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Stories from the benthos: decolonizing ecological baselines for understanding social-ecological resilience

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The people of Nunatsiavut and the Government of Canada have a modern-day treaty that recognizes Labrador Inuit sovereignty on their land and throughout their coastal waters. Together, the Nunatsiavut and Canadian governments outlined the most important research priorities for Nunatsiavut's marine space, which includes setting ecological baselines of the benthos and better understanding Inuit use of benthic resources. This study responds to that priority to understand the social, cultural, and ecological roles benthic species play throughout Nunatsiavut using methodologies that align with Inuit cosmology and concepts of relationality. In doing so, this work attempts to decolonize the process of establishing ecological baselines in Indigenous territories. By conducting semi-structured interviews and adapting network analysis, we show how benthic species are related to each other through the lens of Labrador Inuit knowledge and experience. Labrador Inuit speak of the relationships between the benthos and fish, marine mammals, birds, and terrestrial plants—diminishing the arbitrary boundaries between land and sea to better reflect Inuit worldview. Results also demonstrate how benthic species are integrated into activities such as commercial and subsistence fishing, hunting, play, research, gardening, crafting, ceremony, medicine, and sled dog care. By establishing baselines in this decolonized manner, they contribute to understanding the profound social-ecological effects of climate change that go well beyond the direct and indirect results of changes in species presence, absence, and abundance. Most importantly, however, is the understanding of the complexity of benthic relationships for Labrador Inuit, which supports resilience in the face of climatic change.

KEYWORDS

Arctic, climate change, Nunatsiavut, resilience, decolonization, network analysis, social-ecological, benthic

1 Introduction

Values shape the scientific process. Western science is governed by core tenets that shape our understanding of how the natural world functions and the methodology we use to answer fundamental scientific questions (Douglas, 2023; Elliott, 2022). Some important tenets that underpin the dominant scientific tradition are individualism, reductivism, instrumentalism, and universality. In the dominant tradition, knowledge is individualistic—it is owned by discrete individuals and not something we are collectively a part of Wilson (2008). New knowledge is acquired through reductive processes, assuming that a complex whole can be understood by breaking a system up into its component parts (Smith, 1999). Value is often conceptualized as either intrinsic or instrumental, meaning that something has inherent value due to its capacity and experience or the benefits it confers on others (Callicott, 1995). Lastly, results of scientific inquiry are assumed to be universally applicable (Todd, 2020). These values make up the framework of Western science, shaping how knowledge is generated, validated, and communicated, as well as the decisions over what types of knowledge are accepted.

As biologists, ecologists, and conservationists, we trust that marine spatial planning (MSP) decisions are based on scientific knowledge and are objective and equitable (Tafon, 2018). However, MSP is first and foremost values based. It is underpinned by colonialist, hierarchical systems separating humans and non-humans and belief systems that inform our understanding of ourselves—that we humans are inherently harmful to nature (Watts, 2013; Kimmerer, 2015). As a result, MSP processes and products, such as Marine Protected Areas (MPAs) are often complicit in settler colonialism despite their importance in reaching meaningful ecological and biodiversity conservation goals (Martinez et al., 2023; Sowman and Sunde, 2018; De Santo et al., 2011; Aguilar-Perera et al., 2006). Reflecting on the values that underpin MSP decisions and the methodologies used to support those decisions is critically important given their significant role in the global effort to combat climate change and protect marine biodiversity (Kalinina, 2021).

While conducting research on Indigenous lands, in Indigenous waters, and with Indigenous community members, it is important to reflect on the strengths and limitations of the dominant scientific framework and its applicability in Indigenous spaces. Through ongoing colonization, "Western onto-epistemologies are naturalized as universal while Indigenous Place-Thought and other non-Western ways of being and knowing are erased" (Todd, 2020). In this study, we propose a process to establish ecological baselines that are more reflective of the values inherent in Indigenous knowledge systems—specifically relationality, and show that by doing so, risk and resilience can be more profoundly understood.

One of the first steps to making informed decisions in the marine space is characterizing benthic habitat and community composition as they support marine biodiversity, commercial fisheries, and myriad ecosystem services on which we depend (Hogg et al., 2018). The marine benthos is comprised of the plants and animals that inhabit the bottom of the sea—either living within the substrate, attached to the substrate, or mobile on or just above it (Walag, 2022). Within benthic ecology, the dominant methodology for establishing baselines generally begins with surveying, sampling, laboratory analysis, mapping, and habitat and community characterization (Eleftheriou and McIntyre, 2005). These methodologies establish ecological baselines largely separate from species or habitat relationships with the people that inhabit a place. The goal is to establish a pure baseline on which to assess and monitor human impact—reinforcing the paradigm that humans are not a part of nature but are, for better or worse, actors upon it.

Counter to the dominant scientific framework, Indigenous place-thought understands knowledge to belong "to the cosmos of which we are a part and where researchers are only the interpreters of this knowledge" (Wilson, 2008). Instead of intrinsic or utilitarian values, Indigenous cosmology embraces relationality (Wilson, 2008; Todd, 2020; Smith, 1999; Cajete, 1999). Relationality extends beyond human connections to include connections with the non-human world. This worldview emphasizes that humans are not separate from, but are instead a part of, the environment (Wilson, 2008). With these differences in values, the universalist or reductionist approach to scientific inquiry is challenged.

In the case of MSP in Indigenous territories, social-ecological resilience requires understanding and respecting the value of relationality. In contrast to intrinsic and instrumental values that are most prominent in Western thought, relationality is paramount within Indigenous systems (Cajete, 1999; Todd, 2020). Relational values are those "linking people and ecosystems via tangible and intangible relationships to nature as well as the principles, virtues and notions of a good life that may accompany these" (Klain et al., 2017). The good life, in this sense, depends on the strength of the many relationships between human beings and the environment, and between the many different beings throughout the environment. It is sustained through these connections that in turn foster harmony, mutual respect, and provide cultural and spiritual grounding. In this sense, it is the realization of a resilient system. Approaching environmental issues through the lens of relationality can be a powerful tool to reshape the ways in which we relate to nature and build the systems that govern those relationships. Relationality also brings with it a different set of responsibilities as we start to think about to which relationships our research is accountable.

Positioning baseline studies within a relational context may help identify the tangible and intangible ways in which humans and non-humans support and are supported by the ecosystems they inhabit. It can significantly enhance our understanding of the roles species play within the social-ecological system (González-Quintero and Avila-Foucat, 2019). This perspective may reveal the importance of species that might otherwise be considered insignificant and highlight their interconnectedness. Additionally, emphasizing relational values may help broaden the scope of what is considered valuable in ecosystems to include the wellbeing derived from connections to nature, cultural significance, and social relationships (Arias-Arévalo et al., 2017). Fully conceptualizing the complexity of these relationships can help us to understand how anthropogenic changes may impact the social-ecological system as a whole and the "good life" inherent in a relational existence with the non-human world (Lejano, 2019).

When considering resilience of Arctic communities, relationality is paramount. The resilience of social-ecological systems depends on the ability of the components of that system—human or non-human—to learn, share knowledge, and adjust. In this manner, relationships shape resilience, and strong relationships facilitate adaptive capacity (Folke et al., 2020). Additionally, effective governance of social-ecological systems relies on understanding the relational values of its components and the myriad roles they play within the system (Arias-Arévalo et al., 2017).

In 2005, the people of Nunatsiavut, "Our Beautiful Land" in Inuttitut, signed the Labrador Inuit Land Claims Agreement

(LILCA) with the Government of Canada. This modern-day Treaty recognized Labrador Inuit sovereignty over Nunatsiavut, a region that includes 72,520 km^2 of land, 48,690 km^2 of marine space, and is home to over 7,000 Nunatsiavut beneficiaries living within Nunatsiavut and throughout Canada (Government of Canada, 2018). The first Inuit region to obtain sovereignty, Nunatsiavut is one of four territories that make up Inuit Nunangat—the Inuit homelands in Canada (Nunatsiavut Government, 2024).

Since then, Nunatsiavut and Canada have been engaged in work to devise a cooperative governance structure for marine planning, establish ecological baselines, and better understand the effects of climate change throughout the region. Principal among these is the establishment of the Nunatsiavut-led Imappivut Marine Plan to fulfill implementation of the LILCA (Nunatsiavut Government, 2018). The goal of Imappivut, "Our Oceans" in Inuttitut, is to ensure that the needs, knowledge, values, and interests of Labrador Inuit are reflected in all decisions regarding marine use within the 200-mile Exclusive Economic Zone off the coast of Nunatsiavut (Nunatsiavut Government, 2018). Imappivut's intention is to build social-ecological resilience into marine planning by fully representing community interests as interrelated within the ecological diversity of coastal Nunatsiavut (Nunatsiavut Government, 2018), since the needs of humans and the needs of the environment are inextricably entangled (Gratani et al., 2016; Sangha et al., 2015; Gagnon et al., 2023).

