing knowledge and the authority they can hold when created through collaborative efforts.

Materials and Methods

Positionality of the Research(ers)

The authors come from diverse backgrounds, each offering a unique perspective that influences their individual and collective contributions to this research. Breanna Bishop is of European settler descent with a background in interdisciplinary studies focused on climate change, Indigenous rights, and marine management. Mary Denniston is an Inuk, born and raised in Nunatsiavut, with over 20 years of experience bridging Western science and Inuit Knowledge. Eric C.J. Oliver is an Inuk from Nunatsiavut and an associate professor in the Department of Oceanography at Dalhousie University. His research focuses on connecting scientific and Inuit Knowledge related to the ocean, sea ice, and climate, and finding ways to increase the visibility, respect, and influence of Inuit Knowledge within science and policy fields. Claudio Aporta, originally from Argentina, moved to Canada in 1997 to pursue graduate studies in cultural anthropology. He conducted most of his ethnographic research in Igloodik while completing his PhD at the University of Alberta. Over the past 25 years, he has worked with Inuit communities and organizations across Canada, primarily on mapping and documenting local knowledge.

Initiated in 2018 by Oliver, the Community-based Observing of Nunatsiavut Coastal Ocean Circulation (CONOC) project aimed to enhance observations of ocean circulation in coastal Nunatsiavut by using Western scientific ocean observing methods and recording Inuit Knowledge of the ocean and sea ice. This project was driven by the desire to understand ocean circulation and sea ice in coastal Nunatsiavut and how they might be changing, as well as to predict how Inuit winter travel routes and harvesting could be affected in the future. The project was conducted in partnership with the NG Environment Division and developed with input from participants and Inuit Community Governments. An important aspect of the research's positioning is that Denniston has led efforts to incorporate local terminology. These terms are used throughout this paper and will be defined upon first use. An overview of the terminology and definitions is provided in Table 1.

Research Design and Methods

Various engagement milestones related to collaborative planning, community involvement, sharing results, and knowledge mobilization influenced the research's nature and direction (Fig. 1). Spending time in each community before, during, and after the research was essential, with

Table 1 Inuktitut terminology and associated meanings

Inuktitut/local term*	Meaning
<i>rattle</i>	Area of open water and strong tide within the landfast ice
<i>sinâ</i>	Edge of the landfast sea ice
<i>Kamutik</i>	Sled
<i>Kajak</i>	Kayak
<i>slob</i>	Heavy, slushy, densely packed mass of ice fragments, snow, and freezing water that drifts with the winds and tides
<i>ingigganik</i>	A <i>rattle</i> or open area of water in the ice
<i>nuvulialuk</i>	To make sharp points/peaks
<i>sea-on</i>	Wind-generated sea swells
<i>inganialuk</i>	A place with a strong tide that is always open and never freezes over
<i>inganikoluk</i>	A small place with a strong tide that never freezes over

* Spelling and terminology may vary between communities

over 8 weeks spent in communities during research trips in 2019, 2021, and 2023 (between 5–11 days per community per trip). This iterative and flexible engagement approach allowed us to adjust our research plans during the COVID-19 travel restrictions and pursue a Knowledge Mobilization project, sharing research results through a book based on participant feedback. This effort also helped us outline future work building on this research. Each engagement milestone included in Fig. 1 contributed to various adaptations throughout the project's duration.

We employed a participatory and collaborative approach, utilizing participatory mapping methods that have been applied in Arctic and marine-focused research (Aporta, 2009, 2016a; Puniwai et al., 2016; Tobias, 2000, 2009). The research was designed and developed through early and ongoing communication with the Nunatsiavut Government Research Advisory Committee (NGRAC) within the NG Environment Division. NGRAC participated in decisions regarding the project scope, methods, community selection, research timing and duration, as well as setting compensation rates for research participants, in accordance with NG principles for conducting research in Nunatsiavut. The approach was also guided by the literature on ethical, decolonized research with and for Indigenous communities (Castleden et al., 2012; Kovach, 2021; McGrath, 2018; Smith, 1999; Wilson, 2008). Historically, research relationships between Inuit and southern research institutions have been shaped by colonial practices (Smith, 1999). McGrath's (2018) discussion of research frameworks and methodologies examines how these concepts do not always translate smoothly into Inuktitut contexts. However, focusing on the intent behind these concepts concerning Inuktitut, McGrath proposes a theoretical framework that embodies knowledge renewal, noting that

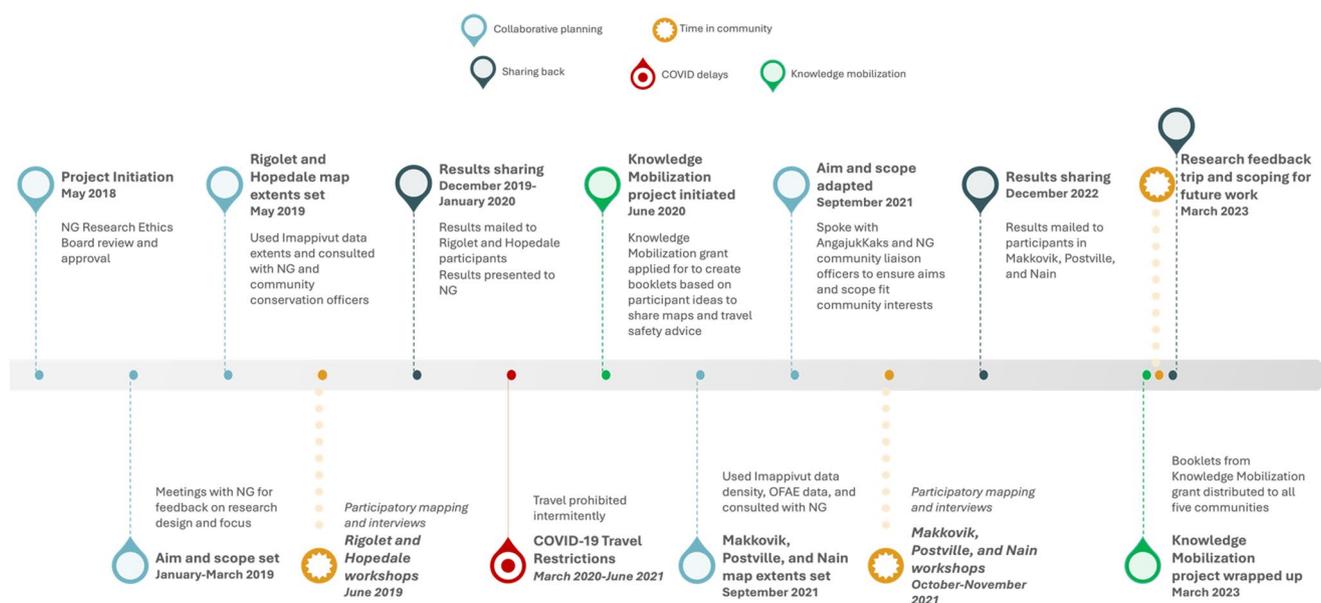


Fig. 1 CONOC engagement milestones involving iterations of collaborative planning, time in community, sharing back results, and knowledge mobilization efforts

“[[framework becomes ikajuutiksaq (something supporting – no metaphor implied or required as it is in English). Knowledge – is conveyed as qaujimajjusiq (something to know by, way of knowing, epistemology), and renewal is more accurately conveyed in the spirit of the question as kajsuttiak – kannirutiksaq (something used to carry further forward or onward, or used to support further continuation)” (McGrath, 2018, p. 207).

This guided our theoretical approach, emphasizing relational accountability as our core value (Wilson, 2008), which methodologically and analytically led us to highlight Inuit ways of knowing. We focused on how Inuit connect with marine environments in Nunatsiavut and how trans-cultural research can support that. This provided us with a framework for a research approach that is not objective and ‘value-free’—assumptions that typically guide traditional marine and geophysical sciences (Weinberg, 1970)—but instead underscores relational accountability and Inuit Knowledge renewal.

Early and consistent engagement with the NG, ICGs, and community members was essential to ensure the research was tailored to meet community interests. In addition to formal discussions about research needs and interests, the project’s iterative development was shaped by many informal conversations that took place within communities, both during and after ‘formal’ research activities. These subtle communications helped us build mutual trust and understanding, clarifying what accountability should look like in

this specific research setting. The various stages of engagement led to the research approach outlined in Fig. 2, which was primarily informed and shaped by the engagement milestones shown in Fig. 1. The different phases of Fig. 2 are explained in detail in Sect. 2.3—2.7.

