

The importance of continuous dialogue in community-based wildlife monitoring: case studies of dzan and luk dagaii in the Gwich'in Settlement Area¹

Rachel A. Hovel, Jeremy R. Brammer, Emma E. Hodgson, Amy Amos, Trevor C. Lantz, Chanda Turner, Tracey A. Proverbs, and Sarah Lord

Abstract: Rapid environmental change in the Arctic elicits numerous concerns for ecosystems, natural resources, and ways of life. Robust monitoring is essential to adaptation and management in light of these challenges, and community-based monitoring (CBM) projects can enhance these efforts by highlighting traditional knowledge, ensuring that questions are locally important, and informing natural resource conservation and management. Implementation of CBM projects can vary widely depending on project goals, the communities, and the partners involved, and we feel there is value in sharing CBM project examples in different contexts. Here, we describe two projects in the Gwich'in Settlement Area (GSA), Canada, and highlight the process in which local management agencies set monitoring and research priorities. Dzan (muskrat; *Ondatra zibethicus* (Linnaeus, 1766)) and luk dagaii (broad whitefish; *Coregonus nasus* (Pallas, 1776)) are species of great cultural importance and are the focus of CBM projects conducted with concurrent social science research. We share challenges and lessons from our experiences, offer insights into operating CBM projects in the GSA, and present resources for researchers interested in pursuing wildlife research in this region. CBM projects provide rich opportunities for benefitting managers, communities, and external researchers, particularly when the projects are built on a foundation of careful and continuous dialogue between partners.

Arctic gwinagoo'ee gwa'an khanhts'at ejuk t'igwinjik k'iighè' nan kak jidii nihàh goo'aii tthak ts'at nits'òo tr'igwindaii geenjit gwiiyeendoo niinji'gwidhat. Ejuk t'igwinjik gwizh'it tr'igwiheendaii ts'at guk'andehtr'ahnahtyaa geenjit gwijiinchii goo'aii ts'at kaiik'it gwizh'it yi'eenoo nits'òo tr'igwiindaii' gwinjik guk'andehtr'ahnahtyaa k'iighè' kaiik'it gwizh'it t'angiinch'uu geenjit guuhadahkat gwijiinchii gwihee'aa ts'at daginuu, juudin nan ts'at nan kak gwinahshii tthak k'aginhahtii kat guuvah gugwitaandak. Nits'òo gwitr'it

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R.A. Hovel. Department of Biology, University of Maine-Farmington, 173 High Street, Farmington, ME 04938, USA.

J.R. Brammer. National Wildlife Research Centre, Environment and Climate Change Canada, 1125 Colonel By Drive, Ottawa, ON K1S 5B6, Canada.

E.E. Hodgson. Department of Biological Sciences, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada.

A. Amos and S. Lord. Gwich'in Renewable Resources Board, 105 Veterans' Way, Inuvik, NT X0E 0T0, Canada.

T.C. Lantz, C. Turner, and T.A. Proverbs. School of Environmental Studies, University of Victoria, P.O. Box 1700 STN CSC, Victoria, BC V8W 2Y2, Canada.

Corresponding author: Rachel A. Hovel (e-mail: rachel.hovel@maine.edu).

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gugwahahtsaa, kaiik'it kat, ts'at diiyah gwizhìt tr'iinlii nits'òo gwihee'aa k'iighè' nihlinehch'i' gwinjik kaiik'it gwizhìt guk'andehtr'ahnahtyaa goo'aii geenjit diiyah gugwaandàk gwiijiinchiì goo'aii niidadhanh. Canada gwizhìt Gwich'in Nan Sridatr'igwijiinlik gwizhìt nits'òo gwitr'it gugwahahtsaa ts'at guk'andehtr'ahnahtyaa ts'at nits'òo gwizhìt tr'igwahnah'aa zhat danh geenjit diiyah gugwaandàk. Dzan ts'at huk dagaii, tr'igwindaii geenjit gwiyeendoo t'atr'ijahch'uu k'iighè' kaiik'it gwizhìt guk'andehtr'ahnahtyaa gwiijiinchiì goo'aii aii geenjit juk nits'òo tr'igwindaii gwinjik gwizhìt tr'igwahnah'aa geenjit gwitr'it gugwahahtsah. Nikhwigwitr'it gwizhìt gwits'agwighah gwiì'è' ts'at dagwiidi'in' geenjit diiyah gwaandàk k'iighè', nits'òo GSA gwizhìt geenjit gwitr'it gugwahahtsaa ts'at juudin nan kak nin gwindaii gwizhìt gugwahnah'aa giiniindhan guuts'at tr'ihiidandal niidadhanh. Juudin jii geenjit gwitr'it gugwahtsii kat nihts'at gigìkhii k'iighè' kaiik'it gwizhìt gwiinzii guk'andehtr'ahnahtyah, gwitr'it gwichit kat, kaiik'it kat ts'at uu'òk gwizhìt gugwinah'in jii k'iighè' gwiinzii digugwitr'it gugwahahtsah.

Key words: community-based monitoring, Mackenzie River, muskrat, broad whitefish, Indigenous knowledge.

Résumé : Les modifications rapides de l'environnement dans l'Arctique suscitent de nombreuses préoccupations au sujet des écosystèmes, des ressources naturelles et des modes de vie. Une surveillance rigoureuse est essentielle à l'adaptation et à la gestion à la lumière de ces défis, et les projets de surveillance communautaire (SC) peuvent renforcer ces efforts en mettant en évidence les connaissances traditionnelles et en assurant que les questions sont d'importance locale, et en contribuant à la conservation et à la gestion des ressources naturelles. La mise en œuvre de projets de SC peut varier considérablement selon les objectifs du projet, les communautés et les partenaires concernés, et nous croyons qu'il est utile de partager des exemples de projets de SC dans différents contextes. Nous décrivons ici deux projets dans la région désignée des Gwich'in (RDG), au Canada, et soulignons le processus par lequel les organismes de gestion locaux établissent les priorités en matière de surveillance et de recherche. Le Dzan (rat musqué; *Ondatra zibethicus* (Linnaeus, 1766)) et le huk dagaii (corégone tschir; *Coregonus nasus* (Pallas, 1776)) sont des espèces d'une grande importance culturelle et font l'objet de projets de SC menés parallèlement à des recherches en sciences sociales. Nous partageons les défis et les leçons tirées de nos expériences, nous offrons des renseignements sur l'exploitation de projets de SC dans la RDG et nous présentons des ressources aux chercheurs intéressés à poursuivre des recherches sur la faune dans cette région. Les projets de SC offrent de riches possibilités aux gestionnaires, aux communautés et aux chercheurs externes, en particulier lorsque les projets reposent sur un dialogue attentif et continu entre les partenaires. [Traduit par la Rédaction]

Mots-clés : surveillance communautaire, fleuve Mackenzie, rat musqué, corégone tschir, connaissances autochtones.

