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Community experiences and perceptions of aquatic change in ᑭᙵᐃᑦ, ᓄᓇᕗᑦ (Kinngait, Nunavut)

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Abstract

Climate change and development are shaping Arctic ecosystems in unprecedented ways intimately known to Inuit. To document changes in aquatic habitats and species near Kinngait, Nunavut, researchers co-created a questionnaire with the Aiviq Hunters and Trappers Association and community technicians. Inuit knowledge, centered on experiences and perceptions of marine, coastal, and lacustrine shifts, was gathered from 39 knowledge holders. Responses indicated that across ecosystems, turbidity and waves are not likely changing, wind and erosion may be changing, and water is warming. Ice is thinner, breaking up earlier, forming later, and diminishing in extent. These shifts are altering harvest timing in the spring and winter, and are rendering travel on the land increasingly difficult. While most knowledge holders reported no change in the diversity and abundance of marine mammals, fishes, and invertebrates, others expressed that ringed seal and beluga whale may be declining, salmon are appearing, and mussels are proliferating. Inuit insights and voices consolidated through this endeavour will serve the community and contribute to a baseline of knowledge to help understand ongoing change.

Key words: Inuit knowledge, community-based participatory research, aquatic change, questionnaire, Arctic

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ᓯᓚᖓ ᐊᓯᔾᔨᕐᓂᖓ ᐊᒻᒪ ᐱᕙᓪᓕᐊᓂᖓ ᐋᖅᑭᔅᓯᔪᑦ ᐅᑭᐅᑕᖅᑐᒥ ᐊᕙᑎᖏᓐᓂᒥ ᓂᕆᐅᓇᖏᑦᑐᓂᑦ ᖃᐅᔨᒪᔭᐅᔪᓂᑦ ᐃᓄᓐᓄᑦ. ᓇᓗᓇᐃᔾᔪᑎᑦ ᐊᓯᔾᔨᖅᑐᑦ ᐃᒪᖏᓐᓂ ᓇᔪᖅᑕᐅᕙᑦᑐᑦ ᐊᒻᒪ ᐆᒪᔪᐃᑦ ᖃᓂᒋᔮᖓᓂ ᑭᙵᐃᑦ, ᓄᓇᕗᑦ, ᖃᐅᔨᓴᖅᑏᑦ ᓴᖅᑭᑎᑦᑎᖃᑎᖃᖅᓯᒪᔪᑦ ᐊᐃᕕᖅ ᐆᒪᔪᕐᓂᐊᑎᒃᑯᑦ ᑲᑐᔾᔨᖃᑎᒌᖏᓐᓂ ᐊᒻᒪ ᓄᓇᓕᒻᒥ ᐱᓕᕆᕆᔩᑦ. ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᖏᑦ, ᕿᒥᕐᔭᖓ ᐊᑐᖅᑕᐅᕙᑦᑕᖅᓯᒪᔪᑦ ᐊᒻᒪ ᐃᓱᒪᒋᔭᐅᔪᑦ ᐃᒪᖓᓂ ᓄᓇᐅᑉ ᑭᓪᓕᖕᖏᓐᓂ, ᐊᒻᒪ ᐃᖅᑲᖓᓃᑦᑐᑦ ᑲᑎᖅᓱᖅᐸᓪᓕᐊᓯᒪᔪᑦ ᓴᖑᓂᖏᑦ, ᑲᑎᖅᓱᖅᑕᐅᓚᐅᖅᑐᑦ 39 ᖃᐅᔨᒪᓂᐅᔪᓂᑦ ᑎᒍᒥᐊᖅᑎᓂᑦ. ᑭᐅᔾᔪᑎᐅᔪᑦ ᓇᓗᓇᐃᖅᓯᓚᐅᖅᑐᑦ ᐊᕙᑎᓕᒫᖏᑦ, ᐃᓱᕐᓂᖓ ᐊᒻᒪ ᒪᓪᓕᖏᑦ ᐊᓯᔾᔨᓂᐊᖅᑑᔮᖏᑦᑐᑦ, ᐊᓄᕆ ᐊᒻᒪ ᓄᖑᑎᕐᓂᐅᔪᑦ ᐊᓯᔾᔨᕙᓪᓕᐊᒍᓐᓇᖅᑐᑦ, ᐊᒻᒪ ᐃᒪᖓ ᐆᓇᖅᓯᕙᓪᓕᐊᓪᓗᓂ, ᓯᑯᖓ ᓵᓐᓂᖅᓴᐅᓕᖅᑐᓂ, ᓯᑯᐃᖅᓴᕋᐃᓐᓂᖅᓴᐅᕙᓕᖅᑐᓂ, ᓯᑯᓇᓵᕐᓂᓴᐅᓪᓗᓂ, ᐊᒻᒪ ᓄᖑᑉᐸᓪᓕᐊᔪᑦ ᐊᖏᓂᖓᓄᑦ. ᑖᒃᑯᐊ ᐊᓯᔾᔨᖅᑐᑦ ᐊᖃᓄᐃᓕᓂᖃᖅᑎᑦᑎᔪᑦ ᐊᖑᓇᓱᓐᓂᕐᒧᑦ ᖃᖓᒃᑰᓂᖓᓄᑦ ᐅᐱᕐᖓᖓᒃᑯᑦ ᐊᒻᒪ ᐅᑭᐅᒃᑯᑦ, ᖃᓄᐃᓕᓂᖃᖅᑎᑦᑎᔪᑦ ᐊᐅᓪᓚᓂᕐᒧᑦ ᓄᓇᒃᑯᑦ ᐱᓪᓚᖅᓯᕙᓪᓕᐊᓪᓗᓂ. ᖃᐅᔨᒪᓂᐅᔪᑦ ᑎᒍᒥᐊᖅᑎᐅᔪᑦ ᑐᓴᖅᑎᑦᑎᓯᒪᔪᑦ ᐊᓯᔾᔨᖅᓯᒪᖏᑦᑐᑦ ᐆᒪᔪᐃᑦ ᐊᔾᔨᒌᖏᑦᑐᑦ ᐊᒥᓱᑦ ᐊᒻᒪ ᐱᑕᖃᑦᑎᐊᖅᑐᓂ ᐃᒪᕐᒥᐅᑕᓂᑦ ᐆᒪᔪᓂᑦ, ᐃᖃᓗᐃᑦ, ᐊᒻᒪ ᓴᐅᓂᖃᖏᑦᑐᑦ, ᐊᓯᖏᑦ ᐃᓚᖏᑦ ᓇᓗᓇᐃᖅᓯᔪᑦ ᑖᒃᑯᐊ ᓇᑦᑏᑦ ᐊᒻᒪ ᕿᓚᓗᒐᐃᑦ ᐊᑦᑎᓕᕙᓪᓕᐊᓪᓗᑎ, ᐃᓪᒪᓐ ᓴᖅᑭᖃᑦᑕᓕᖅᑐᑎᑦ, ᐊᒻᒪ ᑯᑭᐅᔭᐃᑦ ᓱᑲᑦᑐᒥᑦ ᐊᒥᓱᕈᖅᐸᓪᓕᐊᓂᖏᑦ. ᐃᓄᐃᑦ ᑐᑭᓯᐅᒪᓂᖏᑦ ᐊᒻᒪ ᓂᐱᖏᑦ ᑲᑎᑦᑎᑕᐅᓯᒪᔪᑦ ᑖᔅᓱᓇ ᐱᓕᕆᐊᒃᑯᑦ ᐱᔾᔪᑎᓂᐊᖅᑐᑦ ᓄᓇᓕᒻᒥᑦ ᐊᒻᒪ ᑐᓂᓯᓗᑎ ᑐᙵᕕᖏᓐᓄᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᓂᑦ ᖃᐅᔨᒪᔭᐅᔪᓂᑦ ᐊᓯᔾᔨᕐᐸᓪᓕᐊᓂᖅᑐᒥᑦ.

ᐅᖃᐅᓯᓪᓗᐊᑕᐃᑦ:kwdx1403;x14C4;x1403;x1466;x1583;x1405;x1528;x14AA;x152D;x158F;x1466;, ᓄᓇᓕᒻᒥ ᐃᓚᒋᔭᐅᖃᑕᐅᓂᕐᒧᑦ ᖃᐅᔨᓴᕐᓂᖅ, ᐃᒪᖏᑦ ᐊᓯᔾᔨᖅᑐᑦ, ᐊᐱᖅᑯᑏᑦ, ᐅᑭᐅᑕᖅᑐᖅ

1. Introduction

Across Inuit homelands in the place known to some as Canada (Inuit Nunangat[1]), communities are facing unprecedented challenges associated with warming occurring nearly three times faster than the global average (Ford et al. 2021; IPCC 2022). In the Arctic aquatic environment, climate change-related disruptions are profoundly affecting the distributions, seasonal ranges, phenology, and interactions of species (Wassmann et al. 2011; AMAP 2017; Huntington et al. 2020). Meanwhile, changes in temperature and sea ice are resulting in heightened shipping, tourism, and more inten-

[1] Inuit Nunangat (ᐃᓄᐃᑦ ᓄᓇᖓᑦ; includes lands, waters, and ice) is a distinct geographic, cultural, and political region encompassing the Inuvialuit Settlement Region (Northwest Territories and Yukon Territory), Territory of Nunavut, Nunavik (Northern Québec), and Nunatsiavut (Northern Labrador).

sive exploration and exploitation of oil and gas, minerals, and fisheries (Arctic Council 2009; AMAP 2018; Dawson et al. 2020). This multiplicity of threats renders it critically important to discern the magnitude and direction of environmental and biodiversity change. Focusing on shifts occurring at the community scale can enable the identification of species and habitats for assessment and conservation priority, and highlight the ways in which local individuals are affected by changes. Partnerships between Inuit and Western scientists over the past two to three decades have enhanced our collective insight into shifting ecosystems; however, further research centering Inuit voices is needed.

The author team is composed of community leaders in wildlife and resource management and conservation in Kinngait, Nunavut (Aiviq Hunters and Trappers Association; AHTA[2]), community technicians (OM, SP, PQ), and researchers of settler descent.[3] To ensure clarity throughout this manuscript, the non-Inuit (or Qallunaat[4]) authors define our understanding of Indigenous knowledges as a "cumulative body of knowledge, practice, and belief,[5] evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 2018, p. 8). According to McGregor (2004), Indigenous knowledges "encompass […] such aspects as spiritual experience and relationships with the land" and are expressed as a "way of life" and "something that you do" (p. 79). Hereafter, we use *Inuit knowledge* for specificity, and note that the value-centric term *Inuit Qaujimajatuqangit* (IQ) is often used similarly and is defined by Elders as "Inuit ways of knowing, ways of being, and worldview—past, present, and future" (Canadian Polar Commission 2003, p. 6; Karetak et al. 2017). The non-Inuit authors recognize that we do not have access to the full scope of meaning encompassed by these terms, and that community members undoubtedly have unique experiences, and therefore definitions, of Inuit knowledge.