Pre-planning

Oliver launched the CONOC project in 2018 after submitting a successful funding proposal to the Indigenous Community-Based Climate Monitoring Program (Crown-Indigenous Relations and Northern Affairs Canada). The project was done in partnership with Aporta, among others, and received support from the NG. During proposal development in late 2017 and early 2018, ideas were presented to the NG Environment Division and discussed to refine the project, better aligning it with NG priorities, including connections with Imappivut (the Nunatsiavut marine planning initiative aimed at fully implementing Chap. 6 of the LILCA). Oliver submitted and obtained NGRAC approval for the project in May 2018. The project had two main goals: first, to document Labrador Inuit Knowledge of the coastal ocean through participatory mapping approaches developed to focus on travel routes (Aporta, 2005, 2009), but expanded to include recording environmental conditions such as ocean currents and ice conditions; second, to improve scientific observations of coastal ocean circulation through community-based deployment of surface drifters. Bishop joined as a graduate student, submitting and receiving Dalhousie University ethics approval in March 2019 to

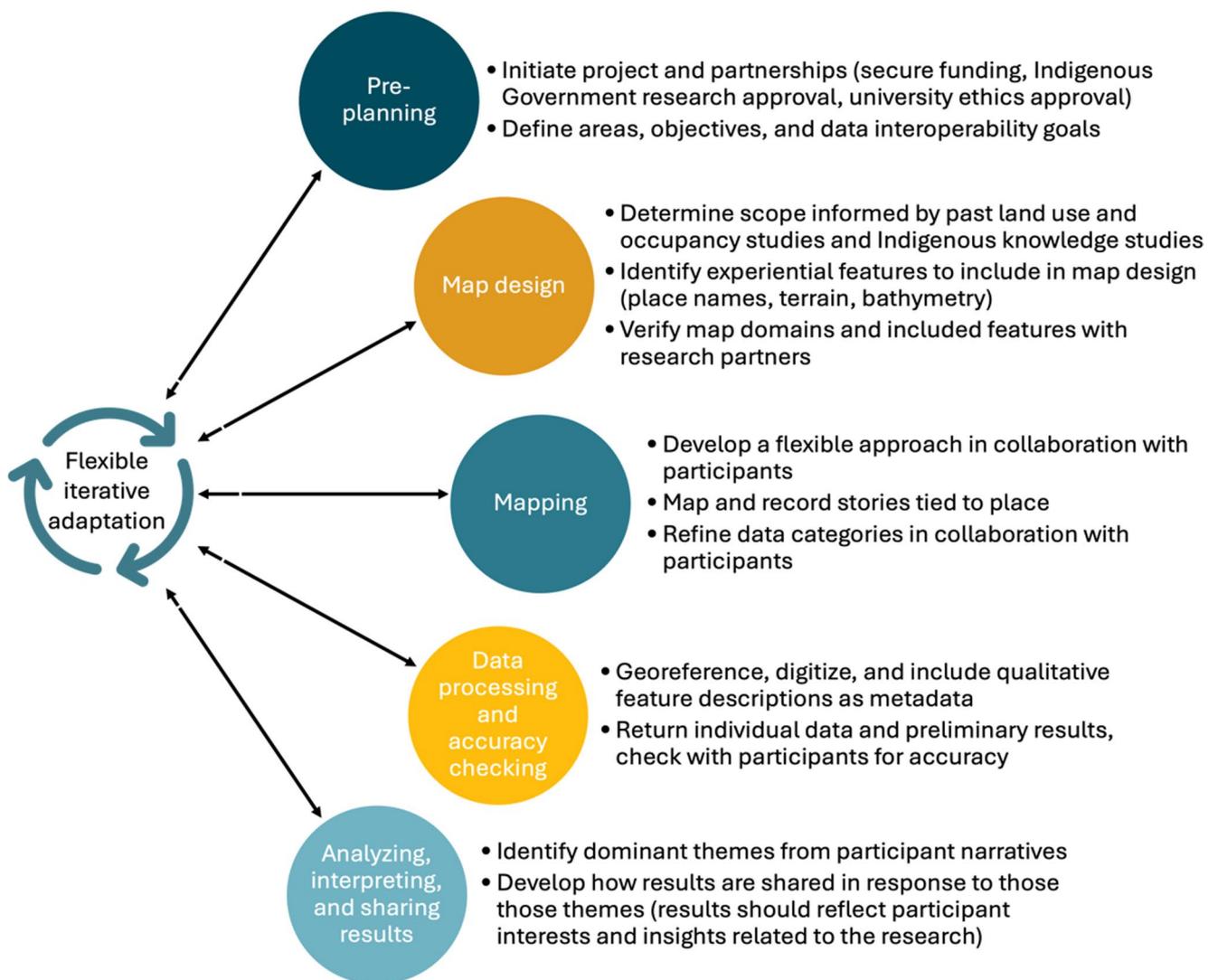


Fig. 2 Research approach for CONOC participatory mapping. The research cycle followed stages from top to bottom: pre-planning, map design, mapping, data processing and accuracy checking, as well as

analyzing, interpreting, and sharing results. Each stage was revisited as the project flexibly evolved and was iteratively adapted from community to community and year to year

conduct participatory mapping and interviews to support the first goal.

When planning the participatory mapping and interviews, we held several meetings with the NG Environment Division, including co-author Denniston, to incorporate their feedback into our approach and align the research with NG initiatives and community interests. It was suggested that our data be compatible with existing spatial data collected through Imappivut (collected at a 1:50,000 scale via direct-to-digital participatory mapping (DeRoy & The Firelight Group, 2016), so it could integrate into the Imappivut database and support NG environmental planning. This guided our map design to adhere to a 1:50,000 scale or finer. Although we used paper floor maps, the digitized data could be compatible with the Imappivut database.

Map Design

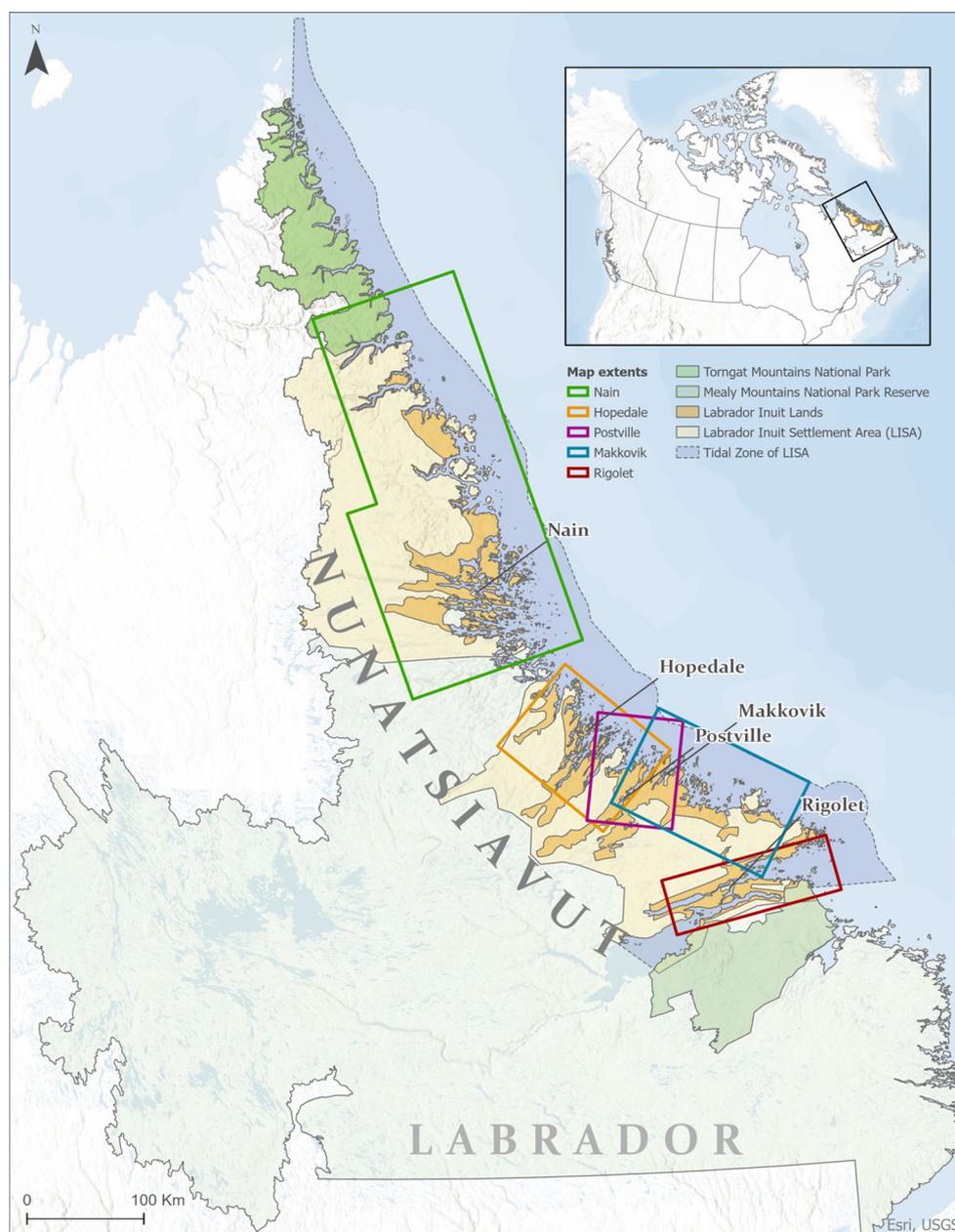
Customized floor maps were developed for each community. The boundaries of each community map were established using existing data recorded through participatory mapping efforts in Nunatsiavut. We relied on the distribution of place names and the seasonal variation of the *sinâ* (edge of the landfast sea ice) documented before the 1970s, as shown in *Out Footprints are Everywhere: Labrador Inuit Land Use and Occupancy in Labrador* (OFAE) (Brice-Bennet & Labrador Inuit Association, 1977). Place names offer deep insight into the oral history linked to Inuit wayfinding, providing both spatial references and spatio-temporal experiences of land, water, and ice (Aporta, 2016a). The *sinâ* locations included in OFAE

represent the typical outward reach of hunting on the sea ice during winter and spring (Brice-Bennet & Labrador Inuit Association, 1977). The maximum extent and density of spatial data documented during the Imappivut Inuit Knowledge study from 2017 onward were also incorporated. Together, these datasets cover Inuit Knowledge studies conducted over more than 50 years and include longer-term knowledge, helping us define our map boundaries to improve spatio-temporal coverage and community relevance (Fig. 3).

The resulting maps were created using white terrain and a greyscale hill-shaded elevation model to depict topography roughly. Bathymetry was included in two shades of

blue to distinguish the intertidal zone, and local place names for land and water features were sourced from a federal toponym database provided by Natural Resources Canada. The simplified map was designed to represent environmental features that Labrador Inuit interact with in the landscape, without including as many details as shown on typical topographic maps of the region. The draft basemaps were shared with the NG Environment Division and community conservation officers to gather feedback on the scale and features before printing. Printed at a scale of 1:50,000 or better, the following map sizes were delivered to each community: Nain – 12' x 32', Hopedale – 12' x 18', Postville – 12' x 12', Makkovik – 12' x 15', and Rigolet – 9' x 21'.

