Monitoring environmental conditions using participatory photo-mapping with Inuvialuit knowledge holders in the Mackenzie Delta Region, Northwest Territories

by

Trevor Dixon Bennett
B.A, University of Guelph, 2007

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER OF ARTS

in the School of Environmental Studies

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Abstract

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The Mackenzie Delta region of Northwestern Canada is a dynamic environment that is ecologically and culturally significant. This region is experiencing rapid environmental change that is expected to worsen with continued climate warming and additional anthropogenic stressors. In northern regions, conventional environmental monitoring strategies can be hindered by complex and cost prohibitive logistics. In this context of environmental change and uncertainty, there is a critical need to draw on traditional ecological knowledge (TEK) and observations to inform decision-making. In some areas changes in land cover are occurring so rapidly that maintaining an accurate inventory is problematic. Knowledgeable land users are in a unique position to assess changes in regional environmental conditions and inventory cumulative impacts.

Environmental decision-making in the Inuvialuit Settlement Region requires Inuvialuit participation in several co-management bodies. The objectives of this project were to develop and field-test a community-based monitoring program that shares Inuvialuit observations with stakeholders in environmental decision-making in a standardized and accessible format. Working with the Hunter and Trapper Committees of Aklavik, Inuvik, and Tuktoyaktuk, the Inuvialuit Joint Secretariat, and the Cumulative Impacts Monitoring Program we[1] adapted a participatory photo-mapping (PPM) method to record Inuvialuit observations of environmental conditions using a strategy consistent with community goals and Inuvialuit culture.

In the summer of 2010, we worked with knowledgeable Inuvialuit hunters and land users to document Inuvialuit observations of environmental conditions using digital cameras

[1] Because chapters 2 and 3 were co-authored, plural was used throughout the entire document.

and hand held GPS units. Subsequently, digital photographs and video footage became the focus of photo-elicitation interviews, which added a detailed narrative to each geo-referenced observation. Following fieldwork and interviews, geo-referenced photos, video, and associated text files were entered into web-based map. Approximately 150 observations were mapped and grouped into 33 themes.

Interviews with monitors and a range of potential map users suggest that web-based mapping is an effective way to record and share observations and concerns related to the regional environment. We found that PPM could be very useful for northern researchers, decision-makers, and planners because it can facilitate knowledge transfer among stakeholders, facilitate community consultation, and contribute to environmental impact assessment and monitoring strategies. Our experience suggests that by providing a record of the location and magnitude of anomalous environmental conditions, this monitoring initiative will contribute northern planning and decision-making, and the communication of TEK and observations among northern stakeholders. Overall, this research highlights the effectiveness of using the web-based PPM tool to document and share Inuvialuit observations. A monitoring program built around TEK and observations that are linked to geo-referenced images (and other media) will significantly improve our capacity to detect the impacts of environmental change.

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Acknowledgements

This project was a collaboration between a variety of groups and individuals. The Hunter and Trapper Committees (HTCs) of Aklavik, Inuvik, and Tuktoyaktuk, with a special thanks to Douglas Esagok, Michelle Gruben, Emanuel Adam, Richard Binder and the Inuvialuit Joint Secretariat in Inuvik, and the Cumulative Impact Monitoring Program (CIMP) staff in Yellowknife Steve Kokelj, Claire Marchildon, and Stephan Goodman were extremely helpful in facilitating fieldwork. I would like to thank all the participants of this study who generously gave their time in interviews.

This research was made possible by funding from the NWT Cumulative Impact Monitoring Program, MITACS Accelerate Internship, Northern Scientific Training Award Program, Aurora Research Institute Fellowship, Dairyland Environmental Scholarships, and a University of Victoria Graduate Student Award.

I would like to thank my supervisory committee, Trevor Lantz, Kara Shaw, and Andrea Walsh, for the support and assistance at every turn of this research. At the University of Victoria, Ken Josephson was extremely helpful with the web-based mapping aspect of this research.

Finally, this would not have been possible without support and guidance from my friends, and my family, Linda, Megan, Kelsey, Louise, and Jim. Thank you so much.