This study focuses on changes in aquatic habitats and species near the community of ᑭᓇᐅᔭᖅ (Kinngait) (64°13′N, 76°32′W; population: 1396, 94% Inuit, Statistics Canada 2022) (Fig. 1). *Kinngait* means "where the hills are" in reference to a mountain on the island that is part of the Kinngait Mountain range.[6] This hamlet is located in the Qikiqtaaluk Region of Nunavut on a small island off the southwestern tip of Baffin Island (Foxe Peninsula) (Fig. 2). Situated on the northern shore of the Hudson Strait, Kinngait has also been referred to as *Sikusilaaq*, meaning "where there is no ice", for the strong currents through the strait that prevent extensive ice formation and result in open water year-round (Henshaw 2006; Laidler and Elee 2008). The proximity of the floe edge and the dynamic sea ice and open water environment near this community characterize local conditions and seasonal processes (Laidler et al. 2010), with this phenomenon being unique in Nunavut (Kelley and Ljubicic 2012). These uncommon features may support species and habitats or allow for biological processes not found elsewhere. Moreover, the year-round open water in the Hudson Strait is contributing to its intensive (and increasing) use as a shipping corridor, and possible adverse effects such as underwater noise or water pollution (Kelley and Ljubicic 2012). These stressors render it important to understand the current state of biological and environmental parameters, how they are shifting, and how these changes are affecting Kinngarmiut (people of Kinngait).

In partnership with the AHTA in Kinngait, our aim was to document experiences and perceptions of environmental and biological change in marine, coastal, and lacustrine ecosystems as well as associated changes in harvesting practices. We use the community's understanding and definitions of these ecosystems, with "marine" encompassing the area beyond the low tide line where there is open water, and "coastal" encompassing the area from the shoreline out to the low tide line. Under the guidance of the AHTA, and through collaborations with community technicians and knowledge holders, we created a written record to retain this knowledge for future generations, and to serve as a baseline for the community in the context of continuous change. The results of this project belong to the community of Kinngait, and can therefore be used in the ways that community leaders wish. It is our hope that this will aid Kinngarmiut in preparing for a future shaped by climate change and increased development. On a broader scale, this study responds to the need for research that also considers social implications of climate change (Wheeler et al. 2020; Worden et al. 2020; Ford et al. 2021), and to calls for approaches that support Inuit self-determination[7] (e.g., Tondu et al. 2014; Carter

[2] In the territory of Nunavut, the Land Claims Agreement allocates the implementation of resource management and environmental monitoring decisions to community Hunters and Trappers Associations (HTAs) or Organizations (HTOs) (INAC 1993; Lokken et al. 2019). HTAs and HTOs often partner with southern researchers to address shared research questions and priorities. In Kinngait, members of the AHTA are elected by the community, and the AHTA has the authority to speak on behalf of the community on subjects pertaining to local resource management.

[3] AKD, LRC, VMN, SMA, and KMD are researchers of settler descent who reside in southern Canada. This research is informed by their environmental and social science backgrounds within academia and government, and is shaped by their collective experiences conducting research with Indigenous communities within and beyond Inuit Nunangat. This paper builds upon the efforts of many Indigenous Peoples, communities, and organizations, and of colleagues in this field.

[4] Qallunaat is a term used to refer to non-Inuit (or Southerners), with the spelling specific to the Qikiqtaaluk (Baffin) region of Nunavut. Qablunaat is more commonly used in the Kitikmeot and Kivalliq regions (Canadian Polar Commission 2003; Tester and Irniq 2008).

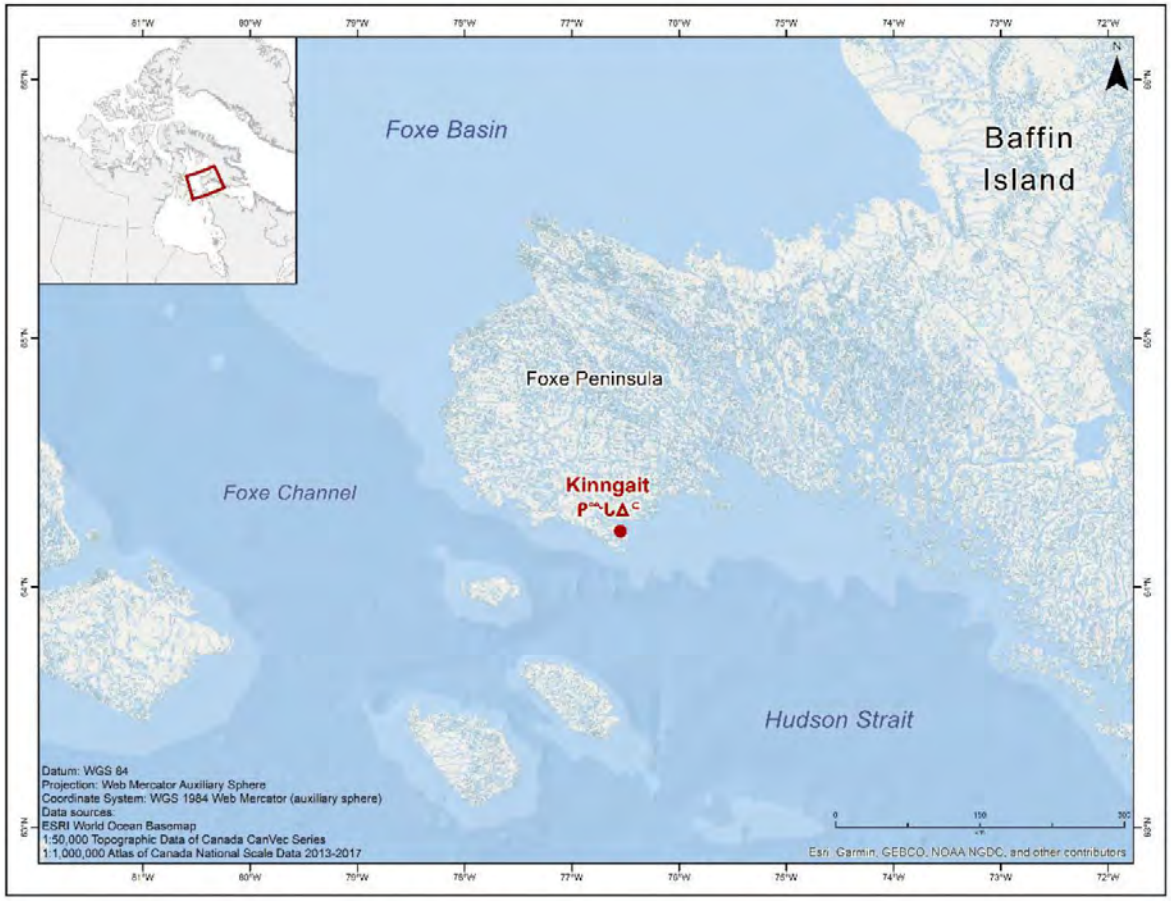
[5] See Reo (2011) for insights into interrelationships between knowledge, practice, and belief.

[6] We use Inuktitut names in syllabic or Roman orthography whenever possible. Indigenous names are records of linguistic heritage and land use history, and can indicate locations of significant events, ecologically important areas, landscape features, and refer to potential dangers (Henshaw 2006; Wong et al. 2020).

[7] Self-determination is the expression of sovereignty; the right to self-government and autonomy in the pursuit of economic, social,

Fig. 1. Overlooking ᑭᖅᓴᒐᑦ (Kinngait) and the Hudson Strait. Credit: Dana Pootoogook.

Fig. 2. Map of ᑭᖅᓴᒐᑦ (Kinngait) and surrounding areas in ᓄᓇᕗᑦ (Nunavut). Land, waterways, and place names accessed from Natural Resources Canada 1:50 000 and 1:1 000 000 scale data (Natural Resources Canada 2017*a*, 2017*b*). Basemap accessed from Esri World Ocean Base (Esri 2014). Credit: Jarrett Friesen.



et al. 2019; Wong et al. 2020; ICC 2021). Through consistent communication and mutual respect, we endeavoured to engage in this research "in a good way", where the research process is as important as the results, and relationships and accountability are central (Ball and Janyst 2008; Wilson 2008; AHA Centre 2018).

and cultural development (United Nations 2007; Borrows and Rotman 2018).

2. Methods

2.1. Methodology

This research was conducted following a community-based participatory research methodology, which studies a phenomenon with the full engagement of those affected by it, and involves collaborative efforts to develop a research plan, gather data, and conduct analyses (Breitbart 2016). This approach commits to applying findings in a manner that benefits the community in tangible ways. This is similar to participatory action research, which emphasizes the involvement of community members in research design and process (Banks et al. 2013). Both of these participatory approaches enhance community capacity and require continuous dialogue between researchers and community members (Breitbart 2016). Participatory research often uses mixed methods, which apply the strengths of both qualitative and quantitative approaches to obtain a greater degree of detail than the independent use of either method (Creswell and Creswell 2018). The mixed method approach used in this paper draws upon text and statistical analyses.

2.2. Project initiation, questionnaire co-creation, and content

Christie et al. (2023*a*) provide the complete details regarding project initiation, questionnaire co-creation, and questionnaire content. This information is provided separately in order to be thorough and transparent in the reporting of these methods (Drake et al. 2022, 2023). Briefly, community interest in an Inuit knowledge study about aquatic ecosystems in Kinngait, Nunavut, was explored in 2019 and 2020 during the implementation of a coastal monitoring program (Arctic Coast program) by the AHTA and Fisheries and Oceans Canada (DFO) team (KMD, LRC, and others). The AHTA was interested in documenting knowledge about nearby coastal, marine, and lacustrine ecosystems to understand environmental conditions and biodiversity change over time, and in broader geographic areas than coastal monitoring sampling sites. Priority questions for the community included changing species abundance and diversity, altered habitat features and the timing of these changes, and the impacts of changes on harvesting. In late 2020, the DFO team and AHTA decided to conduct questionnaires[8] that could be remotely co-developed and administered by community technicians (OM, SP, PQ) to adapt to COVID-19 travel restrictions.[9] An initial draft questionnaire created by DFO and academic authors focused on changes associated with aquatic ecosystems surrounding Kinngait as observed or experienced in the lifetime of participants, where insights into biodiversity at different trophic levels (marine mammals, fishes, invertebrates, plants) were sought.[10] This draft was revised through audio teleconferences (AKD, LRC, OM, SP, PQ present) in January 2021 to ensure alignment with community objectives and to optimize accessibility for knowledge holder participants. Conversations were focused on content (i.e., whether the technicians thought the community might be interested or have knowledge related to various topics) and structure (i.e., whether they thought certain options made sense in terms of the responses we might receive), and questions were re-worded for clarity. AKD and LRC reviewed the questions with the community technicians to ensure that we shared an understanding of the intent of each question, after which a revised questionnaire was provided to the AHTA for approval (Table 1, see Supplementary File 1 for final questionnaire in English and Inuktitut). This work was conducted under a scientific research license (0101221 N-M) from the Nunavut Research Institute, and we received ethics clearance (project ID #115098) from the Carleton University Research Ethics Board.