Fig. 3 CONOC participatory mapping domains informed by Our Footprints are Everywhere: Labrador Inuit Use and Occupancy in Labrador (Brice-Bennet & Labrador Inuit Association, 1977) and an Imappivut kernel density analysis shared by the Nunatsiavut Government. These datasets are subject to data sharing restrictions and are not included in this map



Participatory Mapping

Participatory mapping occurred in Rigolet and Hopedale in June 2019, and in Nain, Makkovik, and Postville in October and November 2021. Although COVID-19 prevented mapping with all communities within a shorter timeframe, it also allowed for deeper reflection, helping us learn and adapt the mapping process from community to community and over time. Participants were identified and recruited with assistance from the NGRAC, Community Climate Change Liaison Officers, and members of the ICGs. Signs were posted in English and Inuktitut on community bulletin boards and social media pages, and information was shared on the local radio station, *OKálaKatiget* Society. During mapping, some participants also helped identify other community members they believed should be included. Recruitment resulted in 36 participants of various genders, with the following numbers from each community: Nain ($n=9$), Hopedale ($n=6$), Makkovik ($n=6$), Postville ($n=8$), and Rigolet ($n=7$). Participants spend and continue to spend significant time on the land, ice, and ocean. Many were born outside their current communities or have family ties and cabins on the land, often traveling to hunt, harvest, work, visit other communities, and connect with their homelands.

The mapping sessions took place over three to four days in each community in an open drop-in format. In 2019, these sessions were held during mornings and afternoons; however, participant feedback indicated a need for evening sessions to accommodate individuals whose schedules prevented participation during work hours. As a result, in 2021, the sessions were scheduled during mornings, afternoons, and evenings, allowing participants and observers to drop in at their convenience. All participants spoke English as either their first or second language and were comfortable participating in discussions using only English. Some participants did speak Inuktitut and shared terminology relevant to the research. The sessions began with an overview of the project, followed by an opportunity for questions, ensuring that participants were informed before giving their consent. Participants could choose whether to have their names included in research outputs or to remain confidential. Maps (spatial data) were credited to collective community knowledge, while any direct quotes were attributed to individuals. Those who wished for confidentiality were assigned a code, and their references were linked to their community in the text. Individuals are formally referenced in the document whenever their knowledge is presented.

Group and individual mapping took place, with groups of up to three people mapping together simultaneously. Group mapping encouraged consensus-based discussion and storytelling about the features being mapped, while individual mapping allowed participants to focus on details and

stories related to specific areas that they and their families have used and inhabited for many generations. To promote knowledge sharing within the community, the mapping sessions were open to the public. Community observers often stopped by, and although they did not directly contribute data to the project, discussions among observers and participants often sparked thoughts or memories that led participants to map features or areas. Each participant provided a wealth of detailed knowledge during the mapping and interviews, reflecting both their personal experiences and collective community knowledge of the regions.

Participants were asked to consider traveling by land, water, and ice, and to think about the features they would encounter at different times of the year. They used colored pens to map *Kamutik* (sled) routes, old dog team routes, boat routes, and *Kajak* (kayak) routes, along with the location of the *sinâ*, *rattles* (areas of open water and strong tide within the landfast ice), unsafe ice areas (similar to *rattles* but that can sometimes freeze over), areas of strong tide or current (with speeds noted as weak, medium, strong, or very strong), and the direction of drifting ice. Some marked the inward extent of unsafe ice (for example, what might be present when the *sinâ* was not clearly defined), as well as the direction of drifting *slob ice* (heavy, slushy, densely packed ice fragments, snow, and freezing water that drift with the winds and tides). Participants reflected on the seasonal changes of these features and the observations they have made over time. Some mapped all the listed features, while others focused solely on one travel route and shared stories along it. Notably, some emphasized pinpointing exact feature locations on the map, while others noted that less precise mapping was acceptable if the relative positions among features were more important. This approach is often necessary in dynamic environments where a static line cannot effectively show the extent of an area characterized by seasonal ice influenced by wind and tides. Consequently, the relative position of a feature to landmarks or other permanent landscape features can be more useful than exact lines on a map.

Codes were used to organize and link participant descriptions to mapped features. The feature category was marked with letters, and a unique number was added to distinguish individual features (e.g., the first winter route mapped would be WR-01; Fig. 4). These were partially determined in advance based on key features of interest (sea ice, currents, travel routes). However, during mapping, more precise codes were identified collaboratively with participants to ensure that the features were represented accurately and clearly in the final (digitized) results (e.g., ice edge, open water, inward extent of unsafe ice, area of unsafe ice, late freeze/early thaw). Feature codes were assigned as people mapped and shared stories, allowing us to connect stories to

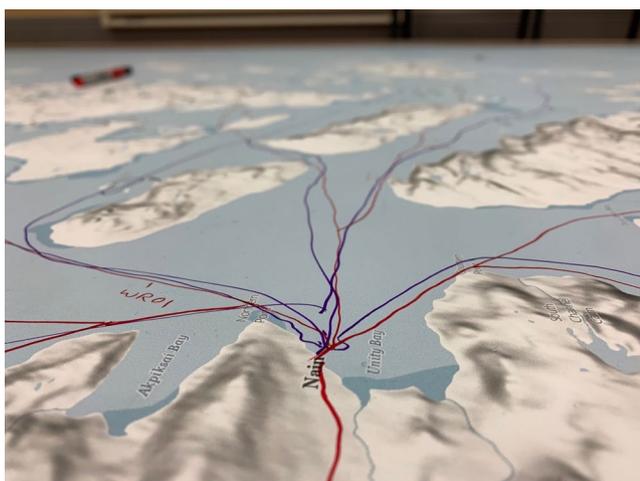


Fig. 4 The Nain floor map shows routes drawn leaving the community, and the assigned codes (WR-01). Note the basemap features, including place names, greyscale hill shading, and coarse-scale bathymetry. The oblique angle of the photograph conveys the perspective of participants as they sat and drew on the map

specific areas of the map being discussed. Some participants ($n=27$) chose to conduct follow-up interviews to reflect further on the mapping, provide details on weather and sea ice changes that were hard to depict, and share any additional information they found important. For other participants, the mapping process itself became an interview because of its semi-guided nature. The final interview question asked all participants how they would like to see the research results shared, and many recommended a book to help make the findings more accessible to their communities.

Data Processing and Accuracy Checking

The completed maps were scanned, georeferenced using 20–30 control points, and digitized by the first author with ArcGIS Pro, verifying features against scanned originals for accuracy. Each feature was digitized, and a unique code was assigned during mapping. Audio recordings of interviews and mapping sessions were transcribed, and along with handwritten notes, all were added to the feature attributes (linked by assigned codes) as the maps were digitized. Details on how the metadata were classified and organized can be found in a publication based on mapping conducted in Rigolet and Hopedale (Bishop et al., 2021). Notably, while the classification system was partially pre-established (travel routes, sea ice features, currents, and tides), these categories were flexible and adapted iteratively based on the mapping process and participants' descriptions while engaging with the map. Therefore, the feature codes that linked stories and descriptions to the map proved very useful, as some features were reclassified based on the descriptions

provided. Printed, digitized maps and transcribed interviews were mailed back to participants, who were followed up with by phone to ensure accuracy and to ask if they had any feedback or requested changes.

Analysing, Interpreting, and Sharing the Results

Travel safety was not explicitly discussed during the mapping and interviews; however, it consistently appeared in conversations with all participants, highlighting it as a key motivation for involvement and a major theme for analysis. Many participants proposed creating a book to share research results with their communities and to help spread knowledge to younger generations. In response, we applied for a Marine Environmental Observation, Prediction, and Response Network (MEOPAR) Knowledge Mobilization Grant to support the development of travel books that would include safety advice shared during the mapping. Community-specific books were developed, featuring maps of each area at various scales and excerpts of safety advice from the mapping and interviews (Bishop & Oliver, 2022a, b, c, d, e). NVivo was used to analyze the mapping and interview transcripts, with all comments related to travel safety or descriptions of potentially dangerous or unique areas coded. These codes helped select content for the travel books, which complemented the maps. The books were printed on water-resistant paper and in smaller sizes, making them easy to carry during travel. All texts were provided in English and Inuktitut side by side to support NG language revitalization efforts. We printed 150 copies of each community's travel book, which were freely distributed to community members through a drop-in open house held over 2–4 days in each community in March 2023. The aim was to return the research to communities in a meaningful and engaging way. It was agreed, in collaboration with the NG, that the books would be shared only within Nunatsiavut for the benefit of Nunatsiavut beneficiaries.

Transcripts from interviews and mapping sessions were further analyzed to identify moments that highlighted participant interactions with the maps and the mapping process. First, transcripts and researcher notes were broadly coded to identify 1) participant comments about the map, 2) participant reflections on the mapping process, and 3) stories and descriptions prompted by the map. These interactions were examined to find themes related to participant engagement with the maps and the overall mapping process. Three main themes emerged: 1) emphasizing travel safety and access to land, 2) depicting journeys through space and time, and 3) mapping features of the marine environment. These themes relate to participants' motivations for participating in the project, how they experienced the mapping process, and the knowledge being documented.