Chapter 1

Introduction

Monitoring and understanding environmental change in the North has probably never been more important. Proposed industrial developments in the North (pipelines, mines etc.) are taking place against a backdrop of rapid environmental change associated with warming temperatures. Recent observations of change in the western North American Arctic include increasing temperature, reductions in summer sea-ice cover, and increased frequency and intensity of extreme weather events (Corell 2006; Parry 2007; Comiso *et al.* 2008; Graversen *et al.* 2008; Moline *et al.* 2008; Perovich *et al.* 2008). Reduction in sea ice extent, increasing coastal erosion, rising sea levels, and permafrost thaw are also threatening the municipal infrastructure of coastal communities and coastal heritage sites (Couture & Pollard 2007; Huntington *et al.* 2007; Alessa *et al.* 2008; Larsen *et al.* 2008) Changes in weather patterns have led to increased risk and difficulty associated with traveling and accessing harvesting areas. These impacts are expected to worsen with continued changes to climate (Jolly *et al.* 2002; Weller *et al.* 2005; Ford, Smit, & Wandel 2006; Furgal & Seguin 2006; Nickels *et al.* 2006; Huntington *et al.* 2007; Krupnik & Ray 2007; White *et al.* 2007; Ford *et al.* 2008; Hovelsrud, McKenna, & Huntington 2008; Huntington *et al.* 2009; Krupnik & Jolly 2010).

The sum total of these perturbations creates an enormous amount of uncertainty about what the environment will be like in the decades ahead. In order to address this uncertainty, there is an urgent need for the development of a systematic and community-

driven strategy for monitoring environmental change that is grounded in traditional ecological knowledge[2] (TEK) and observations. Local holders of TEK are well suited to make a valuable contribution to environmental monitoring efforts because they know where, how, and when the environment changes based on extensive experience and years of observation (Riedlinger & Berkes 2001; Huntington *et al.* 2005). Scientific monitoring in remote northern regions can also be logistically complex and prohibitively expensive (Serreze *et al.* 2000; Pearce *et al.* 2009; Pisaric *et al.* 2011; Kokelj In Press). Many local land users are very interested in sharing their observations broadly (Krupnik & Jolly 2010).

In the Northwest Territories (NWT) there have been repeated calls for the development of a long-term cumulative impacts monitoring program that includes traditional ecological knowledge. Examples include the Mackenzie Valley Resource Management Act, the text of several aboriginal land agreements, the recommendations of the Mackenzie Valley Joint Review Panel, and the McCrank Report to the Minister of Indian and Northern Affairs Canada (McCrank 2008; National Energy Board 2009).

The Mackenzie Delta Region (MDR) MDR includes the large delta surrounding the Mackenzie River from Point Separation north to the Beaufort Sea, as well as areas of upland terrain to the east and west of the delta plain (Burn and Kokelj 2009). The research is this thesis was conducted primarily in the MDR, with additional fieldwork in the Yukon North Slope and the Tuktoyaktuk peninsula (Figure 1.1). The MDR is an area

[2] Throughout this thesis, unless stated otherwise "TEK" refers to the traditional ecological knowledge held by Inuvialuit land users, as defined on page 24.

in the western Canadian Arctic that is both ecologically dynamic and culturally significant. The northern tree line cuts laterally across the MDR, dividing subarctic boreal forest from northern tundra and coastal wetland ecosystems (Burn and Kokelj 2009). The MDR is ecologically rich and is capable of supporting a wide variety of life, and dense human population, unlike its surrounding environments, which are more barren, dry, and resource-poor (Alunik *et al.* 2003). The region has long cold winters (mean January temperature in Tuktoyaktuk is -27.2°C), and short cool summers (mean July temperature in Tuktoyaktuk is 10.9°C) (Johnstone & Kokelj 2008). The MDR provides breeding and staging habitat for hundreds of species of migratory birds and supports diverse populations of fish and mammals (National Energy Board 2009). Like many parts of the Arctic, this region is experiencing dramatic environmental change that is expected to worsen with additional anthropogenic stressors (Weller *et al.* 2005; Burn & Kokelj 2009; Prowse *et al.* 2009; Pearce *et al*. 2011).