2.3. Participant recruitment and questionnaire administration

The community technicians created a list of potential questionnaire participants, 39 of whom were then selected by the AHTA. Research participants were active or past users of local lakes, marine areas, and travel routes for fishing and hunting, and holders of ecological knowledge associated with these areas. Both Elders and non-Elders[11] participated, as the AHTA wished to include participants with a range of experience levels. Non-random sampling is commonly used when seeking expert knowledge; however, this method does not enable us to ascertain whether our results may be generalized to the community level (Drescher et al. 2013; Creswell and Creswell 2018). As the participants were experienced and recognized knowledge holders or leaders within the community, and our sample size was reasonable, we have a greater degree of confidence that questionnaire results may represent community knowledge. All 39 questionnaires were administered from March 10–25, 2021 in the homes of participating knowledge holders by the com-

[8] We define 'questionnaire' as a tool used to acquire information about a population by administering standardized questions to a sample of individuals (McLafferty 2016). Information gathered is often at the household level (e.g., demographics, ecosystem service use, livelihood activities, stressors) or individual level (e.g., related to perceptions, values, sense of place). Questionnaires are structured and can provide quantitative and qualitative data (the latter through open-ended questions).

[9] Our original intent prior to the onset of the COVID-19 pandemic was to conduct in-person interviews in Kinngait to compile and document this knowledge. When travel restrictions were introduced, video or telephone interviews were considered but were not deemed feasible due to difficulties, including language barriers, bandwidth, and technological capacity.

[10] This draft included environmental, biological, and harvest-related questions addressed through close-ended (e.g., checkboxes) and open-ended questions, the latter which enabled qualitative data compilation for contextual insight. The questionnaire was organized by ecosystem, and structured such that sections were related, but could stand alone if challenges were encountered when questionnaires were administered. The options 'not sure' and 'prefer not to answer' were included to allow for a range of responses (McLafferty 2016).

[11] The AHTA considers individuals greater than 54 years to be Elders, and individuals 54 years and younger to be non-Elders. Based on these criteria, 12% of Kinngait's population are Elders, while 88% are non-Elders (Statistics Canada 2022).

Table 1. Questionnaire topics.

Topic		Details
Participant demographic information[1]		Gender
		Age
		Number of years in community
Changes in ecosystems	Ocean	Water temperature
		Wind
		Swells
		Sea ice characteristics (area, thickness, quality, timing of breakup and formation)
		Species diversity and relative abundance (marine mammals, fishes, invertebrates)
	Coast	Water temperature
		Wind
		Swells
		Erosion
		Species diversity and relative abundance (marine mammals, fishes, invertebrates)
		Plant species diversity
	Lake	Water temperature
		Wind
		Waves
		Turbidity
		Ice characteristics (area, thickness, quality, timing of breakup and formation)
		Species diversity and relative abundance (fishes, invertebrates)
Harvest information		Harvesting practices (hunting and fishing), locations, timing, number of years
		Most-harvested species, and changes in their abundance, timing, and locations
		Condition of marine mammals, and marine and lacustrine fishes
Community concerns[2]		Concerns about the ocean, coast, and lake
Feedback and future research[2]		Questionnaire effectiveness and length
		Missing topics and future research interests

[1]Note that the questionnaire contained a question related to employment status that was deemed not relevant.
[2]See Supplementary File 3.

munity technicians. Participants signed a consent form written in Inuktitut or English that informed them about the project, the intended use of information, and their rights in the study. We offered the opportunity to be identified by name, by age and experience (Elder/non-Elder), or to remain anonymous.

Each questionnaire took approximately 30 minutes for community technicians to complete with bilingual (English/Inuktitut) respondents or non-Elders, and 45 minutes with unilingual Inuktitut speakers or Elders. The questionnaires were administered by the community technicians in the participants' language of choice (Inuktitut or English), with the technicians interpreting or providing explanations as needed. For some questions, terms used in the questionnaire differed from those used in this paper. The terms *kinds of species* and *numbers of species* in the questionnaire are referred to as *species diversity* and *relative abundance*, respectively, in this paper. The term *water clarity* in the questionnaire is referred to as *turbidity* here. The use of clear language and minimal technical terms in the questionnaire were important for community understanding and ease of translation between English and Inuktitut. Responses were recorded and summarized by the technicians. The technicians were compensated for each questionnaire administered, and each participant received compensation based upon rates pre-determined by the AHTA.

2.4. Analysis, knowledge verification, and reporting

The questionnaires were digitized and analyzed by the lead author using Microsoft Excel. Some questionnaires contained Inuktitut terms (e.g., species names, locations). Efforts were made by AKD to translate these terms with OM during summer 2021 through email and photo exchange; however, not all terms could be translated due to language barriers and/or the accessibility of knowledge (i.e., known by certain Elders, variation in understanding within the community). Descriptive statistics were generated to summarize changes reported, with results distinguished by Elders and non-Elders due to the interest expressed by the AHTA in including participants with varying years of experience. Preliminary results and further result details were shared with the community through newsletters provided in English and Inuktitut in October 2021 and December 2022 (Supplementary File 2).

As DFO and academic research team members were unable to be present when questionnaires were administered, the nuances and the context of responses were not available and it was difficult to distinguish factual and inferential information (Usher 2000). However, meetings held

in March 2022 with technicians to verify the knowledge compiled and its interpretation helped limit these effects. AKD and LRC held two audio teleconferences with technicians where they reviewed the questionnaire results to ensure alignment with the responses received while administering the questionnaires. The next week, AKD, LRC, and KMD met with the AHTA via video teleconference to share questionnaire results and discuss desired next steps. During this teleconference, the AHTA gave their consent to include copies of the questionnaire with this manuscript, and expressed interest in co-authorship. All original questionnaires have been returned to the AHTA for long-term storage. In November 2023, AKD led an in-person community meeting in Kinngait to share and discuss questionnaire results with AHTA Board members, community technicians, and other interested community members. At this meeting, an advanced draft of this manuscript was provided to all attendees for their input.

2.5. Limitations

Participants may have been reluctant to share sensitive information in the questionnaires; however, these occurrences may have been lessened through strong support from the AHTA, questionnaire administration by community members, and shared concern regarding environmental change. Responses may also have been influenced by community technician connections to participants, and opportunities for iterative interactions between technicians and participants (Brook and McLachlan 2005). In cases where questions were unanswered, it was unclear whether participants did not know or did not wish to answer. To curb these occurrences, technicians were encouraged to differentiate between the two. Furthermore, as the questionnaires were administered in English, Inuktitut, or a mixture of both, it is possible that miscommunications may have occurred in translation and transcription. We recognize that there are inherent limitations in using questionnaires and communicating Inuit knowledge in a manuscript format, as these methods do not allow for the full context of the knowledge to be retained.

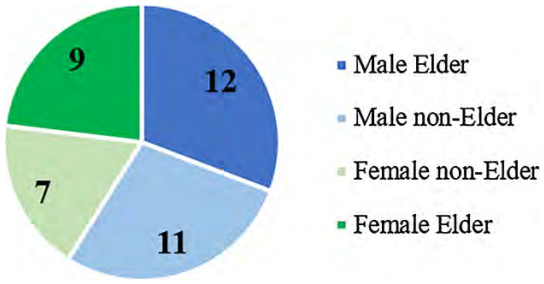
3. Results

Here, we share questionnaire results, including participant demographic information, experiences and perceptions of change in environmental (habitat-related) and biological (species-related) parameters, and related community concerns.

3.1. Demographics

The community technicians administered 39 questionnaires to a similar number of Elders (54%, $n = 21$) and non-Elders (46%, $n = 18$), with approximately 40% of participants identifying as female ($n = 16$), and 60% as male ($n = 23$) (Fig. 3). Male Elders were the most common participant of all categories, followed by male non-Elders, female Elders, and female non-Elders. Participant ages ranged from 27 to 83 years, with an average age of 54 ± 17 years. Years of harvest experience ranged from 15 to 83 years, with an average of 42 ± 20 years of experience. Most (80%, $n = 31$) participating knowledge holders both hunted and fished.

Fig. 3. Number of participants by age and gender, where Elders were greater than 54 years old, and non-Elders were 54 years old and younger.



3.2. Environmental changes

In this section, we describe changes in environmental parameters (water temperature, turbidity, erosion, swells and waves, wind, sea and lake ice). For each parameter, we present detailed results and participant voices[12,13] (Tables 2 and 3), and we distinguish responses by Elders/non-Elders and by ecosystem (Figs. 4 and 5). In summary, there were mixed responses regarding changes in turbidity and swells/waves, with most knowledge holders indicating that there was no change in these parameters. Most non-Elder participants indicated that there was no change in coastal erosion, and about half of Elder participants said that erosion was increasing. While a similar number of participants reported increases and no change in wind, context provided in comments in the questionnaire suggests that wind intensity is increasing, and may be changing in direction and temperature. In the ocean, coast, and lakes, most knowledge holders (primarily Elders) reported an increase in water temperature, and a decrease in ice area, thickness, and quality, as well as earlier spring breakup and later fall formation (by three to four months).

3.3. Biological changes

3.3.1. Species diversity and relative abundance

We describe changes in biological parameters, including species diversity and relative abundance of marine mammals (Table 4), marine and lacustrine fishes (Table 5), and

[12] 'P' refers to 'participant' and is used alongside a number to recognize the contributions of different knowledge holders while maintaining anonymity. Note that identifying numbers for participants (e.g., P54) exceed 39 because the questionnaires were pre-numbered, and some were not distributed.

[13] The experiences and perceptions of change are variable but date back over 60 years to 1961. When available, approximate time scales for change are provided in Tables 2–6.

Table 2. Summary of changes reported in water temperature, turbidity, erosion, swells and waves, and wind.