Limitations

Research for CONOC was conducted from 2019 to 2023 (Fig. 1). This period was partly due to adjustments made in response to travel restrictions caused by the COVID-19 pandemic. These restrictions led to delays and fewer trips than ideal for engaging with communities and establishing strong collaborative partnerships (Castleden et al., 2012). As a result, in-person interactions between researchers, the NGRAC, ICGs, and community members were limited to the weeks when mapping sessions occurred and during follow-up trips for sharing results. All other discussions, including planning and initial verification, took place via video calls or phone calls. While still effective, the most meaningful and impactful interactions occurred face-to-face, and the project might have developed differently with more in-person time. We planned our travel to coincide with sea ice break-up and/or unstable weather to maximize engagement with community members without interfering with their land-based activities. This approach was partly successful; however, sea ice break-up occurred earlier than usual in spring 2019, and people still traveled by boat during the October/November 2021 trips. Consequently, we were unable to connect with all the potential participants identified. We recognize that the knowledge shared with us during mapping and interviews represents only a subset of each community's knowledge, and not the full scope of community expertise on the ice and ocean.

Results

We provide an overview of the mapped knowledge, including examples of the features included, and describe different experiences of transcultural participatory mapping based on interviews and mapping sessions. We highlight three main themes: 1) emphasizing travel safety and land access, 2) portraying journeys through space and time, and 3) mapping characteristics of the marine environment. These themes are derived from participants' descriptions of their engagement with and experience of the mapping process and are further clarified by our reflections as researchers involved. While examining the results, it becomes evident that these themes are closely interconnected from the participants' viewpoint.

Mapped Knowledge and Features

Participants typically started by mapping travel routes across land and sea ice, including *Kamutik* (covering modern snowmobile routes and historic dog team routes), as well as boat routes (both modern and traditional, including boat and *Kajak* routes). These routes served as a foundation

for participants to discuss and identify other features they might encounter during a journey. Figure 5 shows an overview of the mapped areas and features. While many communities mapped similar features, some features were more common in specific communities. This does not mean that the same types of features are absent throughout Nunatsiavut; instead, participants focused more on what they considered most relevant in their communities. For example, in Makkovik, the location of the *sinâ* and its shifts over time were mapped in greater detail than in other communities. In Nain, the discussion included the inward extent of unsafe ice that can occur when the *sinâ* is not visible. Near Nain and Hopedale, participants mapped numerous *rattles* and areas of unsafe ice that recur regularly. In Postville and Rigolet, areas with strong tides or currents—ranging from weak to very strong—were common, along with associated ice conditions such as *rattles* or unsafe ice zones. Hopedale and Makkovik both noted the direction of drifting sea ice beyond the *sinâ*, and in Makkovik, this discussion also led to mapping the direction of drifting *slob ice*.

Emphasizing Safe Travel and Access To the Land

Participants engaged in the mapping process driven by a desire to share their knowledge of the marine environment. Their goal was to support the research project's aim of understanding the ice and ocean, how they are changing, and how the region might be impacted in the future. However, participants also expressed a strong motivation to have their knowledge documented for sharing within their communities and the wider region. There was a focus on the importance of recording Inuit Knowledge as a way of preserving cultural heritage, especially regarding routes that are less traveled or no longer used, along with stories associated with those routes. Sharing knowledge about the ice and ocean was also linked to concerns about travel safety and land access, with many participants noting that young people are increasingly not learning on the land or from their Elders in the same way as in the past.

Emerging from the open-ended nature of the mapping process, many participants, including Levi Nochasak from Nain, noted that “we need more kids to learn the land and knowledge. [...] The stories need to be more told. In the town, in the community. Storytelling is important for our generation” (Nochasak, 2021a). This interest in sharing knowledge with others in their community is amplified under changing environmental conditions, where routes that used to be traveled are no longer used. When describing three trails to choose from, Nochasak noted that “nobody knows the third trail. Not very many of us left” (2021a). With this motivation in mind, as Nochasak mapped, he made sure to identify various points along the route where

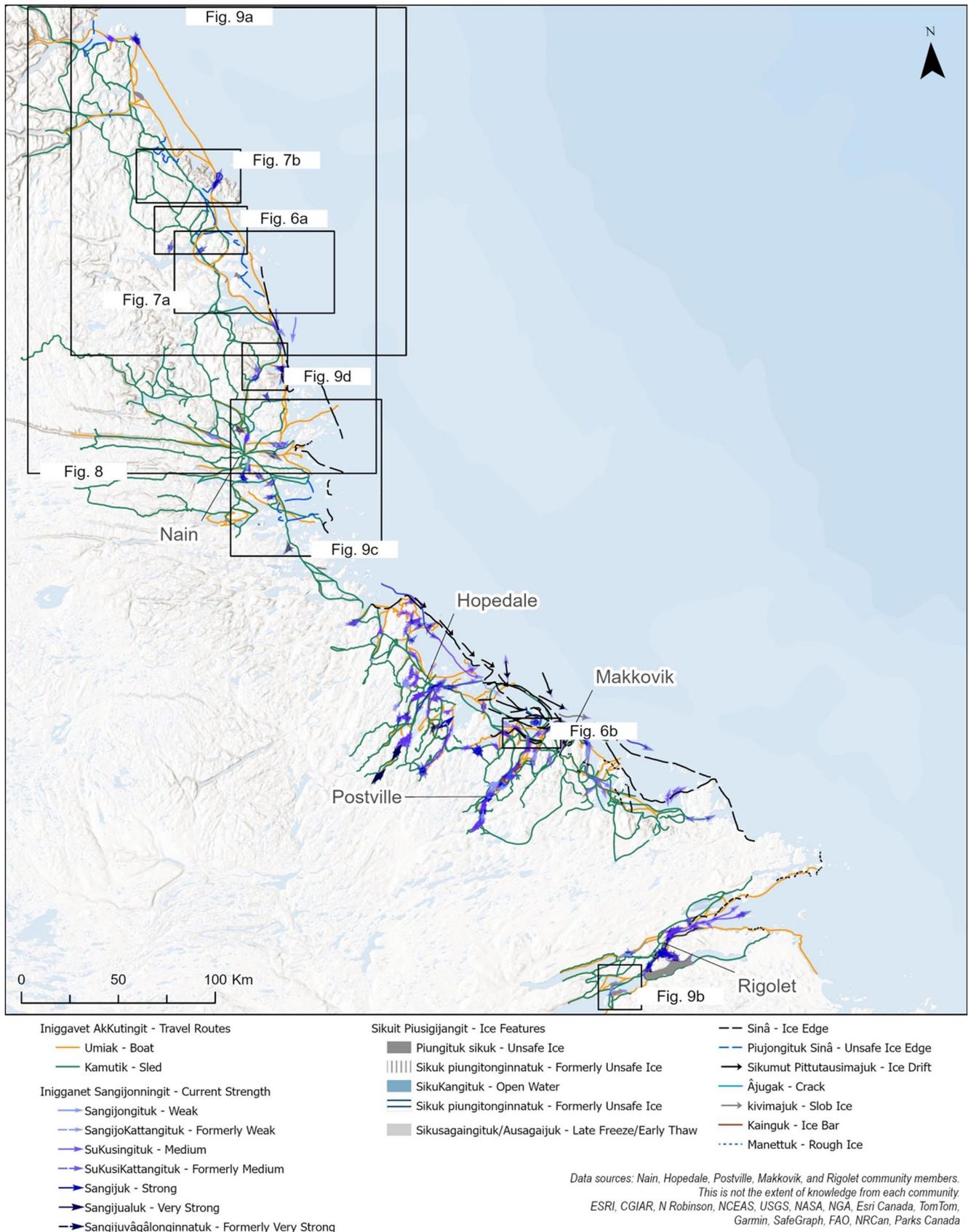


Fig. 5 Overview of Inuit Knowledge from participatory mapping in Nain, Hopedale, Postville, Makkovik, and Rigolet. Box extents indicate the regions represented in Figs. 6, 7, 8 and 9

one would have to choose between two or three trail options (Fig. 6a). Participants emphasized the importance of recording routes that hold cultural significance, even if they are no longer traveled as often. In the case of mapping around Nain, this included routes used to access former caribou hunting areas that are no longer accessed as frequently due to the caribou hunting ban. Ron Webb from Nain describes that “there’s different routes here too that we would use, but it would take most of your paper. Because one of our caribou places is on this land. And there’s only certain way you get up here” (Webb, 2021). These examples highlight participants’ motivation to include specific routes and stories while mapping to preserve their knowledge, to share it within their communities.

Participants emphasized travel safety as they mapped and shared stories. When discussing how much change people in Nunatsiavut have been experiencing, Maria Merkuratsuk from Nain (2021) noted that “there’s nothing that I can do about it, but just try to be safe and keep people safe,” noting that her participation in the mapping was motivated in part by this understanding. Notably, participants took caution to ensure the accuracy of any routes they marked, with Noah Nochasak from Nain explaining that “you’ve got to be careful drawing these [routes and features] in, make sure you get it right [...]” (Nochasak, 2021b). Harold Goudie from Postville described the *sinâ* as an area where you have to be careful and observant: “you’ve got to watch your track. You’ve got to be listening. You put your ear down and hear the ice grinding, you go back, you don’t go out there [...]. We were out there once and had the boys out, and I looked and the ice was gone, [...] had to go jump from one pan to the other” (2021a; Fig. 6b). Tony Anderson from Makkovik (2021) reflects on the mapping and his contributions as serving more purposes than just fulfilling research questions:

This is good, doing this information for the younger generation coming up. Because perhaps their parents never told them or where there’s bad ice and stuff. I try to pass on what I know to the kids and that. And, like, the younger ones who know pretty much every kid around here would be out on skidoo and that, and see them, meet them up in the wood path somewhere or partridge hunting. When they ask where you’re going or, yeah, be careful of this place and that place. Like that. So, that’s good.