The MDR is the homeland of the Inuvialuit and Gwitch'in peoples, who remain strongly connected to their marine and terrestrial wildlife and natural resources for subsistence and livelihoods, still critically linked to hunting and fishing for subsistence (Pearce *et al.* 2009a). The focus of this research was in areas frequently used by hunters and trappers from the communities of Aklavik, Inuvik, and Tuktoyaktuk NT (Figure 1.2). The communities are primarily Indigenous and have a combined population of approximately 4000 (Inuvialuit Communications Society 2009).

Figure 1.1 Screen shot captured from the web-based map of Inuvialuit observations (http://mapping.uvic.ca/mackenziedelta/geobrowser) using Google imagery. The red box defines the research area used in this study. The dotted white lines show provincial and territorial boundaries, the solid line shows the international border with the United States.

Figure 1.2 Tuktoyaktuk after a snowfall in February. Tuktoyaktuk, NWT. 2010. Photo by T. D. Bennett.

Proposed developments in the MDR include the construction of a pipeline that will stretch 1,200 kilometers south to Alberta, all season roads, anchor fields for gas extraction, and pumping stations. Predicted impacts of development include the loss of terrestrial habitat important for waterfowl and migratory birds, and changes to vegetation due to inundation and increased overland flooding caused by subsidence (National Energy Board 2009). Over the entire route, the proposed pipeline will cross over 500 waterways, move through areas of continuous and discontinuous permafrost, and pass through tundra, wetlands, woodlands and continuous forest areas (National Energy Board 2009).

The proposed pipeline will be buried in permafrost terrain and will carry cooled (compressed) materials. The temperature differential between the pipeline and the surrounding ground is likely to cause cooling (freezing) and warming (thawing), which will impact waterways and destabilize terrain surrounding (National Energy Board 2009). Proposed developments are likely to exacerbate the changes associated with climate warming and are expected to have a significant impact on the Inuvialuit, and the wildlife in the region. The 'cumulative effects' of environmental change and northern development will have significant consequences for the Inuvialuit. In this context of rapid environmental change and uncertainty, there is a critical need for careful environmental regulation, monitoring, and stewardship of the delta region.

The goal of this research project is to contribute to ongoing research and monitoring, while simultaneously building local capacity to monitor and understand environmental

change. My overall objective was to contribute to the development of an effective community-driven environmental monitoring strategy focused on Inuvialuit knowledge and observations. My Master of Arts (MA) research involved developing and testing a strategy for documenting and communicating TEK and observations of environmental conditions. This monitoring strategy is intended to be: 1) compatible with contemporary Inuvialuit culture, 2) capable of simultaneously facilitating knowledge transfer within Inuvialuit communities and among northern environmental decision-makers and researchers, and 3) to contribute to the realization of other community goals such as facilitating intergenerational knowledge transfer out on the land, and digital tools skill building.

To conduct this research, I worked collaboratively with the Hunter and Trappers Committees (HTCs) in the Inuvialuit communities of Inuvik, Aklavik, and Tuktoyaktuk, and built on existing partnerships between the UVIC[3] Ethnoecology Lab, the Inuvialuit Joint Secretariat, and Aboriginal Affairs and Northern Development Canada (AANDC). This research builds on and complements a larger collaborative research and monitoring effort between the aforementioned members. This effort (the Mackenzie Delta Cumulative Impact Monitoring Program (MDCIMP)) is a pilot program designed to monitor environmental changes in the MDR.

[3] Several licenses were required in order to conduct this research in the Northwest Territories and Yukon, they included: an Inuvialuit Land Use License (ILA10TN011), a Northwest Territories Scientific Research License (14795), a Yukon Scientists and Explorers Act License (10-61S&E), and a UVIC Human Research Ethics Board Certificate of Approval (10-259).

This research was organized around two research questions, and is written as two research papers. The first of these explores the following research question: can a modified participatory photo-mapping (PPM) protocol adequately document, contextualize, and communicate Inuvialuit observations of environmental conditions? To answer this question the PPM protocol was developed and deployed during 13 outings with 16 Inuvialuit participants from three communities in the MDR (Inuvik, Aklavik, and Tuktoyaktuk). Observations collected using the PPM protocol were analyzed in semi-structured interviews with nine Inuvialuit cultural experts. The findings of this work are presented in Chapter 2.