Introduction

Climate change and industrial development are rapidly transforming the structure and function of northern ecosystems (Raynolds et al. 2014; Kokelj et al. 2015; St. Pierre et al. 2018; Lewkowicz and Way 2019), and these changes have the potential to impact northern livelihoods and cultural traditions by altering fish and wildlife habitat and impeding human access to sustenance species (Goldhar et al. 2014; Brinkman et al. 2016; Brown et al. 2018; Turner et al. 2018). In the face of this rapid environmental change, ongoing monitoring of Arctic species and ecosystems is vital to informed decision-making and adaptation (Kokelj et al. 2012; Johnson et al. 2015). In recent decades, community-based research (or community-based monitoring, CBM) has been advanced as a strategy to meet this need (Bell and Harwood 2012; Johnson et al. 2015; Kouril et al. 2016; Sjöberg et al. 2018). CBM has been defined as monitoring carried out by local stakeholders to address aims and objectives that are relevant to the region (Danielsen et al. 2014). CBM is often rooted in

traditional knowledge¹, increasing the likelihood of detecting environmental change in remote regions, while also ensuring that monitoring is focused on relevant indicators that contribute to decision-making and co-management processes (Danielsen et al. 2014; Johnson et al. 2015). Collaborative CBM projects can also help to optimize the use of limited resources, enhance local capacity, create employment opportunities, and provide access to a wider range of funding opportunities (Sekercioglu 2012). Importantly, the growth of community-based work is also consistent with a legal and ethical responsibility to respect Indigenous rights and title, and work within land claim and settlement agreements.

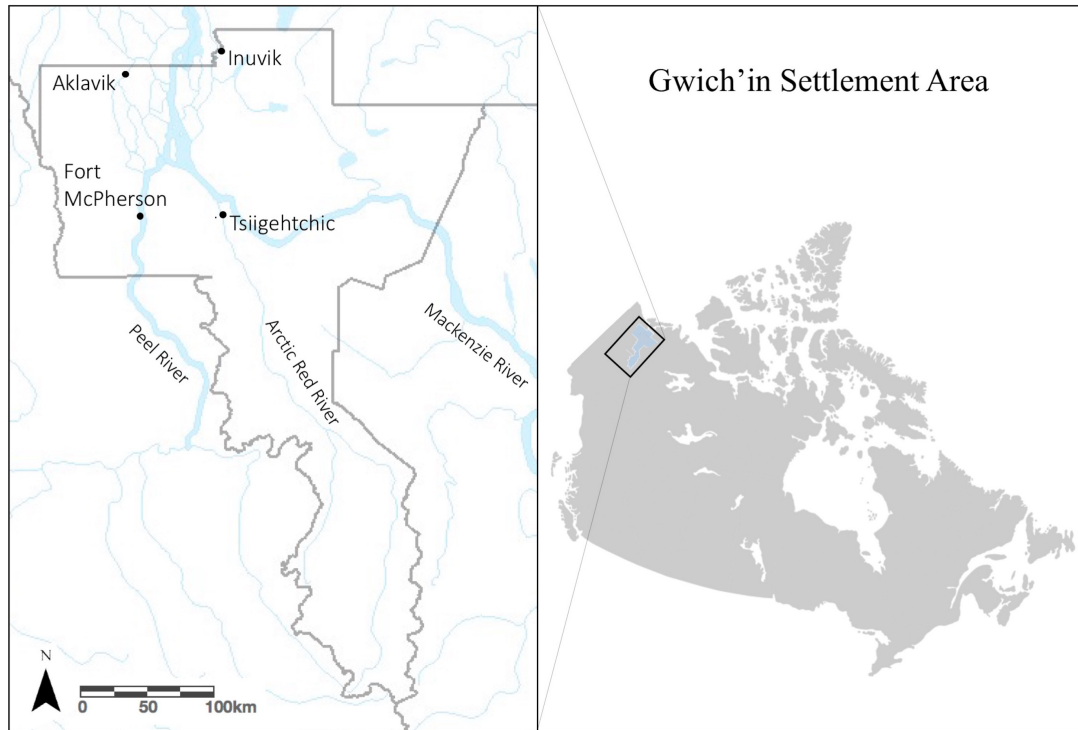
Across the Canadian Arctic, CBM initiatives involving collaboration among communities and external organizations have become widespread in many disciplines (Johnson et al. 2015). Castleden et al. (2012) notes that CBM projects inherently share decision-making power and ownership between external researchers and communities. In practice, the distribution of decision-making in CBM projects varies along a continuum, from externally-led initiatives with local data collection to autonomous monitoring that is entirely community-run (Danielsen et al. 2014; Brammer et al. 2016). The location of any given project along this spectrum depends on numerous factors, including project goals, funding structure, the project team, and the priorities and history of the communities involved. Characteristics of communities can include geographical (e.g., ecosystems used and traditional foods eaten), cultural (e.g., priority activities, seasonal calendars, and language), and legal (e.g., land claim and co-management structure) attributes.

Although CBM approaches are becoming increasingly common, details of project implementation frequently go undocumented. We feel there is value in sharing examples from a range of CBM projects to help inform future work, as new projects likely share circumstances and challenges with established efforts. For example, growing interest in CBM projects can create challenges by increasing demands on local organizations, as personnel may spend significant resources educating external researchers who are unfamiliar with local protocol and procedures. Similarly, the considerable community engagement required for CBM can present a challenge for external researchers existing in a publication-focused environment. Researchers often may have motivations for conducting monitoring that differ from the motivations of community organizations, and determining common objectives requires significant effort. It should also be noted that many of these challenges are rooted in the colonial history of research in northern regions; although CBM is intended to be a collaborative endeavor, it has also been criticized as another form of colonialism and co-optation (de Leeuw et al. 2012). Therefore, initiating new projects demands careful attention to collaborative planning, capacity generation, local governance, and transparent communication.