Founding the Imappivut project, in 2017 the governments of Nunatsiavut and Canada signed a Statement of Intent to collaboratively manage the marine space within the Labrador Inuit Settlement Area (LISA) Marine Zone (Figure 1). To gather data and information and identify knowledge gaps within the LISA Zone, Fisheries and Oceans Canada (DFO) assembled a Canadian Science Advisory Secretariat (CSAS) comprised of members of the Nunatsiavut Government, Newfoundland and Labrador Provincial government, several departments under the Canadian Ministry of Environment and Climate Change, and academia (Government of Canada, 2020; Government of Canada and Fisheries and Oceans Canada, 2019). This resulted in the "Biophysical and Ecological Overview of a Study Area within the Labrador Inuit Settlement Area Zone" report. This report outlines the biological and physical oceanography of the Zone, including Western scientific and local knowledge of sea ice, marine vegetation, fish, marine mammals, birds, the benthos, and Inuit use (Canadian Science Advisory Secretariat, 2021). In the context of this document, Inuit use includes subsistence and commercial harvesting, travel, and activities that connect to culture and economic growth that contribute to Inuit health, wellbeing, and survival (Canadian Science Advisory Secretariat, 2021). The CSAS report identified the lack of research on benthic species as a major data gap within the Zone. Furthermore, it established the need to collect qualitative and quantitative data on Inuit use of benthic species as a foremost research priority to better understand the benthos' relationship to Labrador Inuit culture and food security (Canadian Science Advisory Secretariat, 2021).

To further Nunatsiavut sovereignty in the marine space broadly, and the implementation of the LILCA specifically, it is paramount to establish baselines using methodology that aligns with Inuit culture and values. The goal of this research is to illuminate the social-ecological system linking Nunatsiavummiut (the people of Nunatsiavut) and the benthos from the perspectives shared by Nunatsiavummiut knowledge holders and resource users most intimately connected to the benthos throughout the region. Indigenous knowledge systems, rooted in relationality, are fundamentally different from Western scientific frameworks, which are typically more compartmentalized and analytical (Berkes, 2018; Cajete, 1999). As complementary rather than comparable (Broadhead and Howard, 2021), we do not attempt to compare the social-ecological systems identified within this study to networks representing ecological connectivity based on Western scientific literature. We undertake this in a manner that is underpinned by relationality to more fully explore the depth and breadth of benthic relationships across multiple dimensions. While we approach this research from a decolonial perspective, the scientific methodologies and analytical frameworks we employ are rooted in Western epistemologies. These tools, developed within and shaped by colonial histories, reflect specific ontologies and value systems that don't fully align with Indigenous ways of knowing (Wilson, 2008; Smith, 1999). Consequently, we recognize that the scientific tools and institutions we rely upon impose constraints on our efforts to decenter and honor non-Western perspectives (Tuck and Yang, 2012). However, by recognizing and centering our work on the relationality present in the coastal social-ecological system, the hope is to allow for a better accounting of the current resiliency of the system, a better understanding of its risks, and opportunities for enhancing "the good life" Nunatsiavummiut share with their coastal kin.

2 Materials and methods

2.1 Interviews

We conducted 34 semi-structured interviews with 39 Labrador Inuit Land Claims Agreement (LILCA) beneficiaries between April and September 2023. We chose to conduct semi-structured interviews to allow participants more agency in deciding the scope and direction of the interview, and the type and amount of knowledge shared (Huntington, 1998). All interviews were conducted in English. In five cases, participants chose to interview together with their spouses or relatives. All interviews took place within Nunatsiavut, and all participants were residents of the five communities within Nunatsiavut: Nain, Hopedale, Postville, Makkovik, and Rigolet. Interviews lasted about 1 h. The interviews took place in a variety of locations at the choosing of the interviewee, including in participant homes and cabins, rental spaces, Research Center offices, and on speedboats. All participants were offered CAD $40 in recognition of their time and contributions as per project compensation guidelines; however, recommended compensation has since increased. The lead author conducted every interview.

Before conducting interviews, the research team received ethics approval from the Nunatsiavut Government Research Advisory Committee (NGRAC-44187831) and Dalhousie University (REB 2023-6595). Beforehand, we developed and signed a research agreement with the Nunatsiavut Government Research Center that outlined the project's design, data collection, and analysis. Through the research agreement process, we agreed the research

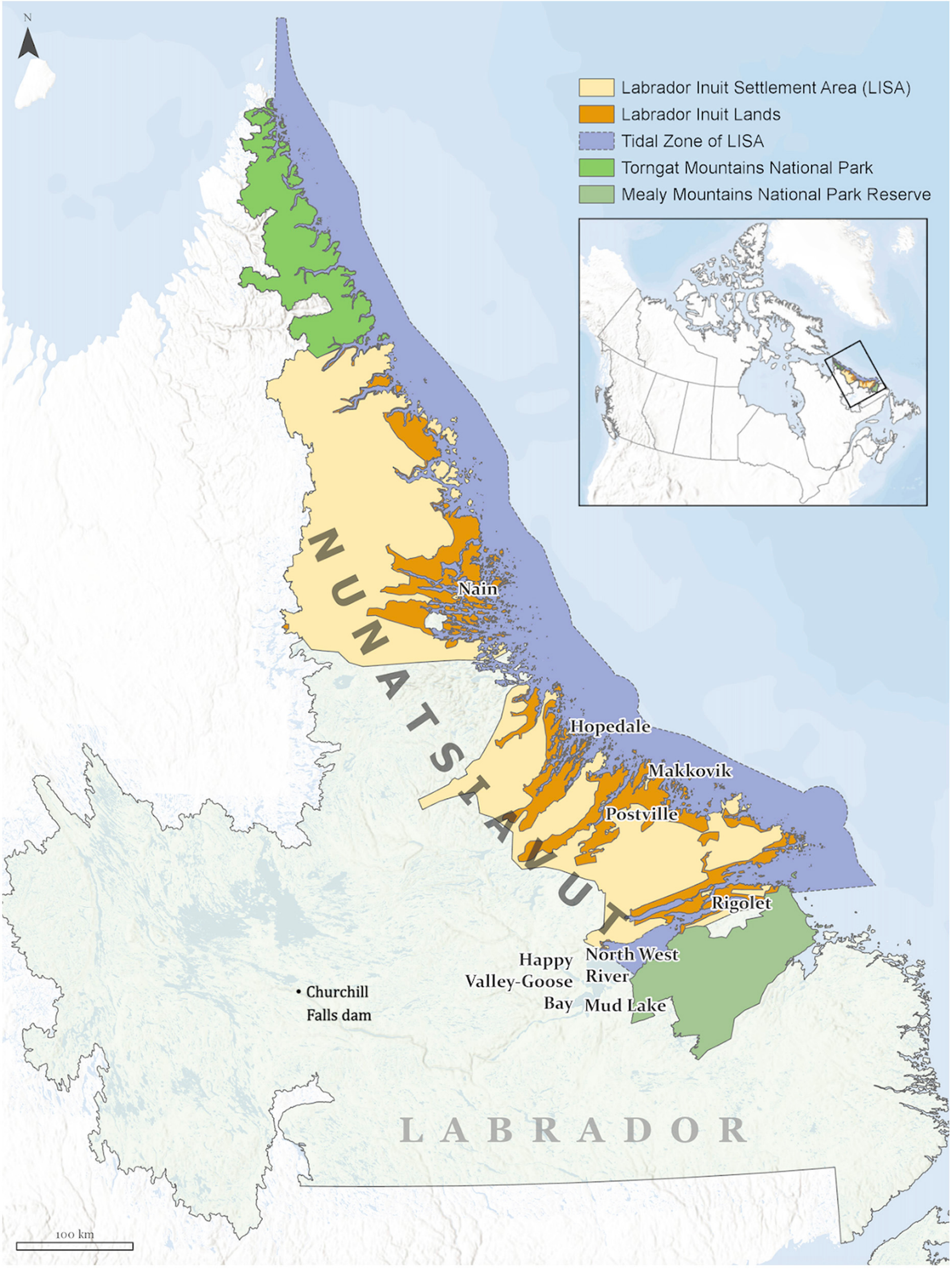

FIGURE 1
Nunatsiavut land claims region. Map of Nunatsiavut showing five Inuit communities of Nain, Hopedale, Postville, Makkovik, and Rigolet, as well as the location of the Churchill Falls dam. Map reproduced and edited with permission from Breanna Bishop.

TABLE 1 Interview participants.

Gender	Participants
Male	27
Female	12
Age range	**Participants**
18–30	7
31–54	15
55+	17
Community	**Participants**
Nain	10
Hopedale	8
Postville	6
Makkovik	6
Rigolet	9
Total	**39**

Self-reported gender, age range, and community representation for 39 Nunatsiavummiut knowledge holders.

would be performed iteratively and with the constant engagement of the Nunatsiavut Government Research Center to ensure the research was done in a respectful manner and remained relevant to the communities of Nunatsiavut. It also affirmed Nunatsiavut Government data sovereignty and beneficiary ownership of all knowledge shared during the study. In accordance with the tenets of Inuit data sovereignty, all data is owned by Nunatsiavut communities, and de-identified data is held by the Nunatsiavut Government Research Center.