The second research paper explores the potential utility of the participatory-photo mapping (PPM) protocol and web-based map, asking: how they can contribute to: 1) existing environmental decision-making and resource management structures in the MDR, 2) the NWT Cumulative Impacts Monitoring Program (CIMP), and 3) other northern environmental research. To answer this question seven key northern ecosystem managers, decision-makers, and northern scientists reviewed the web-based map and examined and evaluated the PPM protocol in semi-structured interviews. This analysis is presented in Chapter 3.

Chapter 4 brings together key findings from each research paper, discusses the potential future of the PPM method, and presents conclusions of the project as a whole. The remainder of this chapter reviews several topics that provide important background on the context in which this research was performed.

Additional background and context

The remainder of this introductory chapter is intended to provide additional background and context, which is important for setting the stage for this thesis research. This section begins with an introduction and brief history of the Inuvialuit People, who are central to this research. The region where this research took place is of particular interest because it is experiencing rapid and dramatic and environmental change, and it also contains vast hydrocarbon reserves. The hydrocarbon discovery eventually led to a Federal Inquiry and subsequent landmark Land Claims Agreement. The Land Claim Agreement was significant in Canada and internationally, partially because it legislated the establishment of a natural resource management co-management regime, the details of which are an important element of this research. Another focus of this research is traditional ecological knowledge, in this chapter it is introduced, reviewed, and defined. Subsequently a brief introduction to traditional use studies and other participatory research methods are introduced.

The Inuvialuit

The Inuvialuit are Inuit peoples of the western Canadian Arctic. Inuvialuit translates into English as “the real people”, or “the genuine people” (Bandringa & Inuvialuit Elders 2010). Inuvialuktun is the language of the Inuvialuit. Within the Inuvialuktun language, the people of Aklavik, and Inuvik generally speak Uummarmiutun. Siglitun is spoken in Sachs Harbour, Paulatuk and Tuktoyaktuk, and Inuinnaqtun is spoken in Ulukhaktok and Sachs Harbour (Bandringa & Inuvialuit Elders 2010).

Historically, six discrete groups of Inuvialuit lived within distinct territories, forming subgroups of the Inuvialuk regional population. The groups include (from west to east): the Qikiiqtaryungmiut (Yukon coast from Shingle point to Barter Island, including Herschel Island), Kuukpangmiut ("people of the Great River", East channel of the Mackenzie River), Kitigaaryungmiut ("people of Kitigaaryuit" the largest village in the Kugmallit Bay area), Inukyuyuut ("Eskimo Lake people", Husky Lakes area), Nuvorugmiut ("people of Nuvugaq" From the Mackenzie River East Channel of the Tuktoyaktuk peninsula to near Point Atkinson), and Avvagmiut ("people of Avvaq" Cape Bathurst area; Anderson River people) (Alunik *et al.* 2003). All Inuvialuit groups are decedents of Thule peoples from Northwestern Alaska (Alunik *et al.* 2003). Contemporary Inuvialuit communities in the MDR are a mosaic of these six cultural groups, Inupiat peoples from Alaska, and whalers who travelled to the region early in the last century (Freeman *et al.* 1992).

Traditionally, Inuvialuit knowledge of the environment and culture was passed down orally through story-telling, song and dance, and land-based activities (Alunik *et al.* 2003; Bandringa & Inuvialuit Elders 2010) (Figure 1.3). Inuvialuit survival was based on successfully harvesting fish, sea mammals, and a wide variety of land animals, as well as berries and roots for food (Inuvialuit Communications Society 2009). The skin of caribou and seals were important materials used for clothing. Inuvialuit traveled to hunting and harvesting camps in the summer, and lived in permanent sod-houses in winter villages (Alunik *et al.* 2003; Conaty & Binder 2003; Inuvialuit Communications

Society 2009). Survival in Inuvialuit lands required a profound understanding of the land, rivers, lakes, and ocean (Alunik *et al.* 2003).

Figure 1.3 Inuvialuit drummers and dancers continue their traditional culture of transferring knowledge and culture through song and dance. Photo taken at celebrations of the 100-year anniversary of the Hamlet of Aklavik, NWT. 2010. Photo: T.D. Bennett, 2010.

In the last two hundred years numerous factors (migration, disease, the arrival of European whalers, the introduction of reindeer herding, the construction of the town of Inuvik, and the discovery of oil and gas) have dramatically altered Inuvialuit traditions and lifeways.