Despite these concerns, our experience in the western Canadian Arctic suggests that respectful and collaborative CBM projects can have significant mutual benefits and address many of the challenges in conducting effective ecological research and monitoring. To share our experience with CBM, here we describe challenges, solutions, and benefits encountered by a team of external researchers and community organizations while developing and implementing two community-based wildlife monitoring projects on the traditional lands of the Gwich'in First Nation (the Gwich'in Settlement Area (GSA); Fig. 1). Specifically, we review the process used by the local resource board to document, define, and disseminate community-based research priorities for fish and wildlife, a process that

¹There is a well-developed literature discussing the definitions of terms used to describe the knowledge possessed by groups with a long history of extensive interactions with their environment (e.g., Indigenous, traditional, or local knowledge; for a detailed historical review see Matsui 2015). Here we use traditional knowledge to denote a living body of knowledge passed on from generation to generation within a community. It often forms part of a people's cultural and spiritual identity (WIPO 2019).

Fig. 1. Map of the Gwich'in Settlement Area (base imagery obtained from Northwest Territories Geospatial Portal; ©Government of the Northwest Territories).



directs the type of projects in the region. Subsequently, we demonstrate how this process shaped the approach of our work on monitoring dzan (muskrat, *Ondatra zibethicus* (Linnaeus, 1766)) and luk dagaii (broad whitefish, *Coregonus nasus* (Pallas, 1776)) in the Mackenzie Delta region. Finally, we share resources and describe solutions, benefits, and lessons associated with these community-based monitoring projects, from our perspectives as professional scientists and resource co-managers in the GSA.

Defining research priorities in the GSA

The structure for promoting community-based wildlife monitoring and research in the Gwich'in Settlement Area grew out of the 1992 Gwich'in Comprehensive Land Claim Agreement (hereafter the Land Claim). The Land Claim stipulates that the Gwich'in Renewable Resources Board (GRRB) is to engage in wildlife research and act as the primary instrument of wildlife management in the Gwich'in Settlement Area. The GRRB operates across the entire GSA and cooperates with independent Renewable Resource Councils (RRCs) that represent the communities of Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic. The RRCs interact closely with the GRRB and act locally to highlight important issues and observations in each community's traditional territory.

To identify research questions and priorities in the GSA, the GRRB has developed a formal process of consulting with the RRCs as co-management partners. As part of this process, the GRRB maintains a long list of community-identified research interests, and a shortlist of GRRB-approved research priorities in the GSA. On an ongoing basis, GRRB staff update a comprehensive "Research and Management Interests" list (Supplementary

Fig. 2. Decision-making during the 2017 Gwich'in Renewable Resources Board (GRRB) Research and Management Priorities Workshop in Aklavik, Northwest Territories (photo property of GRRB; used with permission).

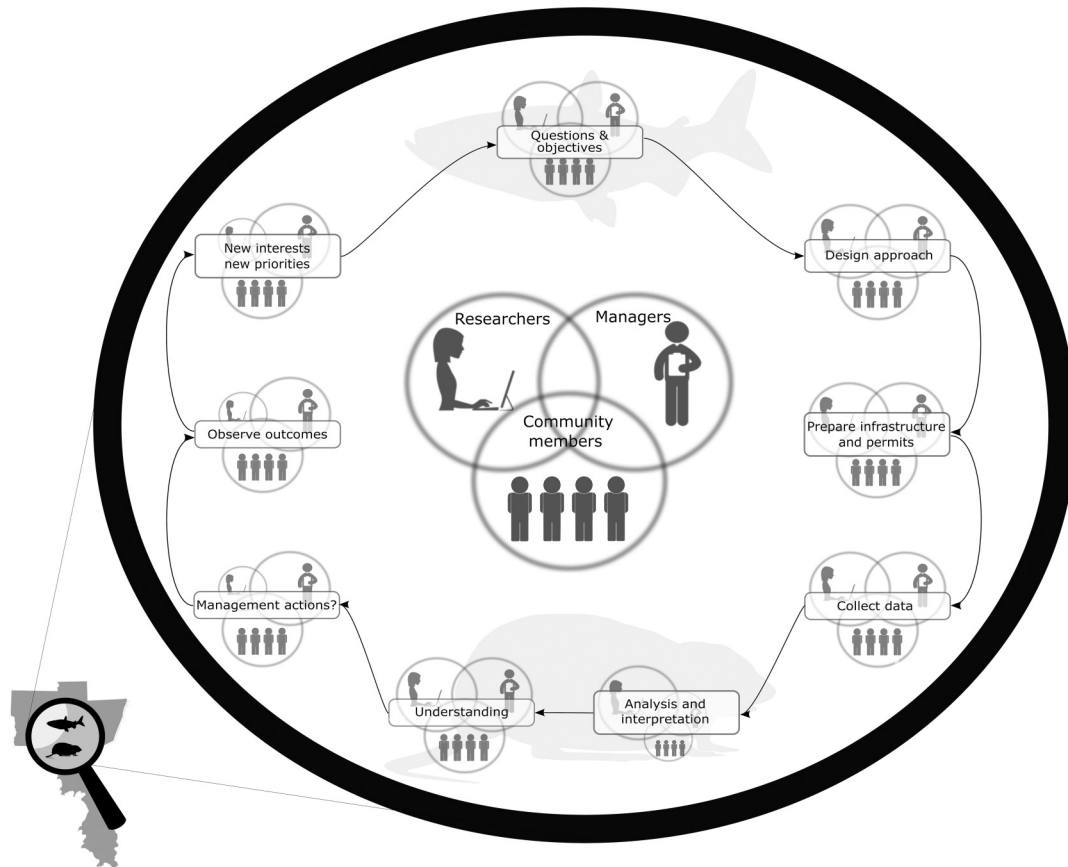


Information S1²) based on feedback and concerns obtained from the RRCs. This list does not consider whether past or ongoing research has addressed these concerns and is not restricted by the GRRB's mandate to manage fish, wildlife, and forest resources. The shortlist of GRRB-approved "Research and Management Priorities" (Supplementary Information S2²) is developed during a Research Priorities Workshop, first held by the GRRB in 2013 and now repeated every five years. This involves analyzing the Research and Management Interests list, omitting interests that have been addressed by past or present research projects, and then scoring the remaining interests according to a set of Board-approved criteria. Criteria for scoring Research and Management Interests have included, but are not limited to, identifying whether an interest fits the GRRB's mandate, is important to communities, and can be addressed using available resources. This is all carried out during a two-day workshop with co-management partners including the RRCs, the Government of the Northwest Territories (GNWT), and the Gwich'in Tribal Council (GTC; Fig. 2). Research and Management Interests are ranked according to their scores, and the GRRB subsequently selects and publishes their Research and Management Priorities on their website.