To recruit participants, we used targeted and snowball sampling to represent participant diversity in geography, age, gender, and familiarity with different benthic species (Table 1). The purpose of this was not to analyze the knowledge carried by these different groups based on these factors, but to attempt to understand the richness of collective knowledge held on this topic (Beaulieu et al., 2023). Initial interview participants were recommended by the Inuit Research Advisor and Research Manager at the Nunatsiavut Government Research Center, and members of the Torngat Fish Producers Cooperative. To expand participant diversity, the lead author would ask interview participants for recommendations of additional participants that would be able to fill particular knowledge gaps or to recruit additional women and youth to the study. The purpose of the study and the main research questions were described to potential participants before being asked if they would consent to taking part in this research.

Prior to the interview, participants were given consent forms to be read by them or read by the interviewer. Verbal or written consent was solicited and received from every participant prior to interviewing, and the consent forms were written to comply with the National Inuit Strategy on Research (ITK, 2018). Participants were informed that they would be able to unenroll from the study within 1 month from their interview date. At that time their data were de-identified and aggregated. If interviews did not conclude after 1 h, participants were notified and asked if they would like to continue.

Interviews began inductively by soliciting information on which benthic species and habitats were of interest to participants, of which they had particular knowledge, and to describe their interactions with benthic species that they brought up. After that, the interviewer presented a "benthic book" containing photos of benthic species with local and Inuttitut names to ensure that species of interest to participants weren't missed in the interviews.

2.2 Data analysis

We used Nvivo software to qualitatively and thematically analyze the interview data. First, we deductively coded interviews for each species mentioned, activities, and places in which Labrador Inuit interacted with the benthos. For this deductive analysis the first author conducted all the coding. To ensure coding was done correctly, the first author coded all interviews a second time and compared the two versions to ensure the interviews were correctly coded. Concurrently the first and second author inductively identified interview themes. The lead author, a settler from the United States, worked with the second author, a Nunatsiavummiut knowledge holder, to identify themes, as we determined it was inappropriate for a settler academic alone to identify the themes relevant to Labrador Inuit. As we each come to research imbued with our own cultural lenses, we thought it important it not only be a settler lens through which themes were identified. We used thematic analysis to categorize themes within the interviews (Braun and Clarke, 2006). The first two authors read through the interview texts individually to familiarize ourselves with the interview content and then followed coding procedure described by Iqbal and Mansell (2021) for coding themes related to wellbeing. The first author identified thematic patterns within the interviews and proceeded with the initial coding to categorize the data within the identified themes. The second author evaluated the themes and their corresponding quotes. Then the first and second author discussed both the themes identified and the quotes that fit within them. In this process, two themes were grouped, and one was divided and renamed to more accurately reflect the themes using language that the second author felt more accurately reflected Labrador Inuit conceptualization of wellbeing. Together, the first and second author then went through all the quotes that had been coded to ensure they fit under their thematic umbrellas.

We analyzed the interview data to identify direct and indirect relationships between Labrador Inuit and benthic species and to understand how the benthos fits into the larger social-ecological system within Nunatsiavut. First, we created a co-occurrence matrix (Scott, 2017) by identifying instances in the interviews where participants mentioned benthic species interacting with each other. When relationships between species were mentioned in the interviews, they were coded to each species. In Nvivo, that cross-coded content was exported into a co-occurrence matrix in a csv file. That matrix was imported into Gephi, a software tool for creating networks to visualize and further analyze the data (Gephi.org., 2022). In Gephi, we used the data to produce network visualizations (Scott, 2017). We repeated this process for the relationships between benthic species and other plants and animals, benthic species and themes (bipartite networks), and benthic species, locations, and activities (tripartite network).

To make network graphs easier to interpret, we used the ForceAtlas2 algorithm in Gephi (Jacomy et al., 2014). This algorithm places the nodes (points in the network) and edges (lines between them) to create a diagram optimized for readability (Jacomy et al., 2014). We further optimized readability by scaling the network diagram between 100 and 200 to prevent overcrowding (Cherven, 2015). We customized the node and edge properties with node size representing the unweighted degree centrality so that the size of each node is a proportional representation of the number of direct connections each node has to other nodes (Koschützki et al., 2005). The edge weight represents how often a specific relationship (edge) was mentioned in the interviews. Thicker lines indicate more frequently mentioned relationships.

After creating the network diagrams, we used the cross-coded matrices from Nvivo and imported them into R. We then used the igraph package in R to calculate degree, weighted degree, betweenness, closeness, and eigenvector centrality measurements for each species in each network (Csardi and Nepusz, 2006; Koschützki et al., 2005). Common names of species are used in network diagrams and tables. Analysis is based upon the level of species specification reported most frequently by community members, and therefore most relevant for communities.

2.3 Bringing back preliminary results

After completing data analysis, we shared our preliminary results with interview participants and community members to maintain their control of how their knowledge is used and shared. We visited Nunatsiavut to follow up with interview participants and held community events to share initial results and solicit community feedback. We also shared initial results in local and regional radio programming in English and translated into Inuttitut and shared them on community Facebook groups. The networks were then updated to reflect participant and community feedback.

2.4 Researcher positionality

The lead author did not start collecting interview data until their fourth trip to Nunatsiavut. They worked with NG to make sure that the research would be useful to the community, would align with NG research priorities, and that the researcher had an understanding of the region's cultural and physical landscape before interviews began. This work is representative of hundreds of hours of conversations with government and community that informed the research questions before data collection began for this study. While those conversations informed the research questions and the way in which research was conducted, the content of those discussions is not represented in the results of this study. Through these conversations, the methodology for this study was developed to be responsive to the local context and are based upon the principle of relationality: that human and non-humans are interdependent with each other, and that researchers carry obligations to respect and nurture those relationships, as well as those that develop between community members and researchers (Wilson, 2008). In the methodology section, we have provided information on establishing research agreements and ethics approval from the Nunatsiavut Government, as we have learned that it is an integral methodological step for conducting research with Indigenous communities and on Indigenous territory (Liboiron, 2021). We have also included details regarding returning data and results to the community as it was an essential step for us to be able to appropriately contextualize the results (ITK and NRI, 2006; ITK, 2018). In this work we take stock of where we are in our personal and professional journeys learning how to do more ethical and relevant research with our Inuit peers and within their sovereign lands and waters.

We have also learned from past researchers in Nunatsiavut and owe a debt to them. We use the term "Sea of Relationships" to describe the following results as an intentional homage and aspiring thematic extension to Oberndorfer's work describing the relationships between plants and fishing in Makkovik, Nunatsiavut, and Cajete's work describing the nature of relationships in Indigenous ontology and epistemology (Cajete, 1999; Oberndorfer et al., 2017). The methodology we used pertaining to ethical research was greatly influenced by the work of Liboiron (2021).

The authorship team is mixed, made up of settlers from the United States (KMO) and Canada (MB) in the academic space, a European academic (JOS), and Inuit from Nunatsiavut (JJ, MS).

3 Results and discussion

3.1 A sea of relationships

Labrador Inuit collectively tell a story of the relationships between themselves and the benthos, and the benthos and other parts of the ecosystem that transcend marine-terrestrial boundaries. They also tell how these relationships have changed, and how they might continue to change in the future.

Labrador Inuit have a profound knowledge of the benthic plants and animals within Nunatsiavut. Interview participants identified benthic and benthopelagic species with whom they have relationships (Table 2). These included sessile and mobile benthic invertebrates, infauna, demersal and benthopelagic fishes, macroalgae and seagrasses. In some cases, participants identified individual species, such as Atlantic, Arctic, or rock cod. In other cases, species groups were identified, such as sea cucumbers, polychaete worms, or flat fish. Within species groups, knowledge holders sometimes differentiated between individual species. For example, within the sculpin group, species were sometimes identified by different color patterns indicating their varying levels of safety for consumption.

3.2 Within the benthos

Knowledge holders discussed 45 benthic and benthopelagic species groups in the interviews, and highlighted relationships between 41 of them (Figure 2). These relationships occur within the benthos and represent complex food web interactions, relationships

TABLE 2 Benthic and benthopelagic species groups mentioned by interview participants.