Foreign contact

Alexander Mackenzie, a Scottish fur trader, was the first European to arrive in Inuvialuit territory in 1789. However, it was Dr. John Richardson who made the first contact with

the Inuvialuit in 1826 while traveling down the Mackenzie River seeking out the Northwest Passage with the British Royal Navy (Alunik *et al.* 2003). Traditional Inuvialuit life was changed with foreign contact beginning with direct fur trading with the Hudson Bay Company in the 1850s, and perhaps most dramatically with the introduction of foreign whaling fleets, which began commercially harvesting bowhead whales in the Beaufort Sea in the 1880s (Alunik *et al.* 2003). By the early 19th century, local caribou herds (a crucial source of food) were decimated by the increased demand from the whaling station at Hershel Island combined with the introduction of advanced rifles (Alunik *et al.* 2003). In 1933, the Government of Canada attempted to introduce reindeer husbandry into Inuvialuit life as a strategy to ensure food security, by importing a herd of 3,000 reindeer and Sami herder families as herder instructors (Conaty & Binder 2003). Active reindeer herding continues to this day, although at a smaller scale (Conaty & Binder 2003).

At one time the Inuvialuit were considered to be the largest and most prosperous Inuit group of Canada (Alunik *et al.* 2003). Foreign contact introduced the Inuvialuit to diseases; an estimated 95 percent of Inuvialuit were killed by disease (Freeman *et al.* 1992; Alunik *et al.* 2003; Bandringa & Inuvialuit Elders 2010). Contact also brought religious missionaries who Christianised and assimilated Inuvialuit youth through formalized "education" in residential schools, nearly abolishing traditional Inuvialuit culture, religion, and language. The first Anglican residential school built in the Inuvialuit territory was in Aklavik in 1919. The Anglican Stringer Hall, and the Catholic Grollier Hall residential schools operated in Inuvik from to 1959 to 1970. Residential

school survivors and their families continue to struggle from the abuse and isolation from their families and culture that occurred during the residential school experience (Alunik *et al.* 2003). Both residential schools were both decommissioned in the 1970s.

Other southern influences were introduced to the Arctic in the mid 1950s. In a response to international airborne invasion threats, distant early warning (DEW) sites were developed across the Canadian Arctic in the early 1950s. In Inuvialuit territory four DEW line sites were established: Bar-1 Komakuk Beach, Yukon, Bar-2 Shingle Beach, Yukon, Bar-3 Tuktoyaktuk, NT, and Bar-4 Nicholson Peninsula, NT (Bright *et al.* 1995). Around the same time oil exploration began in the Mackenzie Delta and off shore in the surrounding Beaufort Sea. Oil and gas workers and the navy introduced alcohol to the region, which also had a devastating impact on the Inuvialuit (Alunik *et al.* 2003). In the 1970s a major gas discovery was made in Inuvialuit territory, and an all season road to Inuvik was completed in 1974. By this time, snowmobiles had largely replaced dog teams. A proposal to build a pipeline to bring oil and gas to southern markets eventually lead to the 1977 Berger Inquiry. Subsequently the Inuvialuit Final Agreement (described below) was signed in 1984.

Over the past century the Inuvialuit have experienced dramatic societal change (Freeman *et al.* 1992; Lyons 2010). Today, the Inuvialuit continue to participate in active hunting, trapping, fishing and whaling, but it occurs on a smaller scale. Over the past sixty years traditional culture and harvesting activities have been progressively re-establishing through the revitalization of hunting activities, which were disrupted by commercial

harvesting practices (Freeman *et al.* 1992). Today most Inuvialuit live in six communities: Aklavik, Inuvik, Paulatuk, Sachs Harbour, Tuktoyaktuk, and Ulukhaktok (Holman), but they are often out on the land at harvesting camps. Contemporary Inuvialuit have adapted to modernity, and are active participants in the global economy, with relative prosperity through partial ownership of petroleum resources (Inuvialuit Communications Society 2009). Today most Inuvialuit speak English, and the Inuviualuktun language is in real danger of being lost (Bandringa & Inuvialuit Elders 2010).