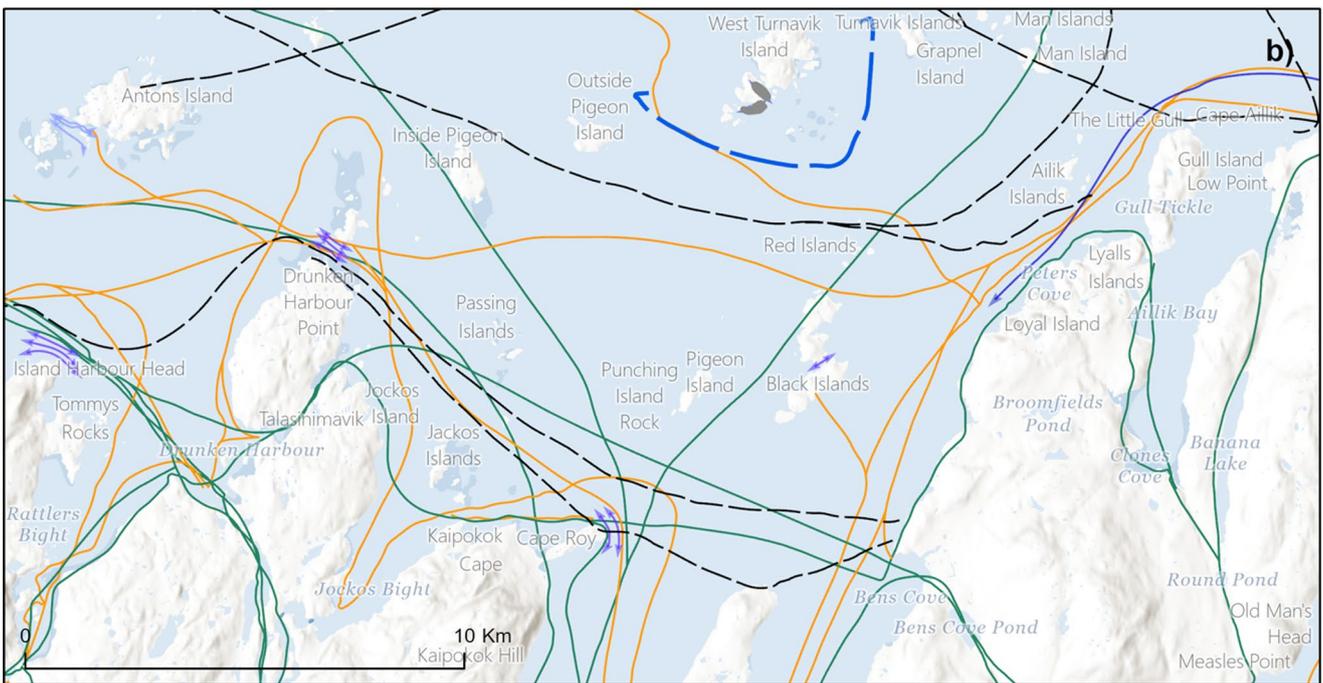
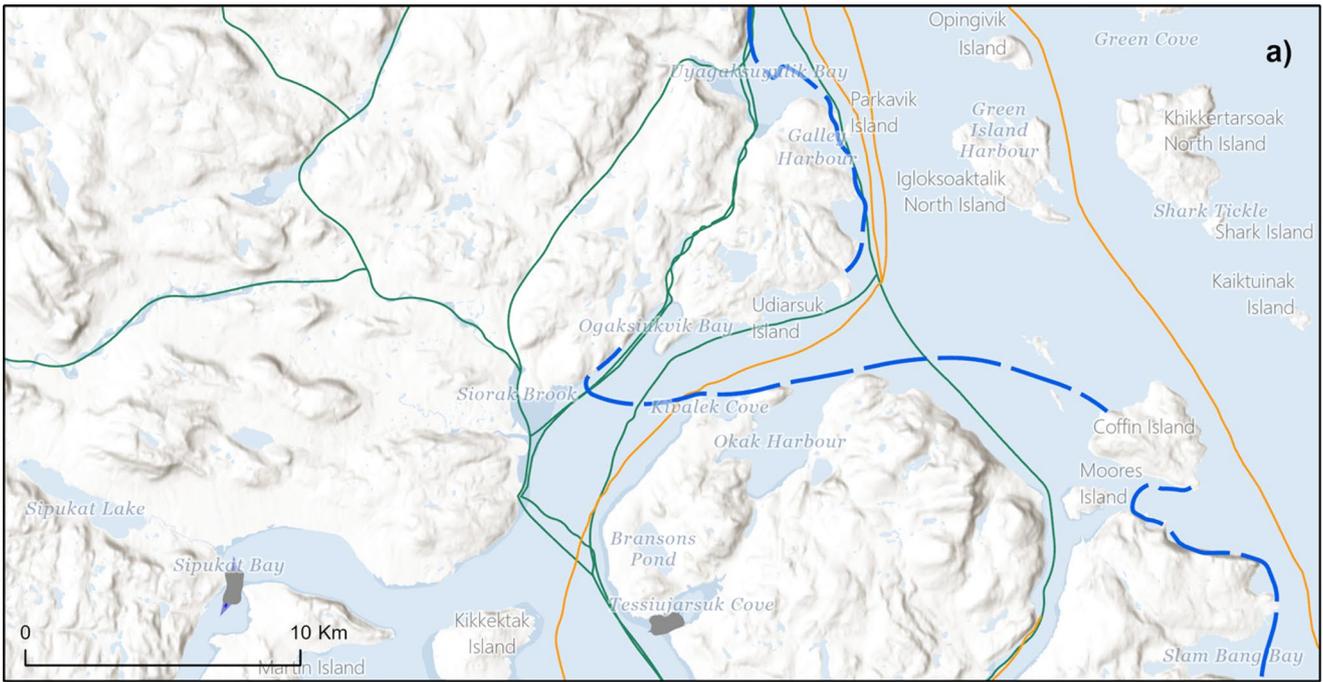
Participants emphasized the importance of finding more effective ways to share knowledge and information within the community and with people from other coastal communities, particularly in light of the multiple factors influencing changes in travel routes. These include reduced intergenerational knowledge sharing and less time on the land due to

work and school commitments. Jim Goudie from Postville said, “we don’t get to talk about it too much to be honest. [...] But yeah, it’s good to be able to kind of get down and just record the story because it’s happening right now. And [...] a lot of this knowledge will be lost very soon” (2021b). Gus Semigak from Hopedale agreed, noting that maps can be a useful tool to record knowledge and share it with younger community members, because “if they don’t learn this now, I don’t know what’s going to happen in the future. Cause like today, the younger people don’t go hunting as we, as the older people used to” (2019). Ultimately, participants stressed that it is not just the maps that matter, but also the stories connected to them that create the greatest value in sharing knowledge in a more meaningful way (Winters, 2019; Semigak, 2019; Merkuratsuk, 2021; Lucy, 2019; Shiwak, 2019a, b; Nochasak, 2021a).

When discussing how results should be shared, Ron Webb and Gus Dicker point out that in the past, researchers would come and take information for their purposes without ever following up with the community members who had provided it. They emphasized that research is an essential part of their way of life, especially in light of ongoing environmental changes (Webb, 2021; Dicker, 2021). These comments were also supported by other participants, with Jim Goudie and Harold Goudie stressing the need to find better ways to share knowledge and information back with communities (2021a; 2021b). The goal of the mapping from a research perspective was to record Inuit Knowledge of the ice and ocean. However, because of the open-ended and flexible mapping process, participants had the chance to explain why recording this knowledge was important to them, which helped us understand how to present the results more meaningfully. This resulted in the creation of travel books to share the mapping with communities in a format that reflects participants’ motivations and goals (Bishop & Oliver, 2022a, b, c, d, e).

Mapping Journeys Through Space and Time

The way people spoke while mapping revealed both their connection to the land and the map’s power to evoke vivid visuals and memories of specific places. One participant reflected that “just imagining the place, marking that route, [you] could see it” (Merkuratsuk, 2021). For example, when describing an area of rough ice, Ron Webb noted that “it could break up anytime if the sea come[s] up. I killed my first polar bear right here, and then we drove right around there, and it was all good smooth ice, but just out that ways it was rough ice” (Fig. 7a). Mapped sea ice conditions are linked to stories of journeys on the land, including memories of hunting and connecting with homelands. For the Labrador Inuit, memories of journeys and environmental



Iniggavet AkKutingit - Travel Routes

- Umiak - Boat
- Kamutik - Sled
- Used to travel here

Inigganet Sangijonningit - Current Strength

- Sangijongituk - Weak
- SangijoKattangituk - Formerly Weak
- SuKusingituk - Medium
- SuKusiKattangituk - Formerly Medium
- Sangijuk - Strong
- Sangijualuk - Very Strong
- Sangijuvâgâlonginnatuk - Formerly Very Strong

Sikuit Piusigjangit - Ice Features

- Sikukangituk - Open Water
- Sikuk piungitonginnatuk - Formerly Unsafe Ice
- Piungituk sikuk - Unsafe Ice
- ||||| Sikuk piungitonginnatuk - Formerly Unsafe Ice
- Sikusagaingituk/Ausagajuk - Late Freeze/Early Thaw

— Sinâ - Ice Edge

- Piujongituk Sinâ - Unsafe Ice Edge
- Sikumut Pittutausimajuk - Ice Drift
- Âjugak - Crack
- kivimajuk - Slob Ice
- Kainguk - Ice Bar
- Manettuk - Rough Ice



Data sources: Nain, Hopedale, Postville, Makkovik, and Rigolet community members. This is not the extent of knowledge from each community. ESRI, CGIAR, N Robinson, NCEAS, USGS, NASA, NGA, Esri Canada, TomTom, Garmin, SafeGraph, FAO, NRCan, Parks Canada

Fig. 6 Map showing subsets of travel routes and *sinâ* locations. (a) An area north of Nain with three options for *Kamutik* (sled) routes (green lines), splitting off at Tessiuarsuk Cove. (b) The variation in the *sinâ* location (dashed black line) and the extent of unsafe ice (dashed blue line), including an area where ice can break up quickly (between the *sinâs* closer to land and those near the outer islands). Note that place names are from a Natural Resources Canada dataset and may differ from locally used names

conditions are inextricably linked. As people recounted their routes, notable sea ice features they wanted to highlight were identified. For instance, areas where the ice broke and people fell through were often recorded, with participants knowing specific details such as who was traveling, what they were using (e.g., a skidoo and *Kamutik*), and sometimes why the ice could not support the weight of the travelers. While research may aim to map features like unsafe or rough ice systematically, storytelling adds valuable context to understand the cultural significance of these areas and the physical properties of the ice, which in this case was prone to breaking up due to wind and waves. This storytelling was not formally requested; instead, we aimed to create a space where our questions as researchers could naturally encourage participants to share stories, often prompting them to reveal detailed memories linked to the areas they were mapping.