Common names	Mentions	Inuttitut (singular)	Local names (if different than common names)	Species notes
Mussel	34	Uviluk		Blue mussel (*Mytilus edulis*)
Clam	33	Ammomajuk		Includes Arctic surf clam (*Spisula solidisima*), Atlantic surf clam (*Mactromeris polynyma*), ocean quahog (*Arctica islandica*), and soft-shell clam (*Mya arenaria*)
Brown algae, kelp	31	Kuannik	Shark's blanket	Includes rockweeds (*Fucus* spp.), *Agarum, Laminaria*, dulse (*Palmaria palmata*), sea lettuce (*Ulva* spp.). Inuttitut only refers to *Alaria esculenta.* Local name is for *Laminaria* spp. only
Sea urchin	30	Itik	Whore's egg, Hoe's egg	*Strongylocentrotus drobachiensis*
Whelk	30	Siutiguk	Cuckoo, wrinkle	*Buccinum undatum*
Scallop	29	Matsojak		*Chlamys islandica*
Toad crab, rock crab	26	Putjotik		Includes Atlantic rock crab (*Cancer irroratus*), great spider crab (*Hyas araneaus*), and toad crab (*Hyas coarctatus*)
Atlantic cod	24	Ogak		*Gadus morhua*
Coralline algae	24	UjaganneKattajut	Live rock	Includes many species of geniculate and non-geniculate corallines
Eel grass	23	Killotik	Goose grass	*Zosteraceae* spp.
Rock cod	22	Ogâtsuk	Tommy cod	*Gadus ogac*
Sea cucumber	20	Ammangitsuatsuk		Includes *Cucumaria frondosa* and *Psolus phantapus*
Sculpin	17	Kanajuk		Includes *Myoxocephalus scorpioides, Myoxcephalus scorpius*, and *Myoxocephalus octogecimspinosus*
Flat fish	16	Sâppatâk		Includes many species of sole, plaice, and flounder
Starfish	16	Ennik		Includes many species
Green hair algae	13	Nujaujak	Slub, slug, green hair	Turf algae that grow on fishing nets set out over time along the shorelines during Arctic char, Atlantic salmon, and brook trout seasons. Undetermined species of filamentous green algae
Snow crab	12	Putjotik		*Chionoecetes opilio*
Rock gunnel	11	KillotiKautik	Tansy	*Pholis gunnellus*
Sea squirt	11	Nakatannak	Turnip	Includes many species
Brittle star	10	AKittuk aggaujak		*Ophiuroid spp.*
Shrimp	9	Kingupvak		Includes many species, including several participants identified as new to the region
Lump fish	9	Nipisak		*Cyclopterus lumpus*
Turbot, Greenland halibut	7	Natânnavak	Turbot	*Reinhardtius hippoglossoides*
Stickleback	6	Kakillasak	Cushy	May include three, four, and nine-spined species
Sand lance	5	Amajâk		Includes several near-shore and deep-water species
Polychaete worm	4	Tinguk, Ijiligak	Sea worm	Includes many near-shore and deep-water species
Soft coral	4	Akittuk IkKamiutak		Includes several species
Porcupine crab	3	Putjotik		*Neolithodes grimaldii*
Barnacle	3	Siitijuk KikKuak		*Semibalanus* spp.
Anemone	2	PigutsianguKataujuk		Includes many species including cerianthids

(Continued)

TABLE 2 (Continued)

Common names	Mentions	Inuttitut (singular)	Local names (if different than common names)	Species notes
Wolffish	2	Itijummiutak		*Anarhichas lupus*
Amphipod	2	Kinguk	Sea lice	Includes several species of benthic-dwelling and infauna in the near-shore area
Razor clam	2	Ammomajommijuk		*Ensis leei*
Arctic cod	1	Ogak		*Boreogadus saida*
Grenadier	1	Ijipvak		May indicate several species
Redfish	1	Redfish		*Sebastes fasciatus*
Skate	1	Pamiuttulagak		May indicate several species
Sucker fish	1	Kanajutannak		*Catostomus catostomus*
Coral	1	Nuvidlujak		May indicate many cold-water coral species
Hermit crab	1	Putjotik		*Pagurus* spp.
Lobster	1	Lobster		*Homarus americanus*. Not present in study area, however one participant was involved in lobster research that occurred within the study area
Periwinkle	1	Siutiguk	Snail	*Littorina littorea*
Nudibranch	1	UviluKangituk		Unknown species from the *Pleurobranchidae* family
Atlantic halibut	1	Natannak		*Hippoglossus hippoglossus*
Greenland shark	1	IKalutsuak		*Somniosus microcephalus*

Mentions indicate the number of interviews in which knowledge holders brought up the species. In some cases, participants identified the plant or animal to the species level. In those cases, the species names are provided. As local and Inuttitut names are used interchangeably within interviews to describe species, this table is meant to aid in better understanding participant quotes and contextualization of the benthic relationships.

between habitat-forming species, and other benthic species that depend on them. Habitat-forming species play a critical role in supporting coastal biodiversity and directly and indirectly contribute to food security (Koivisto et al., 2011), however the relationships between species, such as coralline algae and scallops, are not well understood in Western science (Jardim et al., 2022). In discussing habitat patterns, a knowledge holder in Makkovik described the relationship between sea urchins and kelp: "When you are near the shore there are distinct bands of different habitats. First you have the kelp deeper out, then you get the urchins, which eat the seaweed and control how far up it goes, then you get the wrinkles, and then the other seaweed—the beach wrack." Some of the relationships are less concrete but knowledge holders point to important relationships nonetheless: For example, the relationship between coralline algae and other marine species harvested by Labrador Inuit. In Nain, one knowledge holder said, "We used to haul up live rock in the commercial scallop trawls. There was more of that than the scallops." Another in Nain said, "It means something when you see live rock. I'm curious about it because it seems to mean high biodiversity." In Postville, another said, "Live rock is like caribou moss. It grows slow and it's important [to other harvested species]."

Benthic relations also take into account and are representative of Labrador Inuit knowledge and experience. Clams, whelks, mussels, and urchins are closely linked not just because of their proximity to each other in the marine space but because they are often harvested together as a family activity when people are enjoying being out on the land or visiting their cabins (Brice-Bennet, 1977; Finner, 2015). Likewise, lump fish, stickleback, rock gunnel, sculpin, and flat fish are closely linked because young knowledge holders talked extensively about playing with these specific animals when growing up.

3.3 Beyond the benthos

Benthic and benthopelagic species' relationships transcend the marine-terrestrial interface and challenge the binary land-sea divide common in Western thinking (Bennett et al., 2016; Oberndorfer et al., 2017). Knowledge holders spoke of benthic species' relationships to several different plants and animals within the sea and on land, most frequently relationships with non-demersal fish, birds, marine mammals, terrestrial animals, and terrestrial plants (Figure 3).

During interviews, Labrador Inuit knowledge holders spoke of relationships between benthic species groups and pelagic fish including Arctic char, Atlantic salmon, capelin, smelt, herring, trout, and sharks. These relationships consist of food web interactions, such as cod feeding on capelin and porbeagle sharks feeding on cod, and other important life history behaviors such as smelt, rock cod, and trout using eel grass for spawning and refuge (Rose and O'Driscoll, 2002; Polte and Asmus, 2006). Knowledge

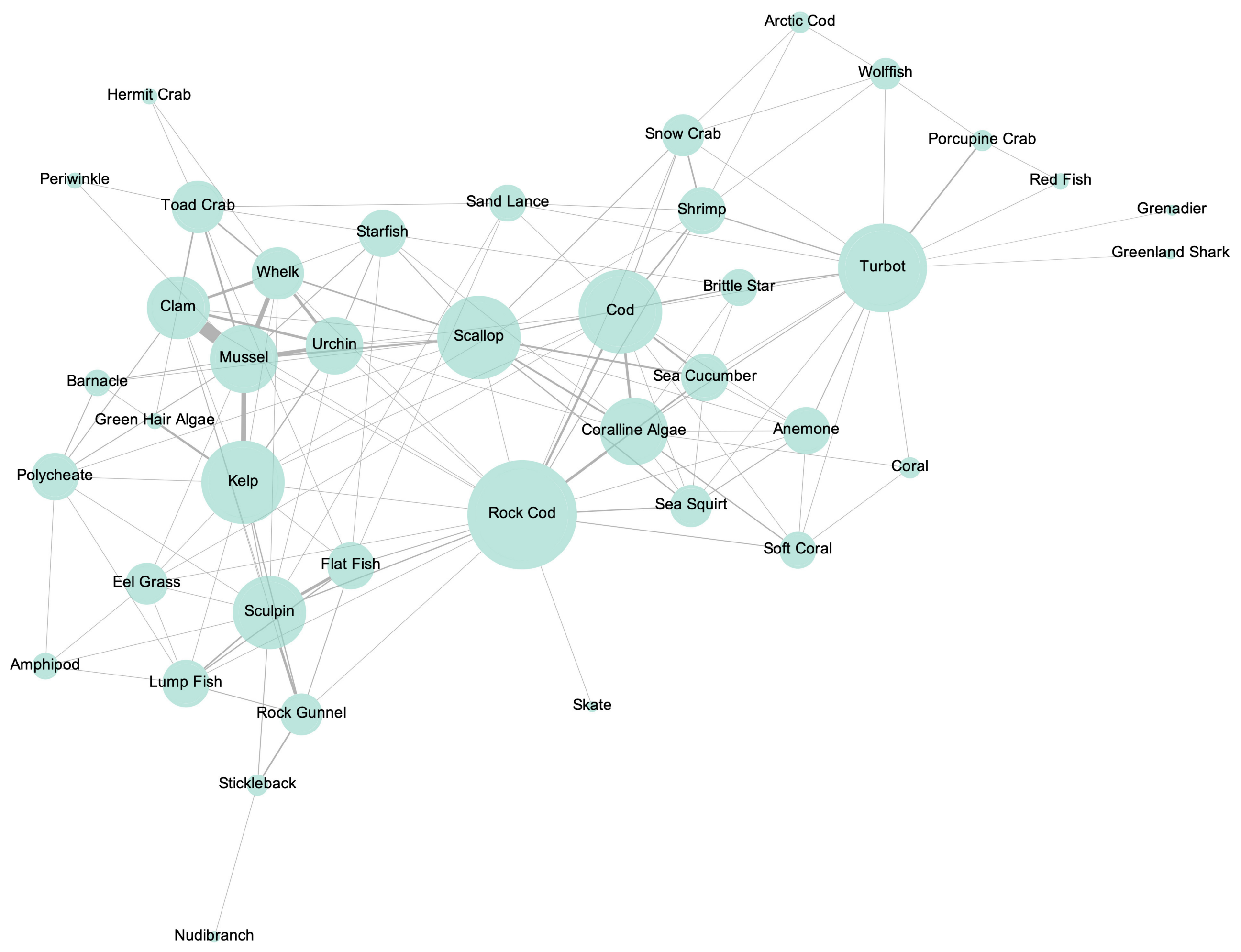

FIGURE 2
Relationships within the benthos. Network map representation of benthic species groups' relationships to each other within the Nunatsiavut coastal social-ecological system.