Northern environmental change

Ample literature suggests that the Canadian Arctic and Subarctic are experiencing rapid environmental change (Parry 2007; Lawrence *et al.* 2008; Herman-Mercer, Schuster, & Maracle 2011). Recent trends include warming temperatures (Comiso 2003; Graversen *et al.* 2008; Moline *et al.* 2008; Burn & Kokelj 2009; Prowse *et al.* 2009), thawing permafrost (Lantz & Kokelj 2008; Burn & Kokelj 2009; Lyon *et al.* 2009), reduction in winter sea ice (Barber & Hanesiak 2004; Comiso 2006; Comiso *et al.* 2008; Perovich *et al.* 2008; Strove *et al.* 2008; Fisher *et al.* 2011), and increases in extreme weather events (McCabe, Clark, & Serreze 2001; Simmonds, Burke, & Keay 2008). In the Arctic, these changes influence ecosystem dynamics, impacting vegetation wildlife, land animals, sea mammals, birds, aquatic wildlife and fauna (Kokelj *et al.* In Press; Ferguson 1996; Hassol 2004; Corell 2006; Alessa *et al.* 2008; Moline *et al.* 2008; Burn & Kokelj 2009; Koski & Miller 2009; Osterkamp *et al.* 2009).

The combined impact of rapidly changing environmental conditions and the associated modifications to ecosystems is changing the way northerners live, and their interactions with the environment upon which they depend for survival. Damage to northern infrastructure, compromised food security, loss of life or serious injury, difficulty with transportation, and loss of historical and cultural sites are among the examples of impacts currently being experienced in the Canadian Arctic (Hassol 2004; Parlee *et al.* 2005; Gearheard *et al.* 2006; Pearce *et al.* 2009b; Ford & Pearce 2010; Krupnik & Jolly 2010; Pearce *et al.* 2011) (Figure 1.4). Ample literature suggests that Indigenous peoples in vulnerable regions will disproportionately face risks associated with climate change (Cohen 1997; Maxwell 1997; Thomas & Twyman 2005; Smit, Hovelsrud, & Wandel 2008; Dowsley 2009; Pearce *et al.* 2009a).

Figure 1.4 Landslides are among the many examples of recent environmental changes occurring in the Mackenzie Delta region. This landslide was identified as occurring in the summer of 2010 by Douglas Esagok (Inuvik). The landslide occurred in the Caribou Hills, near Reindeer Station, North of Inuvik, NWT. Photo by T.D. Bennett. Summer, 2010.

Hydrocarbon discoveries

Under the permafrost-rich MDR, and extending northward into the Beaufort Sea, lies a rich reserve of natural gas that has attracted extensive hydrocarbon exploration. By 1967, exploration sites (small-anchor fields) were scattered across the region both on-shore and off shore (often supported by protective platforms) (Figure 1.5), or on human-built islands (Richardson *et al.* 1987). Ultimately these hydrocarbon discoveries led to the proposed construction of a pipeline linking the Yukon North slope and the MDR with northern Alberta. The proposed pipeline would travel through environments that support diverse ecosystems and several aboriginal cultures. The proposed pipeline development

received attention from the federal Government because at the time, the proposed project was the largest free market enterprise in history, while Indigenous groups expressed deep concerns about the potential environmental and social impacts (CBC, 2011).

Figure 1.5 A photo of a protective platform once used to protect oil exploration/drilling activities from winter sea ice in the Beaufort Sea, is now abandoned in Tuktoyaktuk harbour. Near Tuktoyaktuk, NWT. Photo by T.D. Bennett, 2010.

The Berger Inquiry and the Inuvialuit Final Agreement

Indigenous and environmental activists raised concerns about proposed hydrocarbon developments in the MDR, which included three significant discovery license applications (Taglu, Niglintgak, and Parsons Lake) and a 1,200-kilometer pipeline

connecting the Mackenzie Delta with northern Alberta. Combined pressure on the Federal Government from hydrocarbon developers, Indigenous activists, and environmentalists sparked the Mackenzie Valley Pipeline Inquiry, also called the Berger Inquiry. During the Inquiry, commissioner Justice Thomas Berger held public hearings in all 35 communities along the proposed pipeline route, which was unprecedented at the time, hearing the perspectives of almost one thousand northerners (Berger 1977). Justice Berger's findings and recommendations were delivered in a 1977 report entitled *Northern Frontier, Northern Homeland.* The report highlighted the environmental impacts of the gas pipeline on the porcupine caribou herd, beluga whales, and snow geese staging areas in the Mackenzie Delta and the Yukon North slope. The report also warned that the pipeline threatened the culture and substance activities of local Indigenous peoples (Sabin 1995).