The Research and Management Priorities and Interests that emerge from this process provide a natural structure for community-based fisheries and wildlife research in the GSA and can be used to collaboratively define research questions with partner organizations and external researchers. Depending on the extent to which proposed new work addresses the GRRB's mandate and Research and Management Priorities, the GRRB can assist external researchers by providing letters of support, facilitating involvement of local youth, providing in-kind staff assistance, contributing financially, or partnering directly on the project.

²Supplementary material is available with the article through the journal Web site at <http://nrcresearchpress.com/doi/suppl/10.1139/as-2019-0012>.

Fig. 3. The research and monitoring cycle for fish and wildlife in the Gwich'in Settlement Area, adapted from the participatory adaptive monitoring cycle (Lindenmayer and Likens 2009; Brammer et al. 2016). Circle size highlights the relative contributions of researchers, managers, and community members to the different steps of the cycle. Researchers could include academic, government, and non-profit researchers; managers could include managers at the Government of Canada, the Government of the Northwest Territories (GNWT), the Gwich'in Renewable Resources Board (GRRB), and the Renewable Resource Councils (RRCs).



Direct involvement of communities in the subsequent design and implementation of a project is crucial, and the GRRB can offer greater support to projects that engage community members throughout the research and monitoring cycle (Fig. 3), particularly during the development of project questions, study designs, licensing, data collection, analysis, results, and interpretations. Where appropriate, the GRRB also encourages researchers to partner with the Department of Cultural Heritage of the Gwich'in Tribal Council, to discuss the inclusion of traditional knowledge in research and monitoring projects (see Box 1).

Within this framework, collaborations and interactions among external researchers, management organizations, and communities will vary depending on the nature of the project. In the following sections, we describe two research efforts that evolved around shared interests and priorities in the GSA. We share some background and briefly describe primary findings from these CBM projects and associated cultural research projects, to illustrate concrete examples of wildlife research being carried out in the GSA.

Box 1. Recommendations and resources for community-based monitoring (CBM) projects in the Gwich'in Settlement Area.

Before initiating the CBM project		
1.1	Understand local land claims and governance structures before making initial contacts.	→ Gwich'in Tribal Council: https://gwichintribal.ca/land-claims → Gwich'in Land Use Planning Board: https://www.gwichinplanning.nt.ca/theRegion.html → Gwich'in Land and Water Board: https://glwb.com
1.2	Consult the Gwich'in Renewable Resources Board (GRRB) Research and Management Interests and Priorities Lists and become familiar with past work in the region.	→ GRRB research process and lists: http://grrb.nt.ca/research.htm → Past reports: http://grrb.nt.ca/publications_author.htm
1.3	Contact communities and organizations to discuss interest and capacity to develop a partnership. Identify the most appropriate initial contacts and be targeted in your approach.	→ GRRB contact: http://grrb.nt.ca/contact.htm → Renewable Resource Council (RRC) contacts: http://www.grrb.nt.ca/wildlife_huntingtrapping.html → Gwich'in Tribal Council: https://gwichintribal.ca/connect → Western Arctic Research Centre: http://nwtresearch.com/about-us/contact-us
1.4	Invest in-person time in the region, to develop relationships with collaborators and other community members.	→ Assistance in funding longer trips: http://nwtresearch.com/logistics-support
In establishing and conducting the project		
2.1	Design the project to complement and not duplicate existing efforts. Connect and collaborate with other organizations to maximize resources and minimize local administrative burden. Invest in building new capacity in the region where needed.	→ ArcticNet: http://www.arcticnet.ulaval.ca/ → Aurora Research Institute: http://nwtresearch.com → NWT Cumulative Impacts Monitoring Program: https://www.enr.gov.nt.ca/en/services/nwt-cumulative-impact-monitoring-program-nwt-cimp
2.2	Ensure that study questions and design are suitable by communicating early and often with communities, collaborators, and managers. Involve partners in interpreting and communicating findings. Be flexible and willing to integrate suggestions from local knowledge holders.	→ RRCs can help facilitate community meetings
2.3	Engage with the community (e.g., attend events and celebrations).	→ Listen to local radio stations (CBQM, Fort McPherson) → Look for community Facebook pages and event calendars

Case studies

Muskrat (dzan)

Muskrat (in Gwich'in, dzan; *Ondatra zibethicus*) is an economically and culturally important furbearer in the Gwich'in Settlement Area (Turner et al. 2018). The GSA includes part of the Mackenzie Delta, which is a 13 000 km² Arctic wetland complex with more than 49 000 shallow lakes and channels (Emmerton et al. 2007) that provide a variety of productive habitats for muskrat and other semi-aquatic furbearers (e.g., mink and beaver). During the peak of the fur trade in this region, between 1940 and 1988, muskrats were the most numerous furbearer trapped in the Mackenzie Delta with a value that frequently surpassed that of all other furbearers combined (McTaggart Cowan 1948; Hawley 1968; Chetkiewicz and Marshal 1998). As expressed by one community member from Fort McPherson, “that little animal has raised a lot of families” (Turner et al. 2018, p. 604). Most Gwich'in residents of the Delta engaged in the spring muskrat harvest, or “ratting”, between March and June.

Fig. 4. (A) Rat Sunday collection in Aklavik 1933 (Northwest Territories Archives; used with permission), (B) the flag of the Hamlet of Aklavik featuring a muskrat (Farnel 2017; used with permission), (C) muskrat live trapping by community members (photo by J. Brammer, individual featured with permission), and (D) a community carcass collection project (photo by J. Brammer).