Parameter	Results	Knowledge holder voices[1]
Water temperature	More than twice as many Elders than non-Elders reported an increase in water temperature in the ocean, coast, and lakes beginning as early as 40 or 50 years ago, or as recently as the past 5 years. A few individuals (mainly non-Elders) reported relatively recent declines in water temperature in all ecosystems (i.e., over approximately the past 15 years). Some Elders and non-Elders reported that there was no change in water temperature in all ecosystems.	*"Water temperature getting warmer each year"* (P34) *"Water temperature is causing different ice freeze up on the coastline each year"* (P54) *"Freeze up in the coastal line. Change in temperature in the ocean is causing this in the coast"* (P55) In lakes: *"Water temperature rise makes so much change"* (P54) *"Snow conditions also changed over time, also cause temperature change"* (P55)
Turbidity	Most Elders and non-Elders ($n = 14$)[2] reported that there was no change in turbidity in lakes. A few participants ($n = 5$) reported an increase in turbidity beginning 60 to 6 years ago, and fewer ($n = 3$) reported a decrease in turbidity.	Increasing turbidity: *"Last spring around break-up it was very murky—shallow areas very murky. In the deep it was clear. Around the river was murky"* (P10)
Erosion	Almost the same number of Elders reported an increase ($n = 7$) or no change ($n = 9$) in erosion on the coast. This potential increase in erosion began 40 to 4 years ago. A few Elders also reported a decrease in erosion starting 30 years ago. Most non-Elders ($n = 12$) reported that there was no change in erosion on the coast.	No comments were provided
Swells and waves	Almost the same number of Elders reported an increase ($n = 8$) or no change ($n = 11$) in swells in the ocean. On the coast, several Elders ($n = 11$) reported an increase in swells. These increases began as early as 40 years ago. In comparison, most non-Elders reported that there was no change in swells in the ocean or on the coast ($n = 10$ each). In lakes, most Elders and non-Elders reported that there was no change in waves ($n = 14$ each).	No comments were provided
Wind	Elder and non-Elder responses were very similar with regard to wind across all three ecosystems. In the ocean and coast, almost the same number of participants reported an increase or no change in wind. Increases in wind in the ocean and coast were reported to have begun as early as 60 and 30 years ago, respectively, and may be most prominent in the fall. Most participants reported that there was no change in wind in lakes; however, a few individuals across age/experience levels reported increases in wind. Several participants indicated that winds are coming from the same directions more often (primarily easterly, and possibly southeasterly).	Increasing wind intensity in the ocean/coast: *"More windy in summer into fall seasons"* (P2) *"Winds are increasing in the fall"* (P9) *"The wind seems to be picking up"* (P17) *"When wind is strong than I know it is cold in the ocean"* (P54) Wind direction changes: *"Wind direction changed"* (P55) *"Now the winds are easterly, when it used to usually be northwestern"* (P10) *"Winds are coming more from the same direction…east winds"* (P20) *"Wind direction seems to be coming from the same two directions now"* (P54) *"If the wind comes from southeast and east, it contributes to the thickness of the ice while forming"* (P53) Wind temperature changes: *"The wind temperature is different"* (P20) *"It is not that windy from warm temperature when it's time for freeze-up"* (P36)

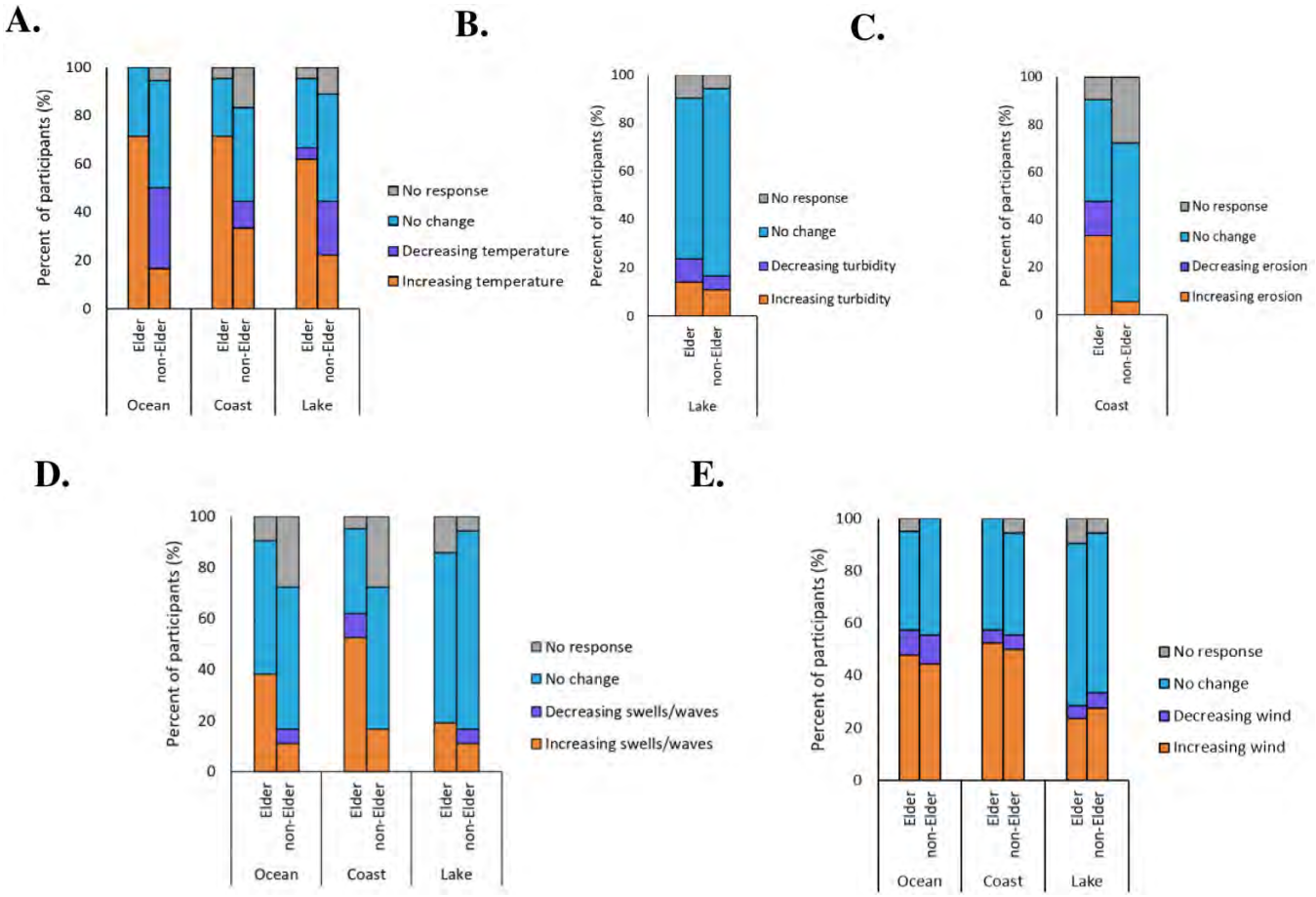
Note: See Fig. 4 for figures associated with these results.
[1]"P" refers to "participant" and is used alongside a number to recognize the contributions of different knowledge holders while maintaining anonymity. Note that identifying numbers for participants (e.g., P54) exceed 39 because the questionnaires were pre-numbered, and some were not distributed.
[2]Note that $n = X$ refers to the number of participants who responded with a particular answer when table context allowed.

Table 3. Summary of changes reported in sea and lake ice, including ice area, thickness, quality, and the timing of ice breakup and formation.

Parameter	Results	Knowledge holder voices[1]
 Ice	Sea ice Nearly all Elders and non-Elders reported a decrease in sea ice area and thickness, as well as earlier spring breakup, and later fall formation. Ice that used to remain until July now breaks up in June, and sometimes as early as April or May. Some participants noticed that there is no flooded water when the ice melts anymore[2]. Ice formation (freeze-up) that used to occur in early November is now often observed in December. Participants reported poorer ice quality, the danger this poses, and the need to take alternate travel routes. Ice is also becoming less sturdy, especially near areas with strong currents. These changes were reported to have begun up to 60 years ago.	Thickness and area: "*More open water and thinning of the ice*" (P37) "*Less of old ice packs*" (P41) "*Less ice formation, now it is like half of what it used to be. Thickness is poorer, as it is thinning and we cannot go out fishing as we would then until June/July*" (P36) "*If the wind comes from southeast and east, it contributes to the thickness of the ice while forming*" (P53) Quality: "*The quality is poorer and dangerous for us*" (P10) "*More dangerous ice conditions, must be aware of your surroundings*" (P41) "*Due to warming temperature…ice conditions seem to be not too good*" (P17) Timing of ice breakup and formation: "*Takes longer to freeze in the fall and earlier break-up*" (P2) "*Freeze-up used to be in early November now it's in December. Break-up used to be in July now it's June sometimes May*" (P10) "*Last year (2020) we didn't have much of a spring because the ice was gone very fast*" (P35) "*Due to warming temperature, ice break-up is sooner*" (P17) "*Warming water causing the formation of ice later*" (P33) "*Ice barely ever froze and very late*" (P13) "*Freezing later, melting earlier…We need to take not regular route due to earlier melting*" (P10) Changing characteristics of ice breakup: "*Less ice around coast in winter. Less floodwater when melting—just break up*" (P54, P55) Changes on the coast: "*Coastal line seems to be changing in freeze up. Water temperature is causing different ice freeze up each year*" (P54) "*The ice pack on some of the coastline, especially where there are strong currents is less sturdy*" (P41) "*Floe edge is getting closer over time*" (P2)
	Lake ice For lake ice, responses were very similar to sea ice, with most Elders and non-Elders reporting a decrease in ice area and thickness, earlier spring breakup, and later fall formation. The only distinction between the ocean and lake was ice area. In lakes, almost the same number of participants reported a decrease or no change in ice area. A few participants noted that ice quality is highly dependent upon the snow present on the ice, and that the fishing season is becoming shorter due to changes in ice. These changes were reported to have begun as early as 60 years ago.	Thickness and area: "*Sometimes thicker ice*" (P9) "*In the winter, it is always thinner*" (P42) "*The lakes are thinner…each year decreasing*" (P60) "*Lakes used to and could be 7–8 ft thick 5–6 years ago. The past couple years it's been 4–5 ft thick*" (P10) Quality: "*Depends on how much snow there is on the ice*" (P36) "*Less snow on lakes now, so this is causing different ice formation and conditions. Snow conditions also changed over time, also cause temperature change*" (P55) Timing of ice breakup and formation: "*I could see that our ice is breaking sooner than usual. And forming later than usual*" (P13) "*Ice melts faster now*" (P35) "*Because weather is warming up—ice breaks up easy*" (P17) "*Thinner ice, later freeze-up, earlier melting, we like to fish longer but we can't*" (P10) "*Fishing is shorter now because in the springtime everything is melted*" (P35) "*Takes longer to go fishing in early winter due to lake freeze-ups in the fall*" (P2)

Note: See Fig. 5 for figures associated with these results.
[1]"P" refers to "participant" and is used alongside a number to recognize the contributions of different knowledge holders while maintaining anonymity. Note that identifying numbers for participants (e.g., P54) exceed 39 because the questionnaires were pre-numbered, and some were not distributed.
[2]See Laidler and Elee (2008) and Alasuaq et al. (2023) for descriptions of sea ice processes in Kinngait and their associated Inuktitut terminologies.