holders describe benthic life inhibiting Arctic char and Atlantic salmon net fishing. "I had some slug in my net this morning," a Hopedale knowledge holder said. "There was long stretches of plant life. Not stinky or smelly, but slimy. It's a pain in the ass to get out of your nets. It makes a difference. If there's too much, the char can see it." While several knowledge holders talked about the frustrations of checking their salmon and char nets just to find the fish had been skeletonized by whelks and urchins. Despite this, a Makkovik knowledge holder said the whelks make the Char tastier. "In later summer, if the fish are near the bottom of the net, the wrinkles will start eating the char. They get on there immediately. It makes the fish taste sweeter. The char that have the wrinkles on them taste sweeter."

Community members also spoke about the relationships between many benthic species groups to seabirds such as gulls, scoters, eider ducks, guillemots, black and brown ducks, mergansers, geese, loons, osprey, and Barrow's goldeneye (Doughty, 1979). "Gulls eat itiks, wrinkles, scallops—They bust the itiks open by dropping them from the sky. They do it with mussels too. On the islands they are all busted open. When you're over there for egging you can see them everywhere," said one knowledge holder in Hopedale. Another in Hopedale said, "Eiders eat from the bottom primarily. They mainly get shells and mussels. They eat little surf clams that are about an inch wide. They swallow them whole, and their stomachs are full of them. They feast on them in the fall. It changes their taste. They are tastier when they are eating these clams than the younger ones in the other seasons that are eating crabs and other bottom critters." Many reported multi-trophic interactions such as the complex relationships between mussels and sea urchins, birds, and terrestrial plants, especially berries. "Goose eat goose grass, and then they poop all over the blackberries, which makes them grow better. Then the cycle repeats," said one knowledge holder in Hopedale. In Nain, a knowledge holder explained how ravens eat mussels and leave the shells in the trees in the forest. When they are out spruce partridge hunting, they see shells in the trees and on the ground from the ravens. He explained that the shells help fertilize the forest.

Knowledge holders reported relationships between the benthos and marine mammals, including bearded, gray, harbor, harp, hooded, and ringed seals, walrus, polar bear, and otters. A

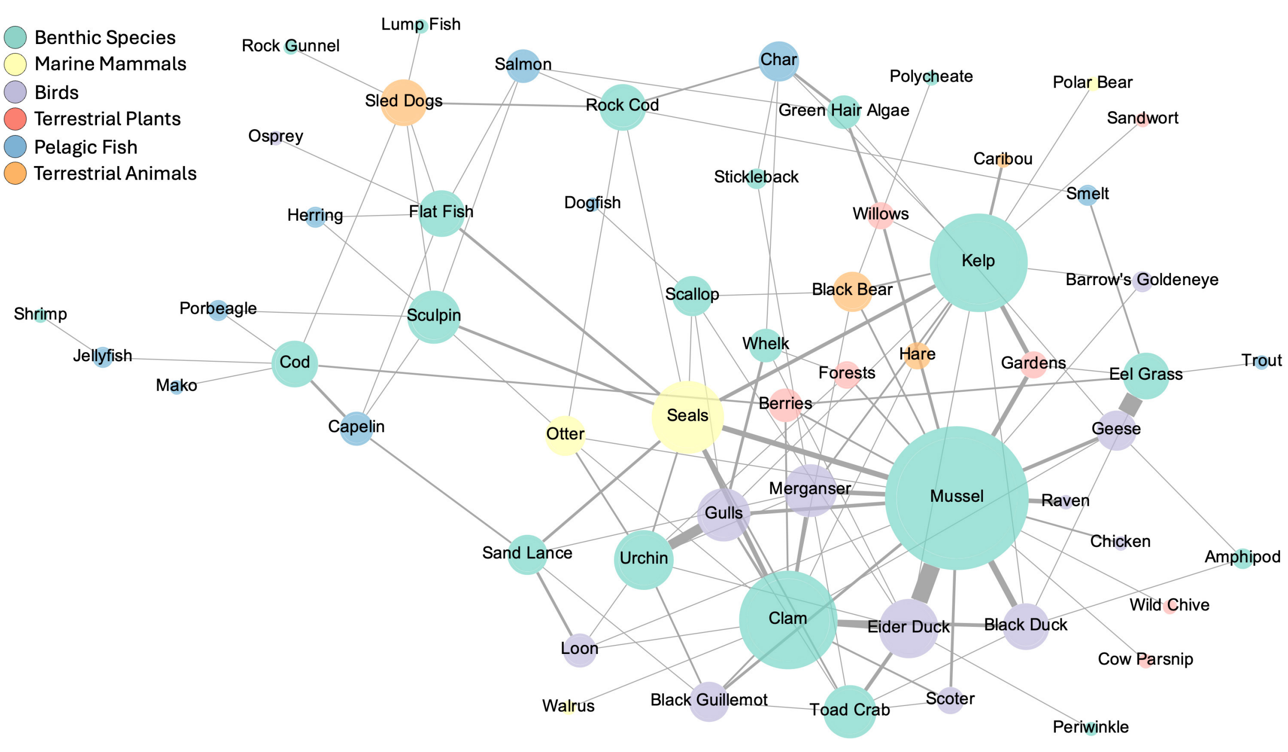

FIGURE 3
Species bipartite network. Network representation of benthic species groups' relationships with other marine and terrestrial flora and fauna within the social-ecological system.

knowledge holder in Nain described the food web relationships between seals and the benthos. "You can tell that some seals prefer benthic critters vs. fish because some have thick, long whiskers and others have short stubby ones depending on if they are eating off the bottom of the sea and wearing them down." Another in Hopedale asked, "You know that seals eat shark's blanket? Young harp seals do. They eat shrimp too. I shot some south of here that had eaten shrimp." Several knowledge holders reported that polar bears eat kelp. Another in Nain talked about how Labrador Inuit used to eat the clams from inside walrus' stomachs, saying it was a delicacy.

Among terrestrial animals, knowledge holders discussed benthic relationships to black bears, caribou, hare, dogs, and chickens. "I've seen black bears eating mussels, clams, and worms at the cabin. I sees them digging in the beach and I finds big claw marks in the sand and mud," said one person in Nain. Other knowledge holders along the coast reported caribou and hare eating seaweed for salt. Relationships between the benthos and terrestrial plants range from culinary to utilitarian. Willow, berries, cow parsnip, sandwort, wild chives, black spruce forests, and plants grown in gardens all have benthic relationships. Many knowledge holders along the Nunatsiavut coast talked about their favorite foods—especially the combination of red berries and stewed cod or cod livers. Others talked about using willow branches to clean fishing nets of seaweed and algae, and still others the use of seaweed and mussel shells as fertilizer in their gardens and to feed their chickens. In a recipe for pickled kuannik, a harvested kelp, sandwort is used to flavor the pickles.

3.4 Between the benthos and Labrador Inuit

Labrador Inuit knowledge holders described their active relationships to the benthos through a variety of activities such as commercial and subsistence fishing and harvesting, hobbies and crafting, medicine, dog sledding, hunting, berry picking, egging, gardening, play, leisure time and community building, tourism, research and education, and ceremony (Figure 4).

Labrador Inuit commercially fish several benthic species including snow crab, turbot, scallops, and shrimp (Cadman et al., 2024). In the past, Labrador Inuit have also commercially fished Atlantic cod and grenadier (Mills et al., 2018). Furthermore, according to knowledge holders, there have been additional attempts to commercially harvest sea urchins, whelk and rock cod. Through Labrador Inuit commercial fishing endeavors, knowledge holders report having built relationships with a variety of deep-water species such as sand lance, coral, porcupine crab, wolffish, redfish, arthropods, anemones, sea squirts, sea cucumbers, and others. Subsistence fishing and harvesting regularly includes several species such as cod, rock cod, clams, mussels, scallops, sea urchins, whelks, flat fish, sculpin, rock and Atlantic crabs, and several types of macroalgae (Brice-Bennet, 1977).