This harvest by trapping and shooting was such a cornerstone of the economic and cultural life of Gwich'in communities in the GSA that muskrats pelts were used for church collections on “Rat Sunday” (Fig. 4A), and the muskrat was included on the flag of the Hamlet of Aklavik (Fig. 4B). The underlying importance of muskrats and ratting season in Delta life was described by a young trapper living in Inuvik, “it doesn’t quite feel like springtime in the Delta if you don’t go out and get some rats, after a long cold winter you get out there in the spring ... it’s just good for you ... Therapeutic, for Delta people” (Turner et al. 2018, p. 607).

As early as 1995, Gwich'in trappers reported concerns regarding the status of muskrat populations in the Mackenzie Delta (Chetkiewicz and Marshal 1998). Muskrat trapping has declined significantly in the past 50 years, as trappers have moved into wage labour (Turner et al. 2018). Despite these changes, muskrat harvesting remains an important tradition for many families. Thus, when trappers reported a large-scale decline in the densities of muskrats, the RRCs relayed this observation to the GRRB. In 2008, the GRRB initiated its formal processes for publishing lists of Research Interests and Priorities. When the GRRB published its first list of Research Interests and Priorities in 2010, muskrats were included under the header “river otter abundance”, which included a description of community concerns that increased otter abundance was negatively affecting muskrats. In 2012, muskrats were added as an independent entry in the Research Interest List. In 2014, it was recommended that muskrats be added to the Research Priority List, and this recommendation was then implemented at the Research Priority Workshop in 2018. Although muskrats in the Mackenzie Delta were the focus of research projects in the 1940s (McTaggart Cowan 1948), 1950s (McEwan 1955), 1960s (Hawley 1964, 1965), 1970s (Martin 1974; EPEC Consulting Western Ltd. 1976), and 1980s (Jenkins 1984), to our knowledge they

had not been studied in the region following RRC reports of general declines in muskrat densities.

Between 2006 and 2014, two university-based muskrat research projects were independently initiated in the region (Research licence numbers: Aurora Research Licence #16274; Tracking Change 11-460 and 15-073; Wildlife Research Permit WL007378; WL500568; NWT Wildlife Care Committee Protocol 2017_20). The first examined environmental determinants of muskrat density dynamics in the Old Crow Flats, north Yukon (approximately 250 km west of the Mackenzie Delta). The second project explored the socio-cultural importance of muskrat harvesting in the Delta. The first project was established as part of the International Polar Year in 2007 (Wolfe et al. 2011; Brammer 2017), whereas the second emerged out of initiatives documenting environmental changes observed by Inuvialuit and Gwich'in land users in the Beaufort Delta Region (Bennett and Lantz 2014; Gill and Lantz 2014). In spring 2014, a chance encounter between the lead graduate student on the Old Crow Flats project and the GRRB's Renewable Resources Manager initiated communication on the GRRB's muskrat Research and Management Priority. This conversation led to an invitation for the graduate student to present to the communities of Inuvik and Aklavik in that year, which led in autumn 2014 to a successful joint funding application between the GRRB, McGill University, and the University of Victoria to expand the scope of muskrat research in the Mackenzie Delta.

This partnership has sought to address regional concerns about declining muskrat populations, by quantifying the magnitude and spatial patterns of the decline and exploring potential drivers of these patterns. Ecological research to date has involved aerial surveys of muskrat pushups (mounds of vegetation that muskrats construct to shelter breathing holes in lake ice and an index of muskrat density; Simpson et al. 1989), a community carcass collection program, and a trapping and field research camp, all of which closely involve community members (Brammer et al. 2019; Figs. 4C and 4D). We estimated baseline muskrat densities across the Delta, using a mix of ground (Stevens 1953; Hawley 1964, 1965; Martin 1974; EPEC Consulting Western Ltd. 1976) and aerial (Department of Environment and Natural Resources, Government of Northwest Territories 1972, 1973) counts of pushups conducted between 1948 and 1976. We found median densities in aerial surveys between 2015 and 2019 were roughly 40% of those in counts between 1948 and 1976, with declines being particularly pronounced in the upper Delta (Brammer et al. 2019). By analyzing carcasses donated by community members, we explored whether parasite burdens, contaminant loads, or predation could be playing an important role in this decline. We found current parasite loads to be similar to those documented in the Delta in the past (McTaggart Cowan 1948); mean liver concentrations of mercury, cobalt, cadmium, arsenic, selenium, mercury, and lead were similar in Delta muskrats compared to those from across Canada; and muskrats were a small portion of the stomach contents in our donated sample of red fox, mink, and otter carcasses (Brammer et al. 2019).

To document traditional knowledge of muskrats and better understand past and present relationships with this species, Turner et al. (2018) conducted 31 interviews with participants from Aklavik, Inuvik, Fort McPherson, and Tsiigehtchic. All interviews were associated with a Traditional Knowledge Research Agreement with the Gwich'in Tribal Council Department of Cultural Heritage and the project was reviewed and approved by the University of Victoria Human Research Ethics Board. Interviews were led by a Masters student from the University of Victoria and research assistants hired through the Gwich'in Tribal Council Department of Cultural Heritage. Interview participants were chosen based on recommendations made by staff members at the Gwich'in RRCs and GTC Department of Cultural Heritage, the results of previous work on environmental change

in the region, and self-identification. These participants included active muskrat trappers, and elders who had significant experience with muskrats but were not active land users at the time of the interviews (Turner et al. 2018). After data collection, key themes were presented to each community via community meetings and in-person conversations, to ensure accuracy and guide analysis and synthesis. Interviews were analyzed using an iterative coding process to identify key themes and explore areas of similarity and divergence among participants (Turner et al. 2018). This research showed that muskrats are less abundant and make a smaller contribution to food and income for residents of the Delta than in the past, but remain a vibrant and vital part of Gwich'in and Inuvialuit cultures. Although the role of muskrats in local livelihoods is shifting, ongoing use of this species contributes to cultural continuity, knowledge transfer, maintaining land-based traditions, and fostering individual and community well-being (Turner et al. 2018).