One participant marked a *Kajak* route from Nain to the North of Hebron (Fig. 3), which followed a route that his grandfather had also travelled by *Kajak*. While participants often spoke of skidoo trails and speedboat routes, many of these retraced similar journeys that were once travelled by dog team and *Kajak*. Noah Nochasak (2021) described that the area he was mapping “is full of [...] archaeological or historical wealth [...]. Very wealthy. Because of people using *Kajaks* before and this would have been their...they would have did what I did...this would have been their travel route” (Fig. 7b). Similarly, as Maria Merkuratsuk mapped with another participant, she reflected on the route they were drawing and what would have her following that route out on the land: “we would say... it’s time to go home. Like, my brothers call me and say, ‘it’s time to go home’, or I would say ‘time to pack for home’” (2021). Mapping allowed participants to re-trace both personal and ancestral journeys spanning space and time, where the observations of the ice and ocean environment are deeply intertwined with their experiences of the land that are given a depth of history through ancestral knowledge, land use, and occupation. While spatially, two or more participants might re-trace the same route on a map, the stories they shared and the journeys they recounted provided unique interpretations of that route, all of which were embedded with personal memories, cultural values and descriptions of physical properties of the environment (Fig. 8).

Mapping Marine Environmental Characteristics

Mapping encouraged participants to recall memories of the land, which revealed various environmental conditions, including those they regularly encountered and areas that had changed over time. As people mapped, they reached certain parts of the map they described as scarier or more dangerous to travel through, which led us to ask for more details about why. This led to a more detailed discussion about specific conditions that could be encountered. These might include regular conditions, such as an *ingigganik* (a rattle or open water area in the ice) or a river area that freezes over enough to cover it but remains unsafe to travel on (Webb, 2021; Angnatok, 2021). Conditions could also arise from the interaction of different factors, such as crossing an area in a speedboat that becomes dangerous depending on the season and weather. For example, a strong tide combined with strong winds can create a *sea-on* (wind-generated sea swells) during certain times of the year, causing the water to hit the land and crash back into the sea, forming sharp points or peaks, or *nuvulialuk* (Merkuratsuk, 2021; Nain participant 02, 2021).

When asked about the typical *sinâ* location, it was clear that using a single line on the map to mark this dynamic environment was not ideal, as “sometimes it goes further out. It depends on the ice. Sometimes it breaks up right into [the mouth of the bay] and you can’t get out” (Goudie, 2021a). Joey Angnatok, from Nain, emphasized that it is important to know that “it varies every year, right? If you’re going to have, like say, a problematic season, it usually comes right in. Like this [season], it’s safe to say that it’ll probably go on right through here because these islands here hold landfast ice. But where it’s open, like, it’ll come right in and go on out” (Angnatok, 2021). This highlights the importance of finding ways to record not only the variation of *sinâ* from year to year but also within an ice season. To address this, based on participants’ mapping requests, we recorded the inward extent of the *sinâ* under ‘bad’ ice conditions, the outward extent under ‘good’ ice conditions, the furthest out people have experienced the *sinâ*, and more prominent ‘typical’ or average locations in between. While this was effective for gaining an understanding of how the *sinâ* varies over time and space, the truly dynamic nature of the *sinâ* could only be conveyed through stories. Angnatok echoed this, noting that “this place here can be solid ice one day, but you get the right conditions and all of a sudden it’s water. [...] There was a trip I made out there the other year, and my cousin went up a few days later, and he said, my skidoo tracks went right through the water there. They were following my skidoo tracks” (2021; Fig. 9a).

Dynamic and changing ice and ocean conditions can significantly affect travel safety, including which routes

Fig. 7 Map subsets highlighting areas prone to unsafe and/or rough ice and a *Kajak* route. (a) An area prone to rough ice between the *sinā* and the unsafe ice edge (not explicitly indicated on the map) that is related to a story about hunting a polar bear. (b) *Kajak* route (colored yellow, as *Umiak*) going north from Mugford Bay, which passes along many sites rich in cultural history. Note that the place names are from a Natural Resources Canada dataset and may differ from locally used names

are accessible from hour to hour, season to season, or year to year. This requires people to find safe alternative routes and respond quickly to conditions that can shift unexpectedly. Longer-term changes have been observed in several communities. In Rigolet, ice conditions changed after the Churchill Falls Hydroelectric dam was built in the 1970s (Bishop et al., 2021). Many participants took time to describe and map where these changes occurred, emphasizing that “pointing out the bad areas, even if they’re not bad now” remains important (Shiwak, 2019a, b, c; Baikie, 2019; Fig. 9b). Gus Dicker from Nain shared a trip to islands called the Pyramids, which would now be “rare though... I can remember sleeping on these islands there. For the spring seal hunting, and the water was just outside there. I mean, that used to be just normal once upon a time, to be able to go way out there on skidoo” (2021; Fig. 9c). Memories of past hunting and reaching those places contrast with current conditions, where the area Dicker described cannot be reached by skidoo anymore, as the ice edge now forms much closer to land.

Levi Nochasak also explained how changing conditions over time affect travel routes between Nain and Saglek Bay. He pointed out specific points along the journey where travelers must choose a route. Historically, there were three options: one for good ice conditions (anywhere there is ice), another for fair conditions (closer to shore), and a third for poor ice conditions (inland). When describing one of these decision points, Nochasak (2021a) said that during winter travel, “as of early March, [the route is] gone. Middle of February, bad. Rough. *Sea-on* breaking it up. East wind breaking it up. East wind. Ice floating in the water all broken up. [...] In April, no good. From there you go inland” (Fig. 9d). Fewer points along the route now offer all three options, and people increasingly have to go inland. “We can’t do no more shortcut trails up the trails we used to do before. We can’t do it no more. We have to go either number two or number three trail. Not on the ice, number one. No, it’s gone. Climate change” (Nochasak, 2021a). The participants’ stories detail these shifts and their impact on travel routes, linking environmental changes to navigational challenges. Their stories also reveal conditions not shown on maps, such as *sea-on* and wind, which vary greatly and depend heavily on specific environmental contexts.

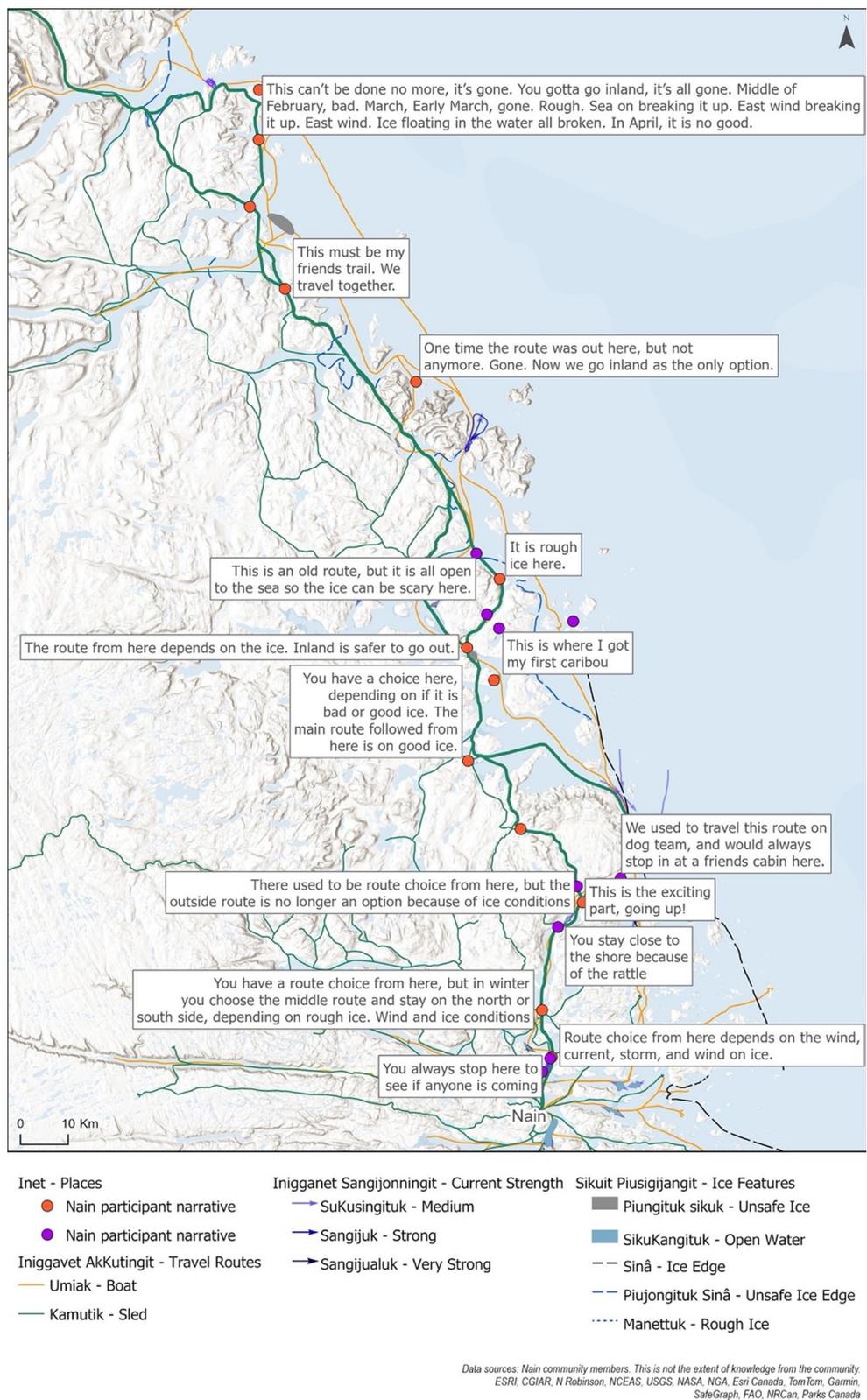
Participants offered unique and sometimes differing insights into the maps. For some, stories helped communicate current conditions or past experiences, while others