Mussels and clams are often harvested during hunting trips. "Anywhere we went, if we were off hunting, kill a seal, we'd see mussels. We'd always bring a bag. We'd carry big potato sacks for the things you find," explained a knowledge holder in Nain. Goose grass also plays an important role in tracking geese for hunting. "I take notice at the rattle in saltwater pond. If there's no geese the

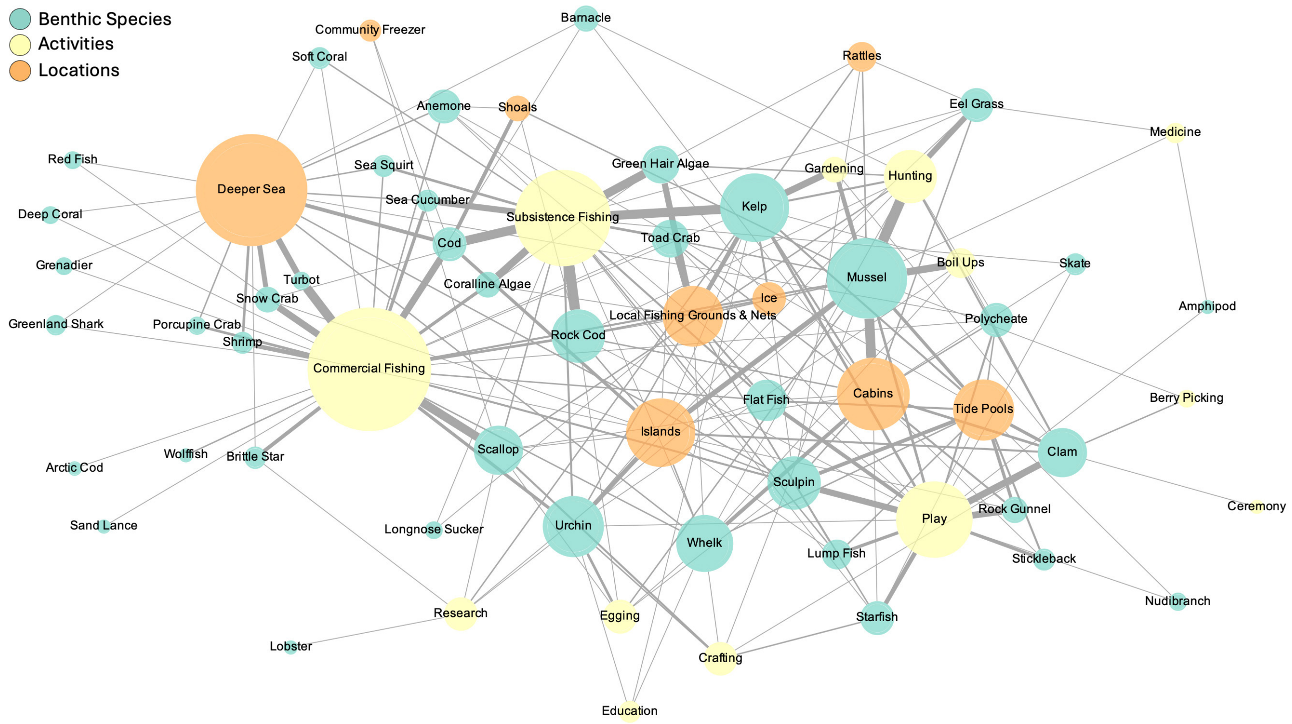

FIGURE 4
Benthos-location-activities tripartite network. Benthic species groups' relationships with Labrador Inuit activities and locations within the coastal social-ecological network.

goose grass tells you if the geese were there. They pick it and leave some along the shore. They always lose some along the way. Even if you don't see geese, you know it's them because nothing else hauls it up."

While going off on the land for berry picking, egg harvesting (egging), or to participate in "boil ups" —campfires on the shore— the benthos plays an important role. Knowledge holders often spoke about collecting clams, mussels, whelks, and urchins on the periphery of all these activities. Often mussels are cooked over an open fire during boil ups, frequently with kelp to enhance the flavor of the mussels and help the shellfish retain moisture.

Knowledge holders talked about using scallop, clam, whelk, and mussel shells as well as sea urchins for crafting and making art (Igloliorte, 2010). Several knowledge holders use the shells for making Christmas ornaments and nativity scenes. One talked about making snowmen out of dried urchins and even building miniature creches inside of them. Three elder knowledge holders spoke generally about the medicinal qualities of amphipods, goose grass, and mussels that they remembered from their parents and grandparents treating superficial cuts and other skin lesions but lamented not remembering the details of the practice.

Many knowledge holders participate in research activities that have deepened and expanded their relationships with the benthos. One knowledge holder talked about conducting box core surveys and getting to know several benthic species in the samples. Another talked of conducting archeology fieldwork explaining that Inuk sites in Labrador are full of mussel shells. Another knowledge holder conducts peregrine falcon surveys from a plane. He explained that he looks for beds of kelp in the water because it gets caught in his char nets, and he wanted to get a sense for how much of an issue it would be that season.

The benthos is an important source of food for dogs (Harris et al., 2020), as reiterated by several knowledge holders. One person from Rigolet described this relationship: "Our family had a dog team, and they would go feed themselves at low tide. They'd be out for hours at low tide eating lumpfish, sculpin, tansies, rock cod, and flat fish. The dogs would get tansies stuck up their noses, and it was such a pain to get them out with their spines. The dogs were nice and healthy though, eating all of this." On occasion, sled dogs are let out on islands in the summer to forage the nearshore benthos for food.

Almost every person discussed playing in the tidal zone in their youth or with their children or grandchildren and described the importance of these experiences, and how they imparted a sense of wonder and contentment. A knowledge holder from Rigolet described this experience: "When we were kids, we'd play on the shore and we'd get sculpins and take them and pretend we were hunting seals. The sculpin would be the seals. The small lump fish would be another animal, and the sea worms would be something else. And we'd play like we were hunting them. We were just pretending, us with our siblings." A knowledge holder in Postville credited playing with benthic animals with how he learned how to ask questions, think scientifically, and to be brave. In Hopedale, a knowledge holder said, "Playing when we were kids was how we interacted with these animals. Playing in the intertidal zone with friends. I sees kids doing it now, just for fun when the ice melts and you can explore. You don't need anybody, and you can do it on your own. It's part of developing independence."

Many themes are interrelated and interdependent, such as conservation, beauty, access, and abundance (Figure 5). For example, a knowledge holder that works in Voisey's Bay Mine said, "I like collecting pretty clam, mussel, and scallop shells. I saves it and uses it for show and tell. I work in camp and I've got a few friends that are 'environmentalists'." He emphasized with air quotes. "One asked for a 12-armed starfish if I can find it so he can keep it, but I don't want to do that, because there's no sense in killing it. Just take it out, admire it, and put it back." A young knowledge holder explained his childhood ambitions of living a sustainable life, saying, "At one point I wanted to live off of rock crab. I wanted to grab a net, walk out and eat crab every day. I thought it would be a really sustainable seafood and all natural. It was my fantasy of food sustainability." In this way, conservation implies protecting the relationships between Labrador Inuit and the benthos, not protecting it from people.

Relationships are not without conflict. Several knowledge holders reported their frustrations with the benthos. Toad crabs, sea urchins, whelks, coralline algae, green hair algae, and kelp frequently get in the way of ideal trout, salmon, and char fishing. Knowledge holders that participate in turbot fishing talked about porcupine crab being a delicious food to eat at your station during long stretches at sea, but also said they were very hazardous. "They taste so good, but they are a nuisance. You have to hammer them out of the net… They poke your fingers. It's just like a porcupine quill but thicker. They are dangerous too, because when you fish, if you pound them out of the net, little bits are still in it, and the fishermen are fast, and they let go of the net and it slides through their hands, and they get stuck with them."

The consistency of access and relative abundance of benthic species play a major role in food security for Labrador Inuit. Knowledge holders reported that mussels, clams, whelks and urchins are ever-present food sources that are abundant and readily accessible. This is especially important when out on the land and staying at family cabins. "We'd just go down and get clams or mussels whenever we needed some. It was good when you needed to change it up. You get tired of seal then you pick some mussels," reported a knowledge holder from Rigolet. "I love fishing for cuckoos," said a knowledge holder in Makkovik. "I will just put a bucket down and it just fills right up." Even people who don't enjoy eating them derive security from them, such as this knowledge holder from Makkovik: "I don't usually get clams or mussels. They are for necessity. If I get stuck at my cabin, I know they are there. I don't bother with urchins. Just like clams and mussels I don't need to, but if I were stuck somewhere and I didn't have any food, I would be fine." Knowledge holders reported that other benthic animals were generally consumed more in the past to weather times of scarcity, especially Atlantic and toad crabs, flat fish, and sculpin, but are still eaten at times and preferred by certain individuals.