Ongoing research and monitoring of muskrats associated with this project involves live-capture surveys to identify how muskrat weight gain, reproductive rates (e.g., juvenile to adult ratios), habitat use, and survival vary across lakes in the Delta (Fig. 4C). We also continue to organize on-the-land research camps, where youth, elders, active harvesters, and researchers from government, academia, communities, and co-management agencies can share knowledge about this species. For all activities on completed and ongoing projects, community partners or interview participants were hired or awarded honoraria at the daily compensation rate set by the Renewable Resource Councils, and this rate is consistent across communities.

Broad whitefish (łuk dagaii)

Broad whitefish (in Gwich'in, łuk dagaii; *Coregonus nasus*), is the primary species in the subsistence fishery of the Gwich'in Settlement Area (Greenland and Walker-Larsen 2001; Thompson and Millar 2007). This abundant species is harvested from approximately June through October at subsistence fish camps in the lower Mackenzie River and its tributaries. Gwich'in fishers set gillnets in open water during summer, and under the ice once rivers freeze, and the captured fish are then frozen or dried in fish houses to preserve for later use or for sale (Fig. 5). Subsistence harvest of broad whitefish is a culturally and nutritionally important activity, and continued access to fish is a primary concern for community members. Speaking about fish on 30 August 2017, Hannah Alexie (Fort McPherson) remarked, "[Fish] is our traditional food. And we live on that. Because nowadays, you get meat from the store, it don't taste like our traditional food so, we rather have our traditional food." (Proverbs et al. 2020).

Broad whitefish is a highly mobile species and may occupy rivers, lakes, and the ocean. Although variation exists in the extent of migrations, a single individual may use multiple of these habitats in a lifetime (Thompson and Millar 2007; VanGerwen-Toyne et al. 2008; Harris et al. 2012). As a result, this species could encounter changing conditions throughout the Mackenzie River watershed, including changes to river habitats through thawing permafrost and altered hydrology (St. Pierre et al. 2018), the potential for Pacific salmon colonization (Dunmall et al. 2016), and shifts in ocean productivity (Ardyna et al. 2014). In response to watershed changes, community members raised questions regarding various fish species, including broad whitefish. As noted by Abraham Stewart of Fort McPherson, "... We need to preserve these things. You get an idea of how much we can have, how much we can use." (Edwards 2019). Currently, broad whitefish populations remain abundant, and within the GRRB's 2013 priorities framework they are included under the "climate change" Research and Management Priority, they are listed on the Research and Management Interests list, and they fit within the goals of establishing standardized monitoring programs. The Department of Fisheries and Oceans has conducted some work on broad

Fig. 5. Whitefish are harvested in gillnets (A) and sampled (B and C) before being frozen or smoked and dried for consumption (D) (photos by E. Hodgson, individuals featured with permission).



whitefish prior to 2005 (VanGerwen-Toyne et al. 2008; Harris et al. 2012; Millar et al. 2013), but relatively few efforts have focused consistently on this species and the GRRB has therefore highlighted an outstanding need for baseline data.

Similar to the muskrat example, two independent projects focusing on fish in the GSA were initiated between 2015 and 2016 (Research licence numbers: Aurora Research Institute Permit #16152; DFO Licence #S-18/19-3015-YK; Animal Care Protocol #1248B-17, Simon Fraser University). One project was designed as a monitoring project focused exclusively on broad whitefish, and the second was a research project focused on how socioecological change may impact Gwich'in fishing livelihoods. The latter project included broad whitefish as an important component of harvest, but this species was not the exclusive focus (Proverbs et al. 2020). The whitefish monitoring project evolved in an iterative manner, after a university-based researcher met community members in Fort McPherson while visiting the area on a paddling trip in 2015, and engaged in casual discussions about the fish species of the region. In these initial discussions, community members indicated concern over the impacts of climate change and development, and identified that fisheries expertise would be of use locally. University researchers then engaged in further conversations with community members, RRCs, and the GRRB about what form of monitoring would be of interest, and identified broad whitefish as a species important to the community and sensitive to climate change and development. The majority of these conversations occurred over phone and email correspondence with GRRB staff and RRC coordinators. Additionally, in 2013, the GRRB had identified a priority of “developing standardized fisheries protocols” (GRRB 2013). Given the GRRB’s limited capacity to implement all research questions in the region, this collaboration was quickly identified as a way to build capacity and contribute resources across all parties. Although this is an example where external researchers identified a research idea through spontaneous community conversations and then initiated the conversation with the GRRB and RRCs, the strong relationships

that emerged were a product of demonstrating intentions for genuine collaboration, respect, and community involvement.

Currently, the whitefish monitoring project maintains a community-based fish data collection effort based in Fort McPherson, Aklavik, and Tsiigehtchic. The sampling sites were chosen by consulting each RRC and through in-person conversations with harvesters in each community, to identify locations where fish are easily captured and where harvest consistently occurs. Working in multiple communities allows more comprehensive engagement across the region and allows the monitoring project to collect samples from the Peel River, the Arctic Red River, and the Mackenzie River Delta. At each sampling location, community-based researchers collected data on broad whitefish that they captured throughout the harvest season, including fish length and weight, scales and otoliths, and fin clip samples. Each fish was also photographed and, where logistically possible, a tissue sample collected for contaminant analysis. Community researchers also recorded information on river conditions and relative abundance of different fish species (through catch-per-unit-effort). Using otolith microchemistry analysis, a technique that analyzes elements archived in fish bones to identify which habitats an individual has occupied ([Kennedy et al. 2002](#)), this project corroborated previous knowledge that some of the broad whitefish captured in the subsistence fishery migrate to the ocean ([Harris et al. 2012](#)). Results from this project also revealed new information on extensive migrations between rivers, indicating that intact habitat throughout the watershed is critical for broad whitefish populations (E.E. Hodgson, R.A. Hovel, E. Ward, S. Lord, and J. Moore, unpublished data, 2020). In the first two years of the project, over 800 fish were sampled by seven community researchers and five youth. Ernest Vittrekwa has remarked, “I enjoy it knowing that we are protecting our water in the Peel watershed, and that we are protecting our fish now.” ([Scott 2018](#)).