Fig. 4. Percent (%) of participants who reported changes in (A) water temperature, (B) turbidity, (C) erosion, (D) swells and waves, and (E) wind, in the ocean, coast, and lakes. Figure results are presented by Elders and non-Elders (i.e., percentages are out of 21 and 18 participants, respectively).



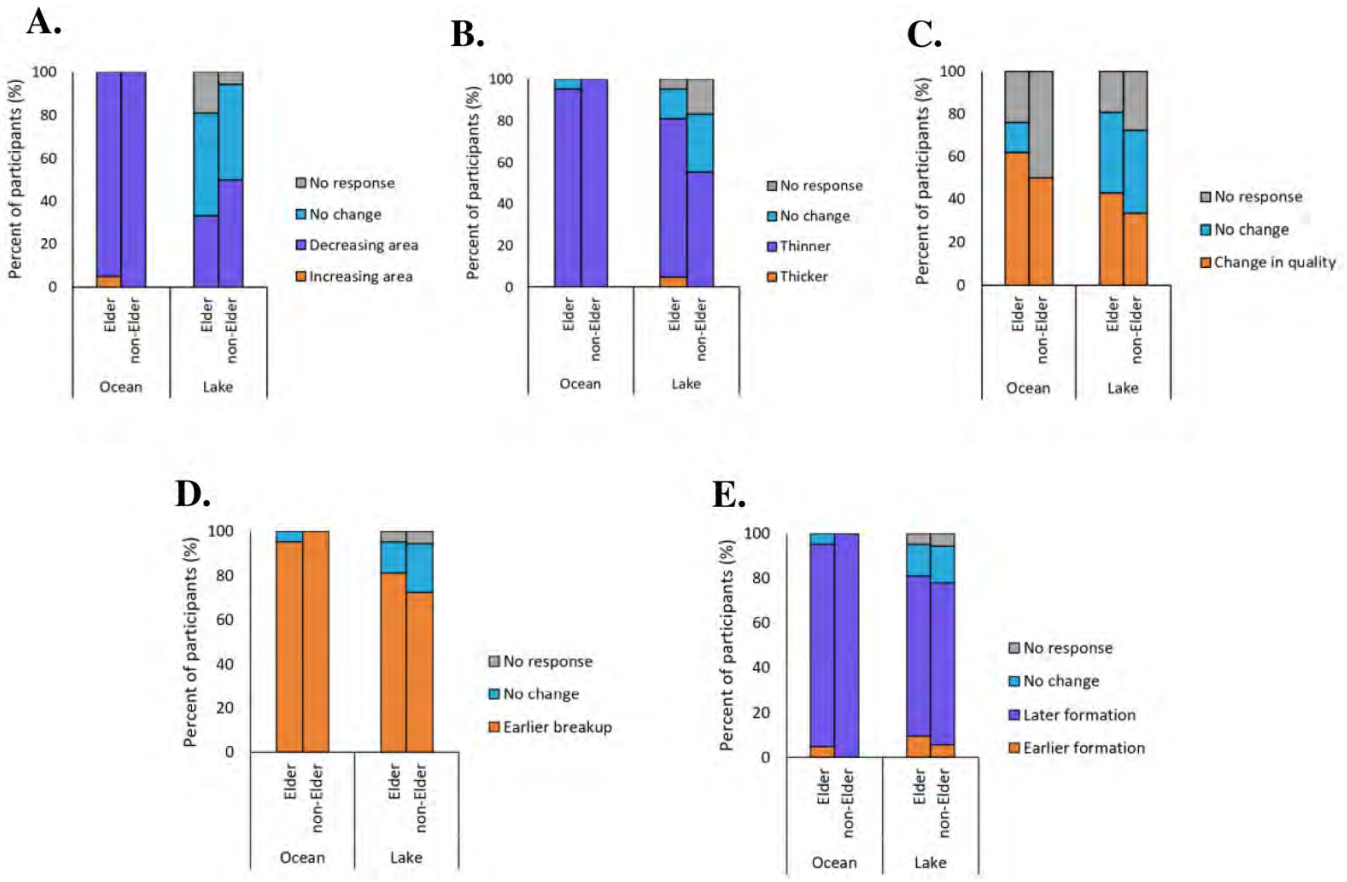
marine and lacustrine invertebrates and coastal plants[14] (Table 6). For each parameter, we present detailed results and participant voices, and we distinguish responses by Elders/non-Elders and by ecosystem (Fig. 6). Most participants indicated that marine mammal species diversity is not changing. In contrast, several Elders provided accounts of decreasing relative abundance of seals (ringed seal *Pusa hispida*, bearded seal *Erignathus barbatus*, harbour seal *Phoca vitulina*, harp seal *Pagophilus groenlandicus*), beluga whale (*Delphinapterus leucas*), bowhead whale (*Balaena mysticetus*), and Atlantic walrus (*Odobenus rosmarus rosmarus*), with most comments focused on ringed seal and beluga whale. The diversity and abundance of fishes, invertebrates, and plants were characterized by most knowledge holders (Elders and non-Elders) as not having changed. Yet, context within comments suggests that salmon have started to appear in recent years, mussels are proliferating on the coast (and may be a new species to the area), and coastal plants may be declining.

3.3.2. Species harvested, species condition, and timing of harvests

The most commonly reported species harvested were Arctic char (*Salvelinus alpinus*), followed by clams, mussels, beluga whale, and seal (most commonly ringed seal) (Fig. 7). Landlocked/freshwater fishes with no English equivalent known to authors (see Section 2.4 in Methods), and landlocked char with morphotypes referred to as *ivitaaru*, *kakirraq*, and *nutilliit* were also harvested (see Reist et al. 1995; Loewen et al. 2009; Burke et al. 2022). For the physical condition of these species, knowledge holders most readily reported changes in scars, parasites, size, and indications of disease (Fig. 8). However, the taste and texture of marine mammals and fishes may also be changing. One participant indicated that marine mammal taste differs depending on diet (e.g., "if a walrus eats seal they taste and smell different, usually they just eat clams", P20). Others mentioned that the texture of ringed seal is different (P55), and that they had "seen parasites on two seals" (P53). Participants shared that in some years there are "more para-

[14] Note that we use the term 'plants' rather than 'macroalgae' or alternatives as this was used by community technicians during questionnaire co-creation.

Fig. 5. Percent (%) of participants who reported the following changes in sea and lake ice: (A) area, (B) thickness, (C) quality, (D) timing of spring breakup, and (E) timing of fall formation. Figure results are presented by Elders and non-Elders (i.e., percentages are out of 21 and 18 participants, respectively).



sites for Arctic char" and "some lakes or fish have parasites and become clean again, you can tell from the gills…seems like every year there are more parasites when it becomes fall time" (P36). Additionally, one participant noted that "when fish go down the river, some smell dirty on the skin" (P20). For lacustrine fishes specifically, participants shared that "diet differs in areas…the skin smells and meat is good" (P20), and that "certain fishing lakes have different texture now…[there is a] soft or different texture in eating the meat" (P54). Fish size was also reported to be increasing among lacustrine and marine fishes (the latter being "bigger than 10 years ago", P36).

There were mixed responses regarding the timing of harvesting, which seems to be changing in the winter and spring[15] (Fig. 9). Some knowledge holders expressed that "winter [is] com[ing] in later and spring weather com[ing] earlier" (P33, 34), with "ice break[ing] sooner" (P6). One participant shared: "I have been hunting all my life and teaching my kids how to hunt but sometimes [it is] hard when early breakups with snow machine" (P42). Many participants highlighted the effect of weather on their ability to hunt and fish, and that they go out at "every chance" (P58, 59); however,

[15] Community technicians informed AKD and LRC that Kinngarmiut generally recognize the following seasons and timing: winter (December, January, February, March), spring (April, May, June), summer (July, August), and fall (September, October, November).

Table 4. Summary of changes reported in species diversity and relative abundance of marine mammals.

Parameter		Results	Knowledge holder voices[1]
Marine mammals	Species diversity	Most Elders and non-Elders reported that there was no change in marine mammal species diversity in the coast or ocean. Yet, some participants reported the appearance or disappearance of species, beginning as early as 60 years ago and 40 years ago, respectively.	**Seals (all species)** *"Less seals appear in some areas. We hear of people not harvesting seals at all for some days now. There used to be bountiful seals"* (P54) *"There are less seals hunted nowadays. There used to be lots around here"* (P55) *"The (ringed seal) skins are not so good quality anymore, it seems like there are less seals too"* (P54) *"Ice formation is less now, and I think numbers are ok but breathing holes are less and seals in open water more, ice coverage is less now, that is why there are less holes"* (P36)
	Relative abundance	A similar number of Elders and non-Elders reported a decreasing abundance of marine mammals, or no change in the abundance of marine mammals, in the ocean and coast. However, many Elders noticed decreases in marine mammal abundance in the ocean. Several participants specifically indicated that there is less ringed seal, bearded seal, harbour seal, and harp seal, and thus fewer harvesting opportunities. The impact of lessened ice formation on seals was discussed. There were observations of fewer breathing holes, and seals spotted more frequently in open water. There were also reports of fewer beluga whale migrating, and earlier migrations, as well as infrequent sightings of bowhead whale. Participants mentioned differences in the taste and texture of walrus and ringed seal. These changes may have begun as early as 60 years ago, and as recently as over the past few years.	**Ringed seal** *"Much less ringed seal for the past few years"* (P15) *"If the winds were strong then there are more ringed seals. Note this winter not alot of breathing holes"* (P36) *"I have noticed there are less ringed seals because of increasing polar bears. Polar bears eat seal pups. Even in the spring the seals on the ice sunbathe. Temperature rise they sunbathe in warmer temperature. Older ringed seals sunbathe early in the year now"* (P18) *Hunts for ringed seal "all year long depends on weather"* (P36) **Bearded seal** *"Bearded seals are not as many seems like…[they] are not seen on a piece of ice anymore"* (P55) *"More bearded seals"* (P18) **Harbour seal** *"Fewer kinds of mammals—mainly harbour seals [that there are fewer of]"* (P2) **Harp seal** *"Harp seals not on coast"* (P31) *"I hunt for harp seals—but in a couple years I have not caught one"* (P9) *"Have not seen harp seals any more* (P31) **Beluga whale** *"Less beluga pods come in, in spring, numbers are less than 20 years ago"* (P55) *"Less belugas around that migrate, maybe affected by the Mary River mine. Not sure but what I think"* (P55) *For timing in the winter, "beluga whale come early"* (P36) **Bowhead whale** *"Bowhead whales were not seen often"* (P55) **Walrus** *"Some walrus can get hungry and can eat seal. Kinngait usually have walrus around the island most year-round"* (P20)

Note: See Fig. 6 for figures associated with these results.
[1]"P" refers to "participant" and is used alongside a number to recognize the contributions of different knowledge holders while maintaining anonymity. Note that identifying numbers for participants (e.g., P54) exceed 39 because the questionnaires were pre-numbered, and some were not distributed.

they "never know how the weather will be, each day is always different" (P15). A few participants noted that earlier ice breakup and delayed ice formation are resulting in a shortened fishing season.