3.5 The first thing I think about are mussels

As showcased in the sections above, Labrador Inuit maintain an immense breadth of relationships with the benthos, and these relationships have profound depth. This depth of knowledge is tied to the everyday experiences of Labrador Inuit and illustrates the many different types of relationships that exist. To illustrate the depth of the relationships between Labrador Inuit and the benthos, stories knowledge holders shared regarding a single species, mussels, will be showcased here:

"The first thing I think about are mussels," said one knowledge holder in Hopedale. Mussels are an essential part of Labrador Inuit life and have been for eons. One knowledge holder in Makkovik talked about conducting archeology surveys across outlying islands. He said that he developed an eye for knowing where archeology sites were because those sites have lush cow parsnip growing. The abundant cow parsnip, he said, is a result of mounds of buried and decomposing mussels enriching the soil. This is an example of how the relationships between the benthos and Labrador Inuit embody the relationships between the past, present, and future of the land and its people. In doing so, these relationships incarnate resilience.

Across every community, mussels are an important part of wellbeing, leisure time, and enjoying company with friends and family. One knowledge holder talked about a place outside of Hopedale called Uviloqtôk, or Mussel Island. In recounting the power of the mussel to bring people together, he said that people used to stay out on that island during weekends. It was so popular that a church was built there, but it stopped holding services in the 1940s or 50s. While berry picking, egging, hunting, fishing, or holding boil-ups, knowledge holders talked about bringing sacks or empty salt beef buckets to collect mussels to enjoy along the trip, to bring home, or to share with other family, especially elders that are no longer able to go out on the land. Mussels are frequently eaten raw, grilled, boiled, and pickled. In communities like Nain with accessible rattles—open water areas surrounded by sea ice—mussels are harvested year-round.

Even for those that don't enjoy eating mussels, they are still an important component of Inuit life in Labrador. "I don't bother with the mussels, but I do use the shells in the garden as fertilizer. I started doing it this year. Our soil up here is really acidic, and the mussel shells help that. It seems to help fix the soil. It's an experimental year though. I'm getting really into it and looking around to learn what I can do. I go off on the land and I get ideas there," reported a knowledge holder in Makkovik. Others collected mussel shells to give to their chickens to help with egg production. Mussels even play a role in tourism. One knowledge holder runs a chartered boat service to Hebron in the North of Nunatsiavut and mussel picking is a featured activity for visitors.

Young knowledge holders often reported happy memories of their time musseling with friends and family. "I used to go musseling in Makkovik. I took a bucket down to the beach and got them. I haven't done it since. I heard my mom talking about how her and my auntie used to go out and get mussels and I wanted to do it. I did it for the thrill of doing it. Just you." Some knowledge holders talked about crawling into ballycatters as children to pick mussels at low tide. Ballycatters are ice that builds up on the shoreline through breakage and reforming resulting from tidal action (English, 1967). In Hopedale, a young knowledge holder said, "I would collect mussels near the shoreline near my family's cabin when I was young. Me and my friends and family would do it just for fun as a kid. We would do it just to be outside doing

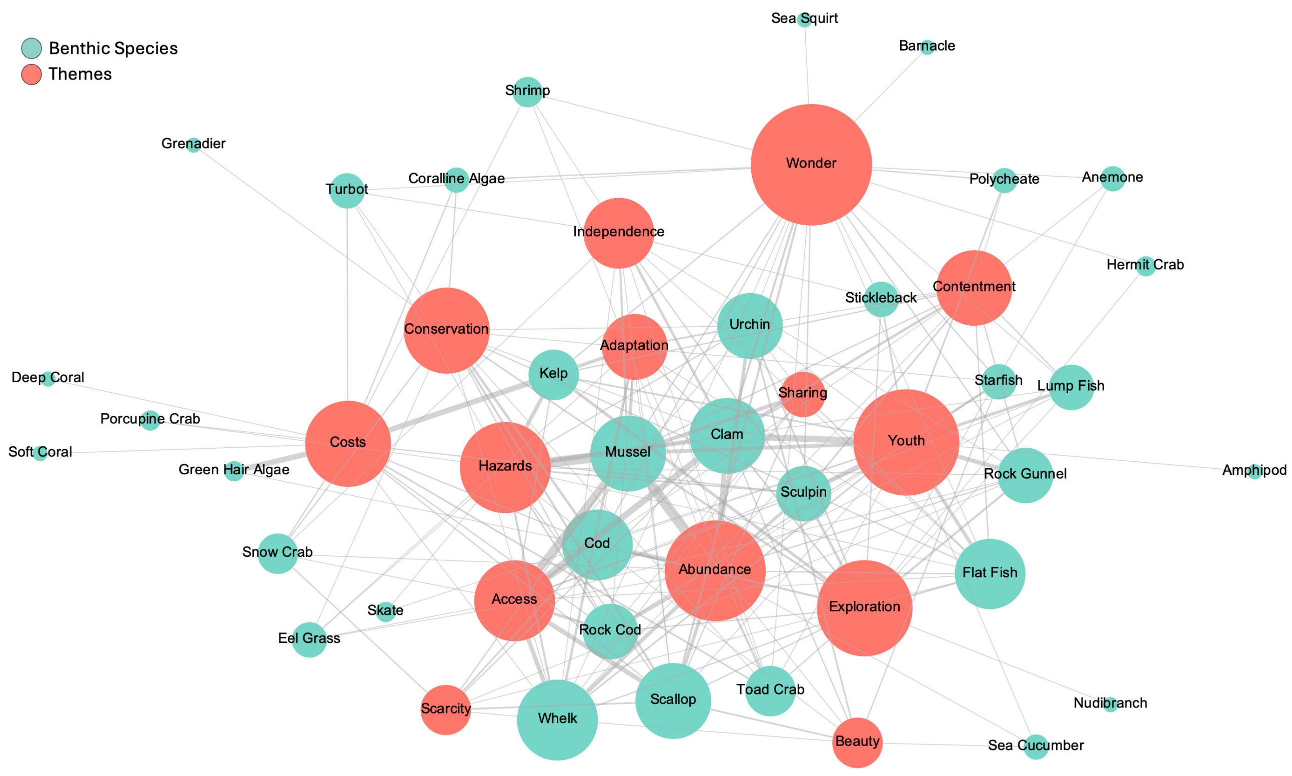

FIGURE 5
Benthic themes bipartite network. Conceptually thematic elements as they relate to the benthos within the Nunatsiavut coastal social-ecological system.

something even if it was cold in the spring and summer, as long as it was sunny. Doing this was a big deal as a kid."

Mussels' ever-presence and abundance constitute important aspects of food security. One Makkovik knowledge holder said "I was stuck at the cabin one time, and I got low on food, but I just went out for mussels. They are always available." A Nain knowledge holder referred to mussels as "the original community freezer"—a sentiment that was echoed along the coast. Mussels also indirectly impact food security, acting almost as co-conspirators while hunting eider ducks. "The eider ducks love mussels, they gorge themselves on them. Duck harvesting is in October and early November. We wait for low tide because the ducks are easier to harvest because they are too heavy. They can't take off as well. We call that 'being shelled.' They can't move because their throats are full of mussels. Just filled with blue mussels. You'll hear the guys saying, 'the ducks are shelled today' when they come back from hunting, and it means they are easy to get." As illustrated by Labrador Inuit knowledge holders, mussels are a very important resource for other harvested marine and terrestrial animals such as bears, and birds, and contribute to the growth of berries, gardens, and black spruce forests.

Labrador Inuit are also important to mussels. In Nain, one knowledge holder talked about how he's seen the mussels increase in size and become more abundant in the cove in which he built his cabin, which he attributes to the added nutrients in the water there from the cabin's waste and from butchering animals and gutting fish on the shore. In Hopedale, a knowledge holder recounted a story of the commercial cod fishing fleet. Boats used to dock and clean the cod fish on a particular island. This was his family's mussel picking location. When the cod moratorium was instituted in 1992, the mussels got smaller, he said. He attributes that to a reduction in nutrients in the water from the lack of fish processing occurring there.

Labrador Inuit also speak to the internal lives of mussels. Several knowledge holders remarked upon the fact that mussel meat is larger during the full moon. It's not only a time to harvest because of increased access, but also because of increased yield. Additionally, knowledge holders talked about mussel flavor changing throughout the year commensurate with ice form-up and ice breakup. The changing salinity impacts the flavor, and some Labrador Inuit expressed their preferences for the salty mussels and others for the sweet ones. They talked about mussels' preference for cohabitating with kelp, attaching themselves to the same rocks and holdfasts. They also reflected on sea star and urchin predatory behavior—saying they will both eat mussels given the chance.

Looking deeply at a single species such as mussels tells stories about its relationships that include elements of food, access, safety, security, play, and kinship. Species are deeply embedded in activities from beach combing to hunting. Tracing the relationships between benthic species, the benthos and other animals and plants, through activities, places, and themes similarly reveals the depth of relationships attached to each benthic species (Figures 2–5).