As the monitoring project was developed, parallel work exploring changes in Gwich'in fishing livelihoods was also conducted by the University of Victoria and the Gwich'in Tribal Council Department of Cultural Heritage. This study was led by a Masters student as part of the Tracking Change project, which is an international effort to document local and traditional knowledge related to fishing livelihoods in the Amazon, Mekong, and Mackenzie River Basins ([Parlee and Maloney 2016](#)). Tracking Change research in the GSA examined the relationship between access to fish and human well-being, and the socio-economic determinants that drive access to fish. As such, this project team conducted interviews with 29 Gwich'in community members from Aklavik, Inuvik, Fort McPherson, and Tsiigehtchic. Interview participants were identified through the recommendation of Gwich'in organizations in each community (e.g., the Renewable Resource Councils, the Ehdiiat Band Office, and the Gwich'in Tribal Council Department of Cultural Heritage), and by word-of-mouth inquiries. Interviews were semi-structured, and questions focused on personal fishing history, determinants of access to fish, and environmental change ([Proverbs et al. 2020](#)). University of Victoria researchers generated an initial list of questions, based on pilot interviews in 2016, and the initial list of interview questions was edited by the GRRB before interviews began. To document experiential knowledge of fishing in Gwich'in territory, the study team also organized gatherings at four fish camps across the GSA. GRRB funding allowed the project team to hire six youth to attend the fish camps near their communities, to assist with interviews, and spend time on the land with harvesters and elders. This project was approved by the University of Victoria Human Research Ethics Board and governed by a Traditional Knowledge Research Agreement with the Gwich'in Tribal Council Department of Cultural Heritage.

Interview participants made it clear that access to fish is important to Gwich'in identity and is intimately intertwined with many facets of well-being. Participants also discussed a trend of declining access to fish, linked to various socio-economic and environmental

barriers. Despite this, all participants were still able to access fish. Analysis of the interviews suggests that several cultural institutions help to sustain and strengthen Gwich'in fishing practices, including social and sharing networks, and adaptive practices that are embodied in land-based education programs and ecological monitoring programs like the whitefish monitoring project (Proverbs et al. 2020). For both the whitefish monitoring project and the interview-based research, external researchers maintained regular contact with Gwich'in partner organizations and made numerous visits to Gwich'in territory over the course of the projects, across different seasons and for periods of time ranging from two weeks to two months. These visits included sharing, discussing, and interpreting project results, using plain-language reports, radio announcements, community meetings, and RRC or GRRB meetings.

Monitoring and research on broad whitefish is ongoing, and the CBM project continues to build sampling capacity in communities across the GSA. Sampling conducted each harvest season is advancing understanding of the ecology of broad whitefish captured in the subsistence fishery and is developing a monitoring data set that can be used to detect changes to broad whitefish ecology or harvester access. As with the muskrat projects, all community partners or interview participants were compensated during these studies at the daily rate set by the Renewable Resource Councils.

Lessons from the muskrat and whitefish projects

The muskrat and whitefish projects have both developed into diverse collaborative networks that have expanded regional monitoring capacity for these species. Components of both projects began by chance, in an aircraft and on a river, but these fortuitous interactions allowed us to quickly establish contacts and identify local priorities (Recommendations 1.2 and 1.3; see Box 1). In both projects, frequent dialogue between community members, RRCs, researchers, and the GRRB facilitated collaboration on research question development, study design and data interpretation (Fig. 3). The paired natural science and traditional knowledge research allowed the project teams to investigate multiple dimensions of these important subsistence species, using a variety of methods. As a result, community-based researchers were engaged in multiple forms of data collection and documentation: facilitating interviews; collecting specimens; traveling via air, snowmobile, or boat to field sites; and living in field camps alongside other members of the project team.

Once the projects were initiated, some elements of both the muskrat and whitefish monitoring projects were refined during implementation. Several challenging questions emerged that required project adaptation, and these included: how to conduct project decision-making, how to administer finances, where to conduct fieldwork, and who should participate in field activities. For example, the two muskrat projects were partnerships between multiple universities, Environment and Climate Change Canada, the Department of Environment and Natural Resources of the GNWT, and local organizations (the GRRB and the GTC). The process of decision-making was challenged to include community, management, and research partners throughout, without straining the limited capacity of all involved. The balance that was struck took advantage of co-management decision-making frameworks already in place, namely the annual general assemblies of the RRCs of the GSA and the biannual meetings of the GRRB, to discuss and make decisions related to both muskrat projects. This decision-making framework highlights the importance of understanding the land claims in a study region (Recommendation 1.1; see Box 1) that define the co-management arrangements, and we found that capably understanding the land claims represented a significant learning curve early in our projects. Administering project finances required a similar balancing act, between efficiently paying

project participants and minimizing the bureaucratic burden on local organizations (Recommendation 2.1; see [Box 1](#)). For both muskrat and whitefish projects, this challenge was managed by allocating different categories of expenses (e.g., honoraria for community members, equipment, travel) to the particular entity best suited to administering that category of expense in a timely and efficient manner (e.g., RRCs, the GRRB, universities, and Environment and Climate Change Canada). This ensured that community participants were paid promptly, and that local agencies that administered payments to community members were not burdened by managing and reporting a wide range of project funds and expenses.

For both the muskrat and fisheries projects, determining the location of field sites and identifying who might participate in field work presented another challenge (Recommendation 2.2; see [Box 1](#)). In addition to ecological considerations, land claims (the Mackenzie Delta contains areas encompassed by both the Gwich'in Comprehensive Land Claim Agreement and the Inuvialuit Final Agreement) and family territories factored into decision-making regarding field sites. For the muskrat project, these decisions benefited from regular meetings with local co-management agencies (i.e., the Department of Environment and Natural Resources of the GNWT, GRRB, and RRCs), and through these meetings we were fortunate to identify the former Canadian Wildlife Services' Experimental Trapping Area ([Hawley 1964](#)) as an acceptable field site. This area was also highly suitable because the elder who was most familiar with the territory also worked as a research assistant during original research in the 1960s. Determining the field work locations influenced the selection of community participants, as those with more interest and experience in the area of the field sites were more likely to be selected. This process, for both muskrat and broad whitefish projects, benefited greatly from the input of RRCs.