3.4. Other related concerns

Many knowledge holders expressed concern regarding occurrences of "lower tides now than before" (P20, 31) resulting in a "dry coast in the summer" (P36). There was also concern about freshwater bodies, with participants sharing that "I heard of fish not making it up river some years due to not enough rain" (P54). This has resulted in lakes drying up over time (P5, 17, 32, and others). One participant raised concerns related to the impacts of shipping, sharing: "I am afraid Mary River iron mine ship will have a route near Kinngait, that it will change migration routes or marine mammals and leave such a difference over the years" (P18). Other research interests were also garnered in the questionnaires (Supplementary File 3).

4. Discussion

This section is intended to provide context around each of the parameters that were discussed in the questionnaires.

Table 5. Summary of changes reported in species diversity and relative abundance of marine and lacustrine fishes.

Parameter		Results	Knowledge holder voices[1,2]
Fishes	Species diversity	A similar number of Elders and non-Elders reported that there was no change in fish species in the ocean, coast, or lakes. A few participants who described an increase in diversity spoke about the occasional appearance of salmon in recent years. A new species of fish with "lumps" was also reported. Cods and sculpins were commonly observed.	Marine fishes: *For new species, wrote: "Heard of salmon around here never seen it though"* (P54) *"At times I heard of salmon caught not so often though"* (P18) *"No change in codfish"* (P16) *"We may get codfish around, I just don't see anybody fishing them"* (P3) *"Three different kinds of sculpins [on the coast]"* (P55) Lacustrine fishes: *"I've seen puffer fish couple times now in the freshwater lakes last 10 years. I don't know if this is new or what"* (P3) *"They are new some kind of fish and has lumps"* (P5)
	Relative abundance	Most participants reported that there was no change in the relative abundance of marine or lacustrine fishes. More Elders than non-Elders discussed increases in relative abundance beginning as early as 60 years ago in the ocean, and 50 years ago in the coast and lakes. Participants mentioned abnormalities or differences in skin characteristics, seasonal changes in parasite numbers, changes in taste and texture (based on what the fish consume and their location), and an increase in average fish size.	Marine fishes: *"Some years differ in terms of marine fishes numbers, but increasing now"* (P20) *"Looks like a lot more Arctic char these days"* (P42) *Differing abundance of Arctic char, "depends on month"* (P36) *"Less trout"* (P31) *"No change in codfish"* (P16) *"Less sculpins, and rarely seen in these areas now"* (P54) *"Less sculpins in the coast"* (P55) *Marine fishes numbers "differ with snow/winter weather"* (P20) *"People nowadays catch less fish in the spring/summer"* (P18) Lacustrine fishes: *"A lot more fish in winter up at the Fish Lakes"* (P42)

Note: See Fig. 6 for figures associated with these results.
[1]"P" refers to "participant" and is used alongside a number to recognize the contributions of different knowledge holders while maintaining anonymity. Note that identifying numbers for participants (e.g., P54) exceed 39 because the questionnaires were pre-numbered, and some were not distributed.
[2]Anadromous Arctic char (*Salvelinus alpinus*) may be accounted for in both ocean and lake ecosystems.

We recognize that here, we situate Inuit knowledge within primarily Western science-based studies due to structural constraints and norms within scientific manuscripts, and the availability and accessibility of documented Indigenous knowledge. While our intention is not to compare, validate, or verify knowledge shared, we acknowledge that presenting both ways of knowing in parallel may invite this interpretation. We note, however, that many studies referenced in this section are centered around community priorities, and speak to concerns similar to those raised by Kinngarmiut.

4.1. Environmental and biological changes

There was considerable variation in experiences and perceptions of environmental and biological change among knowledge holders, with several parameters considered to be changing (water temperature increase, sea ice decline, decline in marine mammal abundance, physical condition of marine mammals and fishes: scars, parasites, size, indications of disease, later harvesting in the winter and earlier harvesting in the spring, drying water bodies), others that may be changing (erosion, wind, taste and texture of marine mammals and fishes, possible new species of marine mammals to the area), and others still that are not likely changing (turbidity, swells/waves, fish and invertebrate diversity and abundance, plant diversity, marine mammal diversity). However, these trends do not represent nuances in responses across Elder/non-Elder groups, species, or ecosystems, and we encourage readers to take a closer look at Figs. 4, 5, and 6, and knowledge holder voices in Tables 2 through 6 to recognize this variation.

4.1.1. Elder and non-Elder responses

The degree to which changes are noticed and how they affect the community is a function of who is using and

Table 6. Summary of changes reported in species diversity and relative abundance of marine and lacustrine invertebrates and coastal plants.

Parameter		Results	Knowledge holder voices[1]
Invertebrates	Species diversity	In the ocean and coast, a similar number of participants reported increases or no change in invertebrate species diversity. This diversity was reported to have begun increasing between 20 and 4 years ago. Most participants reported that there was no change in invertebrate diversity in lakes. A few Elders reported decreases in invertebrate diversity in all three ecosystems beginning as early as 50 years ago. The main invertebrates discussed were mussels and clams.	Marine invertebrates: *"Starting to see more mussels around"* (P33) *"Just more mussels and this type is new to this area"* (P16) *"Some kind of worms in the sea"* (P5) *"Shrimp"* (P31) Lacustrine invertebrates: *"Know of some lakes with clams"* (P20)
	Relative abundance	Most Elders and non-Elders reported that the relative abundance of invertebrate species did not change across ecosystems. However, there were many reports of increasing relative abundance of mussels, which are also being observed in new areas. The increases in relative abundance began as early as 20 years ago in the ocean and coast, and as recently as 6 years ago in lakes. A few participants reported decreasing relative abundance of invertebrates (possibly clams) in the ocean and coast up to 30 years ago.	Marine invertebrates: *"In some areas we used to collect clams, now we get less"* (P55) *"From alot of people clam digging there seems to be less bigger ones around. Mussels are growing in numbers and growing bigger"* (P36) *"Seems to have more mussels where there used to be almost nothing around this area"* (P3) *"Mussels are around now, there used to be nothing around Kinngait"* (P9) *"Mussels have increased in numbers in some areas"* (P60) *"I have noticed more mussels around coastal areas"* (P41) *"Harvests clams twice a season, and there are two extra months to harvest them. Harvests mussels three times a season. They are spreading"* (P36) *"Harvest clams and mussels twice a season. Mussels located in different areas now"* (P51) *"Less jellyfish"* (P31) *"Invertebrate numbers and size are increasing"* (P36) Lacustrine invertebrates: *For mussels, "rivers expanding locations"* (P16)
Plants	Species diversity	Most Elders and non-Elders reported that plant species diversity on the coast did not change, although several Elders reported a decrease in diversity beginning up to 26 years ago.	Decreasing plant diversity and/or abundance: *"Less seaweed. Seaweed seems to be lighter in colour now from increasing water temperature"* (P31) *"There are not much seaweeds in the shore anymore"* (P5) Increasing plant diversity and/or abundance: *"New kinds of seaweed. Changing in 40 years"* (P4) *"More seaweeds. More seaweeds from more winds, summer and fall can get lots of waves and swells and this causes more seaweeds to be washed up"* (P10) Other *"Those botanicals are good as a broth"* (P20)

Note: See Fig. 6 for figures associated with these results.
[1]"P" refers to "participant" and is used alongside a number to recognize the contributions of different knowledge holders while maintaining anonymity. Note that identifying numbers for participants (e.g., P54) exceed 39 because the questionnaires were pre-numbered, and some were not distributed.

experiencing these environments, as well as how (e.g., hunting or fishing), where (e.g., location of harvesting sites), when (e.g., season, year), and for how long they are being used or experienced (Laidler et al. 2010). The disparities between Elder and non-Elder responses, most apparent in the parameters water temperature, erosion, swells/waves, fish abundance, and invertebrate diversity, can likely be attributed to differing years and experiences on the land. While the 56-year age gap between the youngest and oldest questionnaire participant is important when considering the degree of Arctic change that has occurred during that time period, the threshold between non-Elder and Elder is 54 years of age. Therefore, many Elders continue to spend time on the land harvesting and are witnessing changes firsthand.

4.1.2. Environmental parameters

Wind was of particular interest to knowledge holders because its intensity, direction, and temperature influence snow and sea ice characteristics and processes (i.e., facilitate ice formation or deterioration, or lead to instability or break-off), impacting travel conditions and access to harvesting sites (Laidler et al. 2010; Hansen et al. 2013). Studies in Kinngait have documented local ice conditions (including a sea ice decline as noted by questionnaire participants), as well

Fig. 6. Percent (%) of participants who reported changes in the species diversity (i) and relative abundance (ii) of (A) marine mammals, (B) marine and lacustrine fishes, (C) marine and lacustrine invertebrates, and (D) coastal plants (only species diversity). Figure results are presented by Elders and non-Elders (i.e., percentages are out of 21 and 18 participants, respectively).