focused on a systematic and broad overview of essential conditions. This could lead to what might be seen scientifically as discrepancies in how the ice and ocean environment were mapped through different inputs. However, Allan Vincent of Hopedale highlighted the value of diverse contributions, stating that “you should get a lot of information from everybody and it’s different for each person [...], everybody brings their own points. [...] I think with everybody combined, you should have a good overall view of everything what’s there” (2019). This underscores the importance of individual contributions, as people experience and interact with areas in unique ways, and these varied perspectives can help build a more complete picture of what the ice and ocean environment can look like across time and space.

Discussion

Maps are valuable tools for documenting knowledge about the marine environment because they can evoke memories, encourage conversations, and visually and spatially synthesize diverse observations and insights (Laidler et al., 2010). The overview of mapped knowledge shown in Fig. 6 displays typical conditions experienced across Nunatsiavut, which can be seen as the regional climate pattern (Wilson et al., 2021). Participants systematically mapped these conditions by scanning the map and noting locations where all recurrent features, such as *rattles*, needed to be added. These recurring features often had associated place names describing specific conditions. For example, in Hopedale, *rattles* were found in areas with place names like *inganialuk* (a place with a strong tide that never freezes over) and *inganikoluk* (a small place with a strong tide that never freezes over) (Semigak, 2019; Brice-Bennet and Labrador Inuit Association, 1977). This reflects a rich oral history linked to environmental conditions experienced over many decades. Using a systematic approach to document these features conveys a shared understanding held by participants and community members who often visit these areas. To gather more details for research, it was important to follow up with questions about what was being drawn and why. This often revealed the conditions that influence the local climate. Follow-up questions also gave people a chance to reflect on their contributions and share the values they assigned to certain features and places. For example, *rattles* were described as key areas for collecting mussels or, under the right conditions, as places where one could learn to *Kajak* (Nockasak, 2021b). Having an outsider’s perspective during the mapping process was helpful, as unfamiliarity with the land allowed us to ask questions that might not be raised by community members, who often share common understandings. Through this approach, the transcultural nature of the

Fig. 8 Two participants described different places along the same route between Nain and Saglek Bay. The included quotes showcase personal memories, cultural values, and environmental conditions that are interconnected when recounting journeys across the land



research helped emphasise more details about how social and cultural values are embedded in marine areas (Blake et al., 2017; Gadamus & Raymond-Yakoubian, 2015).

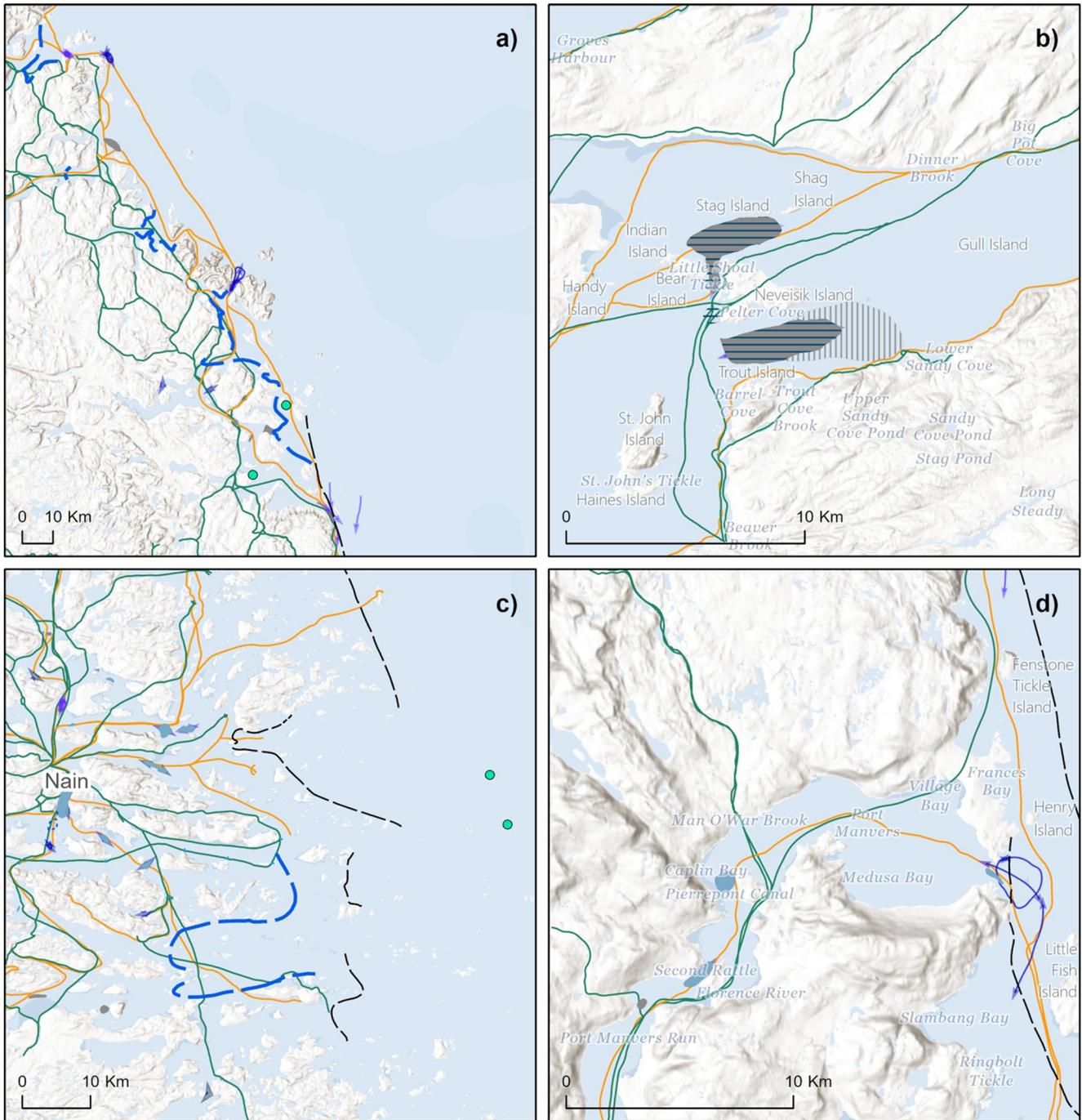
In addition to the ‘typical’ conditions that depict a localized climate, detailed narratives can also offer specific snapshots of conditions at a particular moment, such as an area that usually forms an ice bridge that freezes later than usual (Goudie, 2021a). These snapshots reflect what Wisniewski calls ‘knowings’, which represent individual, personal perspectives that, when shared, “allow for both shared common understandings and personal engagements with commonalities” (Wisniewski, 2010, p. 276). A key part of the idea of ‘knowings’ is appreciating and expecting differences, where knowledge comes from the collective accumulation of individual experiences and personal interactions. For instance, descriptions of a specific feature or process from different people might seem to contain discrepancies rather than a shared understanding; however, these unique perspectives are valuable because they reflect individuals’ connections with a changing landscape and can contain potentially lifesaving information about encountering certain ice or ocean conditions. This type of flexible, context-specific knowledge gains importance through activity and engagement (Wisniewski, 2010). Large floor maps and a flexible, iterative approach facilitated knowledge-sharing processes, encouraging the sharing of memories and stories about such engagements with the land. Future research should consider mapping and exploring stories of conditions at specific places and times that unexpectedly impacted safe travel. Doing so could help identify anomalous events, including factors that may lead to the development of unusual conditions or atypical events. These efforts could assist in planning for future climate change scenarios.

Importantly, researchers must recognize that mapping Indigenous Knowledge can create opportunities for extractive research, especially when the research is designed and planned outside the specific geographic, social, cultural, and environmental contexts in which it occurs (Breckwoldt et al., 2021). When participation levels and the autonomy of Indigenous research partners are not adequately considered, participatory methodologies can produce data that is tailored solely to the interests of researchers. In such cases, participatory marine research risks reducing Indigenous partners and Knowledge Holders to sources of information, data, or support for fieldwork (Breckwoldt et al., 2021). Therefore, participatory marine research should prioritize relational accountability (Wilson, 2008) as a core value, where “the relational perspective and its attendant responsibilities are foundational in respectful cross-cultural research” (Ljubicic et al., 2021, pp. 5–6). This can be put into practice by ensuring relationships guide the entire research process, including selecting research topics, choosing data collection methods,

analyzing and interpreting data, and presenting research results (Wilson, 2008). Our approach aimed to embody relational accountability, which was achieved through iterative cycles of collaborative planning, community engagement, sharing results, and knowledge mobilization (Fig. 2). This flexible, iterative, and adaptive process was vital, as it let each stage of the research cycle be revisited and adjusted as the project developed.