Justice Berger recommended a ten-year moratorium on oil development so that land claims in the region could be settled. In subsequent years, the Government of Canada worked closely with the Inuvialuit to develop a land claim agreement, and create a co-management regime to manage the impacts of resource use on the local environment and on the people. After 10 years of negotiations between the Inuvialuit and the government of Canada, the Inuvialuit Final Agreement (the Agreement) (also known as the Western Arctic Claim) was settled in 1984, it established the Inuvialuit Settlement Region (ISR) (Figure 1.6). The Agreement was designed in part to manage the impacts of change associated with oil and gas developments in the ISR.

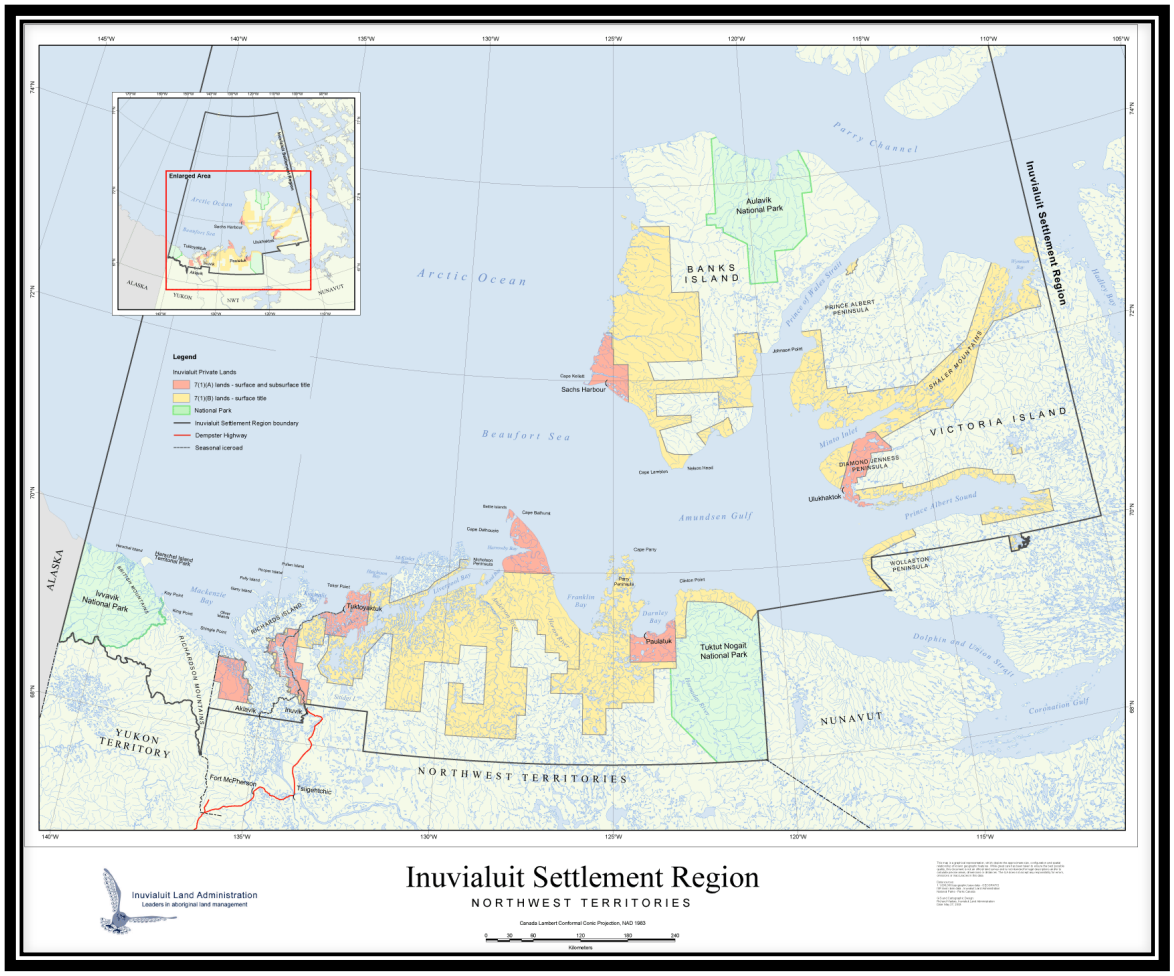

Figure 1.6 Map of the Inuvialuit Settlement Region showing Inuvialuit and Crown lands, surface and subsurface rights, and National Parks established as a result of the 1984 Inuvialuit Final Agreement. Inuvialuit Private Lands surface and subsurface rights are shown in red, Inuvialuit surface title only in yellow, and Tuktut Nogait, Ivvavik, and Aulavik National Parks in green. Map accessed from [http://www.inuvialuitland.com/]. Republished with permission from the Inuvialuit Land Administration, Parks Canada, and Inuvialuit Fisheries Joint Management Committee.

Today, Indigenous stakeholders in the MDR are largely in support of oil and gas development in the MDR, provided local communities will benefit and the impacts are well managed (Voutier *et al.* 2008). Inuvik, NWT currently uses natural gas for power generation and heating, which is less expensive than shipping in diesel (Inuvik Gas Ltd. 2011). The natural gas is shipped along 50km of pipeline from the Ikhil gas field in the

Caribou Hills. Equal ownership of the Ikhill pipeline is divided between the Inuvialuit Petroleum Corporation (Ikhil Resources Ltd.), AltaGas Services Inc., and Enbridge Inc. (IRC, 2007).

Environmental decision-making in the Inuvialuit Settlement Region

The Agreement is a comprehensive land claim agreement that establishes among other things, the structure for resource management and related decision-making in the ISR. Legal mechanisms in the Agreement ensure Inuvialuit HTC members have permanent and equal membership on five co-management boards. HTC membership on the boards is the mechanism intended to ensure that Inuvialuit interests and knowledge is represented in decision-making (Keeping 1989). Together