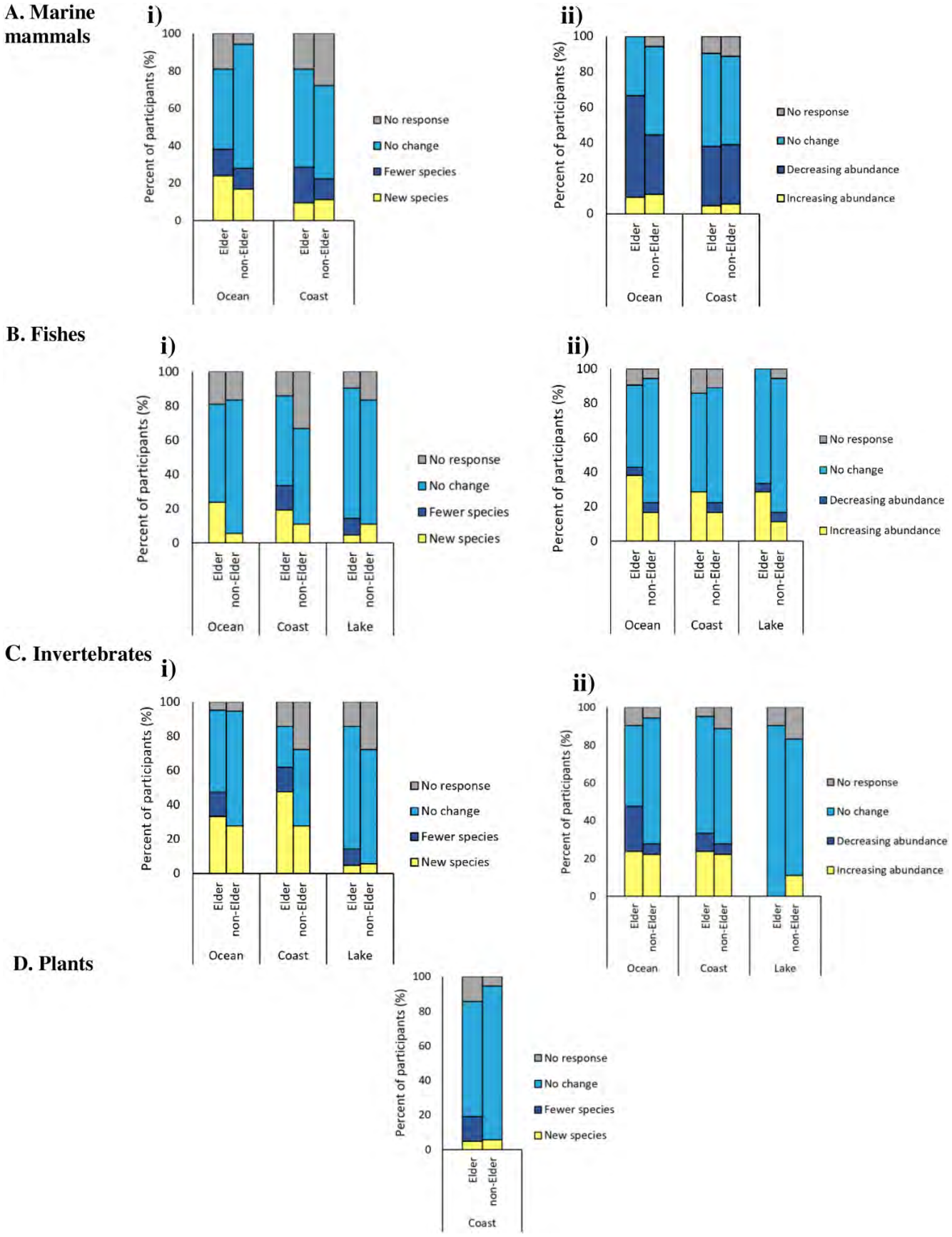
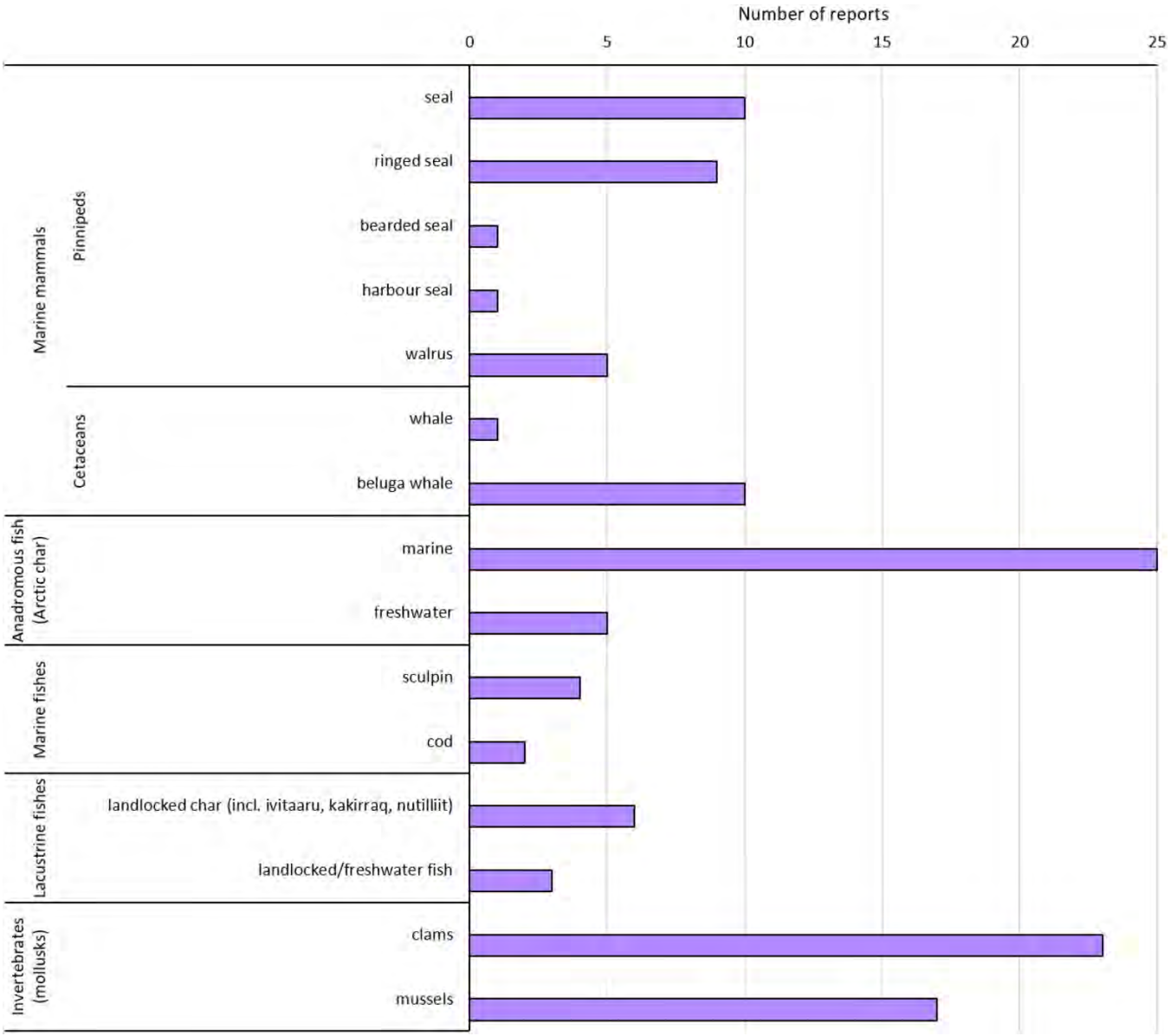


Fig. 7. Harvested species reported in the questionnaire. Note that landlocked char are non-anadromous Arctic char (*Salvelinus alpinus*).



as freeze/thaw processes and the influence of both winds and currents on ice, with a strong emphasis on Inuktitut terminology (see Laidler and Elee 2008; Laidler et al. 2010; Alasuaq et al. 2023). Additionally, sea ice thickness and snow depth data have been collected since 2020 through a community-led coastal monitoring program in partnership with DFO (Arctic Coast), which will support the identification of trends in future years (Christie et al. 2023*b*). When comparing across ecosystems, a greater number of participants reported increases in swells/waves and wind in the ocean and coast than in lakes. These differences may be due to the geography of exposed and comparably flat ocean and coastal areas over which the wind carries and contributes to swells. This process could help explain some reports of coastal erosion, although to our knowledge, this has not yet been widely observed in Kinngait. Accordingly, it is not surprising that turbidity, influenced by erosion among other factors, was not noticeably changing. Decreasing water levels, and the drying and draining of rivers and lakes reported by participants, is a widespread issue across the circumpolar Arctic (Knopp et al. 2022) and warrants further local-scale research at key sites. Similarly, increasing sea surface temperature, an Arctic-wide phenomenon (Timmermans and Labe 2023), should continue to be monitored near Kinngait (Christie et al. 2023*b*) to understand local variability (e.g., due to water input from freshwater sources, proximity to the coast) and elucidate long-term trends.

Fig. 8. Number of reports of changes in the condition of marine mammals, and marine and lacustrine fishes. Note that anadromous Arctic char may be accounted for in both marine and lacustrine fish reports.