Participatory mapping, including mapping Indigenous Knowledge, has been critiqued because the maps created tend to establish fixed, impermeable boundaries in landscapes that are characterized by movement, networks, and fluctuating social relationships (Gearheard et al., 2011; Sletto, 2009). If we focus only on the resulting maps (spatial data), this critique holds, as a map cannot fully convey Inuit Knowledge of the land, which involves integrating multiple aspects of environmental assessment and prediction to understand complex and dynamic realities. Aporta (2004) distinguishes between routes (*aqquitiit* in Inuktitut), which “is used when discussing knowledge of courses that remain and evolve in the [memories] of the people, while trails (*igliniit*) refers to the physical manifestation of routes, through the carving of sled tracks on the snow year after year” (Aporta 2004, p. 19). Here, trails translate into fixed features on a map, while routes encompass the broader context of Inuit ontological views of territory—something that systematic mapping of static features might overlook. To encourage participants to engage with the maps in a way that mimics experiences on the land—conceptualizing routes in this way was essential to go beyond simply marking lines on a map. While GPS coordinates or lines may indicate the physical locations of features that help understand regional climate patterns, participants’ memories reveal how routes interact with various ocean and sea ice features and social-cultural values that influence journeys across the land. This broader context is vital and is best captured when research is guided by and responsive to community interests and priorities.

What was notable throughout our experiences with participatory mapping is that, while the lines on the map became static representations of the landscape, the ways people interacted with the maps conveyed a sense of fluid interpretation. The static features served as convergence points, where a line depicting a route allowed individuals (participants and observers) to retrace their journeys along that route, sharing stories and memories that conveyed the dynamic physical landscapes—ones given meaning through movement and mobility (see Fig. 8). This enabled us to go beyond merely mapping to document spatial data, as the exchange between researchers and participants fostered narratives and dialogue that connected everyone to the places being mapped. While mapping does not replace engagement with the land, the scale



Iniggavet AkKutingit - Travel Routes

- Umiak - Boat
- Kamutik - Sled
- Used to travel here

Inigganet Sangijonningit - Current Strength

- Sangijongituk - Weak
- SangijoKattangituk - Formerly Weak
- SuKusingituk - Medium
- SuKusiKattangituk - Formerly Medium
- Sangijuk - Strong
- Sangijualuk - Very Strong
- Sangijuvâgâlonginnatuk - Formerly Very Strong

Sikuit Piusigijangit - Ice Features

- Sikukangituk - Open Water
- ▬ Sikuk piungitonginnatuk - Formerly Unsafe Ice
- ▬ Piungituk sikuk - Unsafe Ice
- ▬ Sikuk piungitonginnatuk - Formerly Unsafe Ice
- Sikusagaingituk/Ausagajjuk - Late Freeze/Early Thaw

— Sinâ - Ice Edge

- Piujongituk Sinâ - Unsafe Ice Edge
- Sikumut Pittutausimajuk - Ice Drift
- Âjugak - Crack
- kivimajuk - Slob Ice
- Kainguk - Ice Bar
- Manettuk - Rough Ice



Data sources: Nain, Hopedale, Postville, Makkovik, and Rigolet community members. This is not the extent of knowledge from each community. ESRI, CGIAR, N Robinson, NCEAS, USGS, NASA, NGA, Esri Canada, TomTom, Garmin, SafeGraph, FAO, NRCan, Parks Canada

Fig. 9 Maps of areas prone to sea ice break-up, changes in ice conditions over time, regions previously traveled, and zones where route options have been limited due to ice changes. **(a)** An area north of Nain where ice often breaks up, as Joey Angnatok described, recalling how the ice was solid one day and open water the next. **(b)** An area around Rigolet known as Pelters Island (Nevisik Island on the map), where participants observed changes in ice conditions following the development of the Churchill Falls Hydroelectric dam (see hatched areas and legend for details). **(c)** Locations (green dots) where people used to travel by snowmobile across the sea ice, which are now inaccessible. **(d)** An area north of Nain, where three *Kamutik* route options (green lines) used to be available, now only one or two options remain, most of the year—the westernmost, or landward, routes. For clarity, place names appear only on maps with a scale of 1:275,000 or better. The place names come from a Natural Resources Canada dataset and may differ from locally used names

of the maps used and the landscape features depicted helped evoke memories of engagement, along with the knowledge and values tied to the places being mapped. Incorporating travel routes into the process of mapping environmental knowledge allowed the context of Inuit mobility to situate and ground the knowledge being shared (Aporta, 2010).

Participating as researchers in this process fostered a stronger connection to place through the stories people shared during mapping. In this way, we highlight the value that participatory mapping offers in encouraging knowledge-sharing. The iterative and collaborative method described in Figs. 2 and 3 created a deeper sense of relational accountability in the research (Wilson, 2008). In our case, this was driven by insights from our research partners at the NG Environment Division and participants' interest in mapping to share knowledge about safe travel and land access. Comments throughout the mapping activity, along with participants' evident motivation to share knowledge important for safe travel and land access, led us to reflect on how we, as researchers, can remain accountable for producing and sharing research in ways that collaborators and participants find meaningful and valuable. This ultimately influenced the approach used to develop and distribute the travel books (Bishop & Oliver, 2022a, b, c, d, e). The maps and map books became authoritative sources for conveying Labrador Inuit Knowledge of the ice and ocean in Nunatsiavut. Since their creation, they have been used in different ways, such as supporting the validation of an ice-ocean model (Bishop et al., 2021), assisting research planning for on-ice fieldwork and marine bird surveys, integrating into educational programs, and serving as a potential resource for maritime search and rescue operations in Nunatsiavut.

At the same time, participatory mapping has limitations, especially when using a static tool to represent Inuit Knowledge of a highly dynamic environment. While the maps are created through research, they may omit details crucial for understanding the ice and ocean conditions shown. For example, weather conditions that could make an area particularly

dangerous are often not mapped. Although participants and community members can review the maps and interpret the changing environment flexibly, external researchers lack the same ability to do so. This can cause tension or disconnect between researchers and participants, especially when researchers have not yet experienced the environment firsthand. Addressing this partly involves considering how the map might be interpreted and read, and during mapping, dedicating time to clearly explain the broader context of the knowledge represented. Besides mapping, participants also highlighted other important factors for conducting transcultural marine research and conveying nuances, such as trips on land where researchers can see and experience the ocean and sea ice firsthand to better understand what the Inuit share. Moreover, as John Andersen from Makkovik (2021) describes,

Come and live here in the fall and come back in the spring. And talk to people when you see them coming back from out on the land, out on the ice, the sinâs and everything. And that's where you would get all the information that you would need. Because you can do all kinds of studies, you can put down thermometers and what have you. You'll never get the information that you'd get from the hunters, and the wooders, and all the people that travel to their cabins and that kind of thing. That's where scientists would learn. Then it won't take as long...things that they know that we don't know and put it together. And they'd have a much more true picture of what's happening.

The marine environment in Nunatsiavut is highly dynamic. Researchers will never fully grasp the details that Inuit recognize and experience through daily observations and knowledge passed down over generations. While mapping is one tool to support and foster engaging conditions for transcultural research, the importance of firsthand experiences and spending time in communities cannot be overstated (Brunet et al., 2016; Castleden et al., 2012; Felt & Natcher, 2012; Inuit Tapiriit Kanatami, 2018; Nickels & Knotsch, 2012). This is where critical relationship building and developing a more contextually grounded understanding occur, which is essential for the success of any transcultural, participatory, and collaborative research effort.

Conclusion

Participatory mapping can support transcultural and collaborative interdisciplinary marine research—and similarly research in other environmental fields—that aims to decolonize the authoritative production of knowledge about marine spaces. For marine research seeking to engage with participatory

mapping methodologies, it is essential to conceptualize, design, and conduct research in collaboration with Indigenous research partners to ensure the most comprehensive and current data. Equally important, it helps co-develop information that is useful to the Indigenous community residing in and relying on the study area. Collaboration and participation should be encouraged through a research approach that involves stages such as pre-planning, map design, mapping, data processing and accuracy checking, and analyzing, interpreting, and sharing results. This approach allows participatory mapping to facilitate knowledge-sharing processes that uncover more nuanced and contextual details, which are vital for accurately and appropriately translating knowledge across cultures. In this context, the map can serve as a boundary object (Bishop et al., 2021) to enable collaborative research while also affirming Indigenous Knowledge of the marine environment.

Our case study of participatory mapping in Nunatsiavut demonstrated that while ice and ocean features documented on the maps provided relevant ‘data,’ the iterative and collaborative process of the project allowed the ‘data’ to be integrated into broader stories and experiences of travel across land-, sea-, and ice-scapes. Proper documentation of these stories enabled Inuit Knowledge to be communicated and shared more effectively. This conveyed social and cultural values that are essential for understanding Inuit Knowledge and their perceptions of the local climate, as well as snapshots in time and space that illustrate the ice and ocean conditions and processes in coastal Nunatsiavut, not only on the map but also seasonally.

Transcultural research will always involve ontological tension. However, when based on relational accountability as an axiology, it can be guided by and responsive to community interests and priorities. This can be achieved by maintaining relationships throughout the process of selecting research topics, choosing data collection methods, analyzing data, and presenting research findings. Ultimately, this approach can help uncover and address some of the tensions that often go unexamined in transcultural research settings. It also promotes ethical and equitable practices for conducting marine research with and for Indigenous communities.

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Data Availability In support of Inuit data sovereignty, data that support the findings of this study is owned by and remains with the knowledge holders and communities where the research took place. The Nunatsiavut Government Research Advisory acts as stewards of this data on behalf those knowledge holders and their communities.

Declarations

Ethical Approval The Dalhousie Research Ethics Board and the Nunatsiavut Government Research Advisory Committee provided ethical approval for this research study.

Competing interests Author C.A is an Editorial Board Member for Human Ecology. The authors declare there are no other competing interests relevant to the content of this article.

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