3.6 Changing relations

Knowledge holders expressed concerns and questions about the benthos. Many were concerned about the safety of eating mussels, clams, whelks, and urchins given warming water temperatures. They were wary of eating them and wanted to know indicators for safe consumption of shellfish given the rapidly warming water temperatures in coastal Nunatsiavut (Manore, 2018). Of particular concern was the potential for increased parasite load, especially in mussels, clams, and rock cod. Across Nunatsiavut, knowledge holders wanted to know if they were sustainably harvesting mussels, concerned that they may be picking too many, too frequently, or harvesting from limited locations. Also of interest was a desire for more information on potential heavy metal, methylmercury, polychlorinated biphenyl (PCB), and wastewater contamination of harvested benthic species close to towns, near past and present mining sites, and in proximity to an abandoned U.S. radar base with known PCB contamination (Muir et al., 2025; Schartup et al., 2015; Calder et al., 2016). Several expressed frustrations over perceived research prioritization of commercial fish and rarer species as compared to non-commercial and more abundant seafood resources that Labrador Inuit depend on directly and indirectly for food security. In Rigolet, knowledge holders wanted to know why mussels had changed size and locations after the establishment of the Churchill Falls dam (Bishop et al., 2022). In Nain, knowledge holders wanted to know what happened to the flatfish that they haven't seen in the same abundance and size in decades. In Postville, they asked if the community's sewage was impacting the nearshore benthic animals. In Makkovik and Rigolet, knowledge holders expressed deep concern over ghost fishing gear from cod fishing fleets (Fisheries and Oceans Canada, 2024), saying they believe it is affecting cod spawning grounds and increasing cod and snow crab mortality.

3.7 Network centrality roles of benthic species

Mussels play an outsized role across all four networks and five centrality measurements due to their numerous interactions with benthic and non-benthic species and the lives of Labrador Inuit (Table 3). This is indicative of mussels' crucial role in both ecological and social-ecological systems within coastal Nunatsiavut. Mussels' strong connection, bridging role, and influence highlight its likely importance in maintaining network stability and facilitating interactions between many species as well as between benthic species and Labrador Inuit. Species like turbot, rock cod, kelp, and clams frequently appear with high betweenness and closeness centrality. Their roles as efficient network connectors indicate their fundamental nature supporting social-ecological resilience and robustness. The high eigenvector centralities of mussels, clams, and cod suggest that these species contribute significantly to networks' stability and resilience due to their positions within each network. It is important to note these species with high centrality values as they are less frequently commercialized within the region and in high abundance, and therefore have lower research investment (Pita et al., 2020). This points to a potential mismatch between the species in which research energy is invested and which species support social-ecological resilience.

TABLE 3 Benthic species network centrality metrics.

Centrality type	1st	2nd	3rd
Benthic species network centrality (Figure 2)			
Degree	Rock cod	Atlantic cod	Turbot
Weighted degree	Mussel	Clam	Rock cod
Betweenness	Turbot	Rock cod	Scallop
Closeness	Rock cod	Atlantic cod	Kelp
Eigenvector	Mussel	Clam	Whelk
Benthic and non-benthic species bipartite network centrality (Figure 3)			
Degree	Mussel	Kelp	Clam
Weighted degree	Mussel	Eel Grass	Kelp
Betweenness	Mussel	Kelp	Atlantic cod
Closeness	Mussel	Clam	Kelp
Eigenvector	Mussel	Clam	Eelgrass
Benthic species, places, and activities tripartite network centrality (Figure 4)			
Degree	Whelk	Clam, mussel, scallop	Cod, flatfish
Weighted degree	Mussel	Clam	Kelp, cod, scallop
Betweenness	Mussel	Clam	Scallop
Closeness	Scallop	Atlantic cod	Mussel
Eigenvector	Mussel	Clam	Atlantic cod
Benthic species and themes bipartite network centrality (Figure 5)			
Degree	Mussel	Kelp	Urchin
Weighted degree	Mussel	Kelp	Scallop
Betweenness	Mussel	Kelp	Clam
Closeness	Kelp	Urchin	Scallop
Eigenvector	Atlantic cod	Kelp	Mussel

Benthic species that hold the first, second, and third most central place in the benthic species networks (Figures 2–5) as measured by degree, weighted degree, betweenness, closeness, and eigenvector centrality for each network described and illustrated above.

Most important, however, is the diversity of species that play network centrality roles. This diversity is indicative of a complex, resilient system. Even though there is a selection of benthic species that have high network centrality, this should not discount the importance of the rest of the benthos to the overall function and resilience of the social-ecological system. Each species plays important and varied roles, and it is the diversity of these roles that impart resilience. This is why it is important to understand the depth and breadth of these relationships in a qualitative manner beyond decontextualized centrality measurements. Dominant social and natural science practice relies on the decontextualization of relationships and therefore oversimplification of complexity, which can obscure reality (Avilés Irahola et al., 2022). This is problematic when working with Inuit knowledge, given it is highly contextualized within Inuit onto-epistemology and connection to place (Bishop et al., 2022). It is important to understand that the relationships and networks demonstrated here are contextualized through Labrador Inuit experience, knowledge, and storytelling. Each link between benthic species, to other plants and animals is Labrador Inuit knowledge and experience. This is the scaffolding for each network. Therefore, even when observing the network within the benthos, it is impossible to extricate people from the system.

3.8 Implications

In establishing social-ecological baselines, it's important to understand not only the components of a system but also the many ways in which they are related—how they support each other, depend on each other, and are impacted by one another. These relationships are the fabric of resilience (Cajete, 1999). When these bonds are altered, through climate change, development, or social or technological changes, it can have major impacts on the entire system. For example, knowledge holders described how development (dams), geopolitical events (U.S. radar base destruction at the end of the cold war), and climate change all contributed to the increase in persistent pollutants in the environment that impact shellfish. As demonstrated here, mussels play important roles in the lives of Labrador Inuit directly as a source of food security, indirectly as food for waterfowl and marine mammals, and intangibly as a source of joy through crafting and time with family on the land. However, the effects of external drivers are never clear-cut. Even for climate change, increases in water temperature may make mussels grow bigger more quickly, which may mean more habitat, more harvesting, and potential commercialization opportunities (Zippay and Helmuth, 2012; Ytrøy, 2008). When viewed this way, one can see how change radiates throughout a system to effect resilience in nuanced ways.

Setting social-ecological baselines may also help steer research and environmental monitoring in directions most relevant for communities. In searching for literature on mussels within Nunatsiavut, we only found one published journal article (Calder et al., 2016), which investigated methylmercury content across several benthic species. This may suggest opportunities for monitoring programs for frequently consumed benthic invertebrates within the region. Tailoring research to community interest and needs is especially important considering the 20-fold increase in environmental research conducted on Indigenous lands and waters in the past two decades, especially within the Arctic (David-Chavez and Gavin, 2018; Aksnes et al., 2016). This increase in research has contributed to research fatigue, which in turn can reduce community engagement (Flåøyen, 2023).

Directing research efforts toward community interests can help reduce research fatigue while also creating space for Indigenous agency over setting research agendas (Koster et al., 2012). As Inuit and other Indigenous Peoples have described in their own research protocols, it is ethical and essential for researchers to engage with community members at every step of the research journey (ITK, 2018; Carroll et al., 2020; Bull, 2019). After establishing social-ecological baseline networks, it's important to continue conversations with communities to understand how evolving environmental and social drivers affect the overall social-ecological system, as it is never static. Furthermore, community members, with wide and profound knowledge of their environment, can and should be those engaged in monitoring species of social-ecological relevance. Integrating local and traditional knowledge into ecological monitoring and assessment can dramatically increase their impacts and reliability while simultaneously helping to preserve traditional ecological knowledge (Bauer et al., 2022). Understanding the drivers of relational change and measuring their effects within this system are important next steps. But to do so in ethical and efficient ways, there first needs to be an understanding of how species are situated within the larger social-ecological system. This may lead to more targeted, ethical, and responsive science for communities, greater community engagement in the scientific process, and more efficient targeting of limited resources, while respecting traditional ecological knowledge.

Data availability statement

The datasets presented in this article are not readily available because the anonymized analyzed datasets for this study as well as the deidentified interview data can be requested from the Nunatsiavut Government Inuit Research Advisor. The datasets are decontextualized data only and should only be used to reproduce networks and network centrality measurements. They should not be used or interpreted independently from their context. All data collected in this study are held by the Nunatsiavut Government Research Centre, and all collected data are owned by Nunatsiavut knowledge holders and community members involved in this study. Contact the Nunatsiavut Government Inuit Research Advisor for reuse of de-identified data gathered as part of this study. Requests to access the datasets should be directed to research@nunatsiavut.com or through the Nunatsiavut Government Research Advisory Committee at: https://nunatsiavutresearchcentre.com/ngrac/.

Ethics statement

The manuscript presents research on animals that was approved by the Nunatsiavut Government Research Advisory Committee.

Author contributions

KO: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. JJ: Formal analysis, Validation, Writing – review & editing. MS: Conceptualization, Methodology, Resources, Writing – review & editing. JS: Funding acquisition, Methodology, Supervision, Writing – review & editing. MB:

Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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