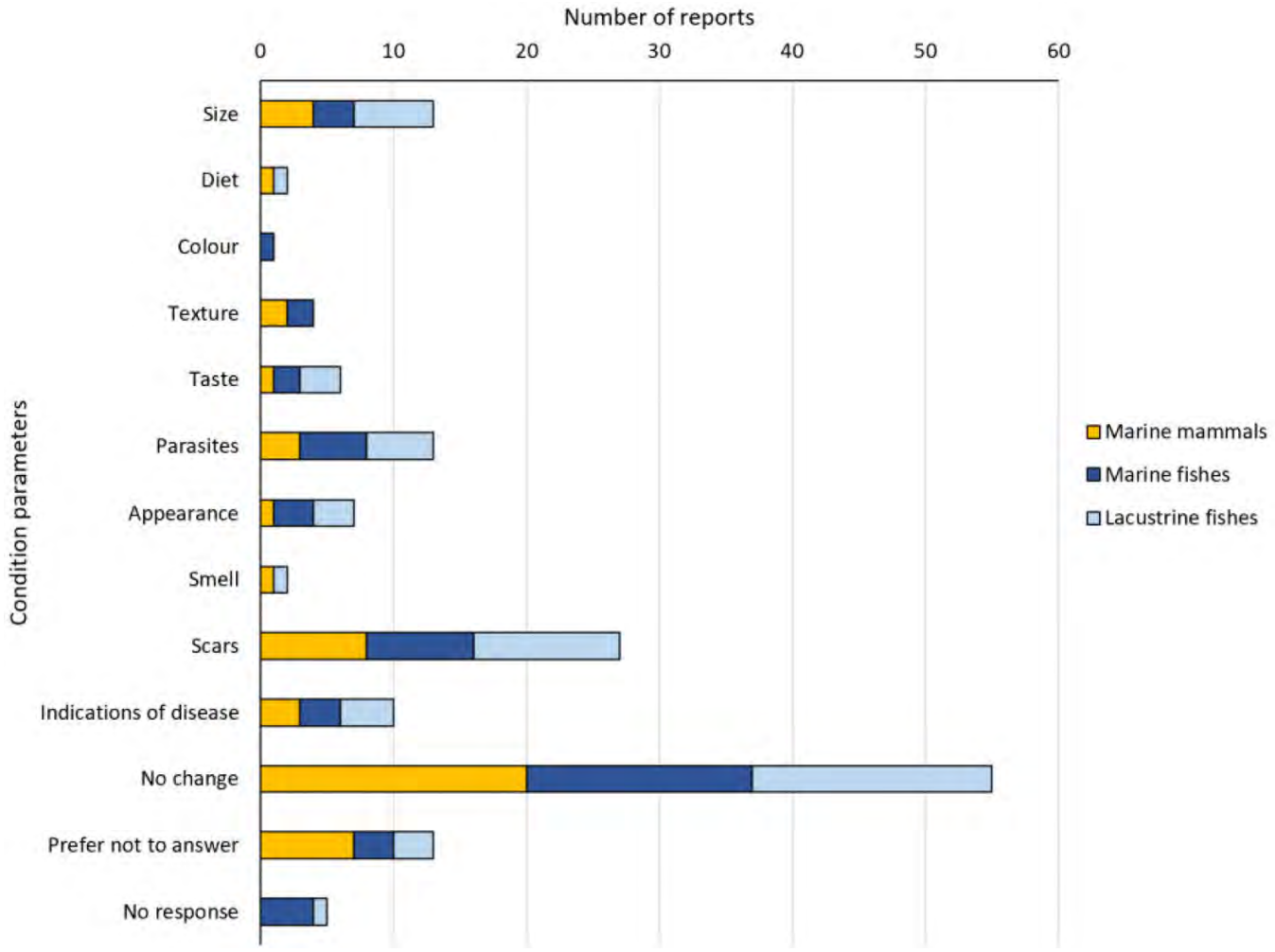
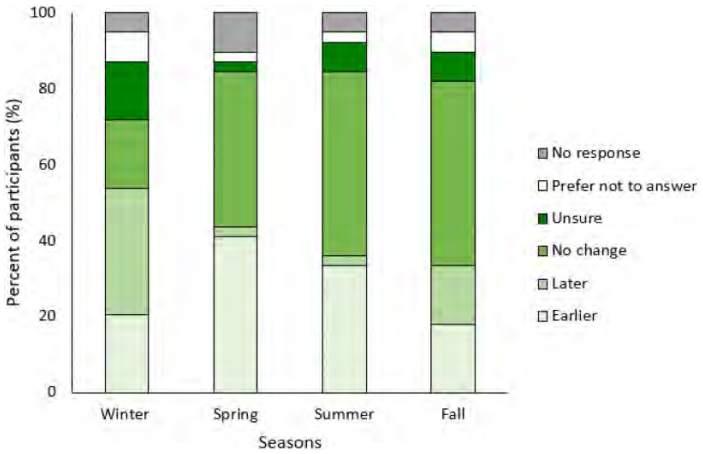


Fig. 9. Percent of participants (%) who reported changes in the timing of harvesting across seasons.



4.1.3. Marine mammals

Lowered ringed seal abundance and condition have been echoed in other studies and linked to changes in seal diet and diminishing sea ice through a dependence on ice for reproduction, molting, and protection from cold and predators (Kushwaha 2007; Harwood et al. 2012; Ferguson et al. 2017). Beluga whales, another key species discussed by knowledge holders, may be part of the Western or Eastern Hudson Bay populations, which overlap in their wintering grounds in Hudson Strait and during spring and fall migrations (COSEWIC 2004; Turgeon et al. 2012). Threats to these

populations include abundance and population uncertainties, icebreaking in Hudson Strait, ship traffic, and hydroelectric activities (NAMMCO 2018). Eastern Hudson Bay belugas have been observed to be beginning their spring migration about seven to ten days earlier, likely in response to earlier ice breakup (Hammill 2013), which aligns with earlier migrations noted by questionnaire participants. Research should focus on specific causes of declines in locally important marine mammals and corresponding impacts on food security. The presence of one or more new species noted by knowledge holders also warrants study as this information was not available in the questionnaires. Finally, possible links between changes in the taste and texture of marine mammals (walrus, ringed seal) and climate-related changes in animal health (Kushwaha 2007; Ostertag et al. 2018) require further investigation.

4.1.4. Fishes

Reports of increasing fish species diversity and relative abundance in the questionnaires seem to be associated with recent observations of Atlantic salmon (*Salmo salar*), whose distribution is shifting northwards with warming water temperatures (Bilous and Dunmall 2020; Dunmall et al. 2021). Pink salmon (*Oncorhynchus gorbuscha*) could also begin to be observed in coming years, as this species has already been seen near communities in Nunavut and Nunavik (McNicholl et al. 2021). The Nunavut Coastal Resource Inventory (NCRI)[16] documented the presence of cods (*Gadidae*), sculpins (*Cottidae*), and other "landlocked" or "freshwater" fishes with names known in Inuktitut. Fishes captured during coastal monitoring undertaken in recent years include Arctic char, Grubby sculpin (*Myoxocephalus aenaeus*), and Shorthorn sculpin (*Myoxocephalus scorpius*) (Christie et al. 2023*b*). Future research should also focus on differentiating landlocked, anadromous, and marine Arctic char locations, morphotypes, and terms (Young et al. 2021; Burke et al. 2022). As changes in fish condition (e.g., skin abnormalities, parasites, changes in taste and texture) are a growing concern for community members, these observations should be investigated.

4.1.5. Invertebrates and plants

Among invertebrates, research is required to understand the recent proliferation of mussels and their distribution into new areas. It is possible that habitat heterogeneity and climate change-induced temperature changes may be allowing mussels to inhabit these areas (Thyrring et al. 2019); nevertheless, the causes for the proliferation, and magnitude and direction of effects on other species (e.g., clams, kelp) near Kinngait are not known. Other invertebrate phyla documented through community-led coastal monitoring include mollusks, annelids, arthropods, and echinoderms (Christie et al. 2023*b*). Additional research into benthic diversity, which enables an understanding of ecosystem health and stability, will be increasingly important as most benthic data are limited (i.e., dated, at low spatial resolution) and Hudson Strait is an area of high productivity (Pierrejean et al. 2020). Among coastal plants, a potential decline in diversity noted by Elders warrants further research, as benthic flora are understudied (Brown et al. 2011).

4.1.6. Harvesting changes

Phenological shifts and the lessened availability of locally important species (e.g., beluga, ringed seal) are altering harvesting practices; however, Kinngarmiut face further challenges due to the unpredictability of weather and increasingly dangerous conditions for travel, especially near Hudson Strait currents. These observations echo other studies in Kinngait (see Laidler and Elee 2008; Laidler et al. 2010) that have noted greater reliance on alternate routes that follow shoreline contours and areas with thicker ice, which are usually longer and over difficult terrain. Environmental and biological changes will continue to challenge harvesting and will require adaptations by harvesters and community members who rely on key species and habitats for sustenance, livelihoods, and physical, mental, emotional, and spiritual well-being. Therefore, additional insight into these changes, and the reverberating ecological and social impacts on Kinngarmiut, are necessary.

4.2. Importance

This knowledge was gathered by the AHTA and technicians for use by the community of Kinngait (Christie et al. 2023*a*). For example, questionnaire results may inform local co-management decisions, conservation plans, economic plans, or the mitigation or prevention of shipping impacts.[17] We emphasize that any use of this knowledge should be determined by those to whom the knowledge belongs to avoid "the appropriation of IQ as a management tool" (Tester and Irniq 2008, p. 49). Accordingly, the knowledge recorded holds "governance value" for the community (see Whyte 2018; Latulippe and Klenk 2020).

There is strong community interest in continuing to document Inuit knowledge, with an AHTA Board member iterating that : "…in the future we want more meetings because I think we can learn from each other…" (pers. comm., 8 March 2022). Questionnaire participants shared: "there is too much

[16] The Nunavut Coastal Resource Inventory (NCRI) is a Government of Nunavut initiative by the Fisheries and Sealing Division within the Department of Environment (at the time), undertaken annually in different communities since 2007. The NCRI is intended to document the presence, distribution, and characteristics of coastal resources to facilitate their assessment for economic development, coastal management, and conservation. In 2017, nine interviews were conducted on one occasion in Kinngait (Government of Nunavut 2018), where three interviewees were also participants in this study. AKD received permission from the Government of Nunavut to cite this report in this manuscript.

[17] The location of Kinngait on the Hudson Strait places this community on an important shipping route, as the strait connects shipping networks in the Labrador Sea with the port of Churchill, Manitoba (Kelley and Ljubicic 2012). The Hudson Strait is also the seventh alternate Northwest Passage route, which runs from the Labrador Sea, through the Hudson Strait to Foxe Basin, to Fury and Hecla Strait, and through to the Bering Strait and Bering Sea (Headland 2010).

we don't know about the ocean" (P43), "I have too much to tell and not enough time" (P20), and "keep surveying, keep surveying, keep surveying" (P1). The AHTA indicated that the questionnaire will serve as a record for younger generations, and that "for the future of our descendants this will be useful" (P17). Several AHTA Board members shared that this baseline will enable comparisons in coming years. Continued research and monitoring will be essential for the community to better understand and adapt to current, expected, and unknown impacts of changes (Huntington et al. 2004; Salomon et al. 2007), and will enhance the breadth of documented knowledge available for use in decision-making settings.

Lastly, the environmental and biological changes reported in this study help address "intermittent" baseline (Western scientific) knowledge of Arctic marine environments (Niemi et al. 2019), freshwater environments (Knopp et al. 2022), and their species (Dey et al. 2018). The documentation of Inuit knowledge enabled insights into historical ecological conditions that may have otherwise been obscure (Government of Nunavut 2018). Continued efforts will be key in distinguishing ecological trends from underlying variability (Huntington et al. 2004), which will become increasingly important as the climate changes. This knowledge may also help discern whether the presence (or abundance) of some species can be attributed to the year-round sea ice and open water features associated with Hudson Strait currents.

5. Conclusion

Through a partnership between researchers, and the AHTA, community technicians, and knowledge holders in Kinngait, Nunavut, we documented Inuit knowledge of coastal, marine, and lacustrine change. Experiences and perceptions of change for most environmental and biological parameters as well as the effects of changes on harvesting were nuanced and variable. Additional research is required to delve into habitat-related trends (e.g., water temperature increase, sea ice decline, wind direction changes, drying water bodies), species-related trends (e.g., decline in marine mammal abundance, changes in the condition of marine mammals and fishes), and their impact on harvesting, which in turn affects community sustenance, livelihoods, and wellbeing. This knowledge belongs to the community of Kinngait and AHTA, and may serve as a baseline that can inform local and regional decision-making and planning while elucidating Arctic ecological insights and uncertainties. By centering Inuit voices, we hope to contribute to a transition in the manner in which research is conducted and shared within and beyond Inuit Nunangat.

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Competing interests

The authors declare there are no competing interests.

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Supplementary material

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