Scheduling sampling timelines, fieldwork, and reporting trips also presented some logistical challenges for all projects. All itineraries were necessarily scheduled around cultural events such as celebrations or festivals, and demanded flexibility to account for unanticipated circumstances, especially those, like funerals, that require particular sensitivity (Recommendation 2.3; see [Box 1](#)). In the first year of the whitefish project, researchers were naive to the annual Gwich'in celebration at Midway Lake on the August long weekend, and scheduled data collection training at a time when most community members were enjoying this event. Sampling, reporting, and other project-related activities are now designed to explicitly accommodate community events that are scheduled in advance, and external researcher travel builds in extra contingency time to anticipate delays.

The initial implementation of both projects also highlighted the need to sustain ongoing interactions and slowly build trust in communities (Recommendation 1.4; see [Box 1](#)). For both projects, university-based researchers frequently returned to communities to discuss project planning and results. These interactions proved essential to building trust and positive relationships with community-based researchers, and included providing updates at regular GRRB and RRC meetings, delivering presentations and demonstrations at the local schools and college, holding evening community meetings and discussions, and presenting key findings on the local radio station. However, engaging in conversations solely around research is not sufficient, and our experiences also suggest that spending unstructured time in the communities and attending local events is critical to allow familiarity, sustained relationships, and rewarding friendships to develop. New faces often stand out in smaller communities, and individuals from outside of the area may receive questions such as, "Who are you and what brought you here"? A university-based researcher on the whitefish project was asked this question in an encounter with a community member who was initially reserved and hesitant. In this interaction, as in many others, the community member warmed up considerably when the researcher explained the work on broad

whitefish and ongoing collaborations with community members. Conversations such as this emerge easily when attending local events, and external researchers on both the muskrat and whitefish projects found the Midway Lake music festival to be a powerful introduction to the importance of spending unstructured time with community members beyond those directly engaged in the projects. Unstructured conversations also allow for further discussions on project topics, and contribute to the iterative process of evolving research priorities and interpretation. This has been found to be the case by others engaging in CBM projects as well ([Castleden et al. 2012](#)).

Conclusions and resources for work in the Gwich'in Settlement Area

Collaborative CBM offers a wide range of benefits and opportunities for management bodies, resource users, and external- and community-based researchers from multiple disciplines. In our experience, CBM collaborations can ensure that a project has the necessary resources and capacity to succeed. Specifically, community-based collaborators can inform questions and study designs and facilitate data collection and interpretation, external researchers can contribute additional funding and analysis, and traditional knowledge holders provide a wealth of information on the landscape ([Castleden et al. 2012](#)). Additionally, our projects were greatly enriched by connecting natural resource and socio-cultural research. These linkages highlighted the roles of each species in local cultures and livelihoods, and demonstrated how changes to access to these species can impact human health. We recognize that it may not always be possible to conduct traditional knowledge research parallel to natural science monitoring approaches, but we feel that extensive engagement with community members throughout any monitoring project contributes to more effective research and management ([Armitage 2005](#); [Armitage et al. 2011](#); [Herrmann et al. 2014](#)). Ongoing communication can amplify traditional knowledge and ensure that the work addresses locally relevant questions. Importantly, monitoring projects that are built around community concerns can, therefore, more effectively document the causes and consequences of rapid socio-ecological change ([Prno et al. 2011](#); [Ford et al. 2016](#)). Shifting monitoring and research to prioritize community concerns and questions are also essential steps to move research from a colonial framework toward one that is collaborative.

Knowing these benefits, we feel that external researchers should assume a greater share of the burden of sharing information on experiences with community-based monitoring. To help inform future research in the Gwich'in Settlement Area and provide context for projects elsewhere, we outline some recommendations from our experiences with CBM projects and provide associated resources for individuals new to the region ([Box 1](#)). Our intent is to highlight the process we undertook to initiate and conduct CBM in partnership with the GRRB, but these resources do not serve as an exhaustive roadmap for the connections that should be pursued if working in the GSA. Although our approaches to iteratively develop and implement research questions and hypotheses, study design, and interpretations were developed for projects specific to the GSA, these steps could likely apply to CBM projects in other regions. Best practices can vary widely by project and by community, so we recommend investing sufficient time early in the process to become familiar with local structures and expectations.

Although external researchers are responsible for learning about local systems and cultural context when working in a new region, we feel that effective community partnerships can be further supported by funding agencies and the broader scientific community, through targeted grants and support for networks and training. At present, a small number of funding sources support the repeated travel necessary for initial community consultations, the follow-up visits that are essential for collaborative research, and any

reporting-related travel (e.g., researchers to community gatherings and community members to scientific conferences). Additionally, time and funding available to university-based researchers may not be adequate to foster effective partnership building, especially in cases where communities and co-management organizations have limited ability to engage with new projects. There is opportunity for a greater range of funding agencies to facilitate collaborations between researchers, co-management agencies, and community members by including community engagement as a component of requests for proposals and dedicating funds to these efforts. We also see a growing need for mechanisms to develop connections between researchers and the community organizations that might have questions relevant to particular expertise, and for more routine training for university-based researchers on topics of co-management frameworks and land claims.

In summary, CBM projects are essential and effective tools, with particular relevance to rapidly-changing environments. Through our own experiences in community-based work, we underscore the necessity for strong local relationships and the importance of an ongoing dialogue with local organizations to understand the context surrounding the research and management process. This requires frequent, iterative communication with local governments, co-management organizations, local councils, and community members. As outcomes, these efforts return meaningful relationships, and knowledge that informs management decisions and reflects local priorities.

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Kaiik'it gwizhìt dzan ts'at huk dagaii gwizhìt gugwinah'in gugwitr'it geenjit nikhwits'at tr'igiinjik geenjit jii kat mahsi' guuvaadinuh, jii kat gwizhìt t'igiinch'ù', Teetlit Gwich'in, Gwichah Gwich'in, Nihtat, ts'at Ehditit RRCs; GTC Department of Cultural Heritage, diiyah gwitr'it t'agwah'in' kat, Alice ts'at Ernest Vittrekwa, Abraham Stewart, Mary Effie Snowshoe, William ts'at Wally Tyrrell, Louie Cardinal, Doug Esagok, Leslie Cardinal, ts'at

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