the co-management bodies assist relevant government agencies with environmental reviews, screen proposed developments, and provide advice on wildlife and fisheries management issues (Keeping 1989). The Inuvialuit entered into the Agreement to protect land and territorial rights, traditional harvesting activities, facilitate economic self-determination, and spiritual fulfillment (Duerden 1996).

The Agreement was the first comprehensive land claim settlement in the Canadian Arctic and only the third comprehensive land claim agreement in Canada (Table 1.1). Because the Agreement is a form of treaty it falls under the subsection 35(3) of the Constitution Act of 1982, which supersedes all other federal and territorial legislation (Keeping 1989; IDC 2007; Shawn Hon. Murphy 2008). In accepting the terms of the Agreement, the Inuvialuit ceded, released, surrendered, any and all aboriginal claims in return for

ownership in fee simple of about 90,000 square kilometers of land[4] and total payments of nearly $170 million (Keeping 1989).

The establishment of the co-management regime was designed (in part) to achieve the obligations and goals for both parties to the Agreement (Keeping 1989). The Inuvialuit and the government of Canada sit with equal representation on five co-management boards or committees. The primary role of these bodies it to provide advice and make recommendations to relevant government authorities (Table 1.2).

Each of the five co-management bodies is comprised of four or six permanent members (total), with equal representation from both Inuvialuit and the Government of Canada (2 or 3 Inuvialuit sit on each co-management board). No single co-management board has distinctively more influence on decision-making, or in the ability to offer advice or make recommendations than another board. Table 1.3 outlines the range of decision-making abilities of each of the co-management bodies.

Table 1. 1 Landmark land claim agreements settled between Inuit groups and the Government of Canada.

Landmark Inuit land claim agreements	
James Bay and Northern Quebec Agreement	1975
Inuvialuit Final Agreement	1984
Nunavut Final Agreement	1993
Creation of Nunavut Territory (Map of Canada Changes)	1999
Nunatsiavut Final Agreement	2005

[4] The original claim was for was for over 335,000 square kilometers of land (Fraser, 2007).

Table 1.2 Five co-management bodies were established under the Inuvialuit Final Agreement. Table shows co-management bodies (left) and the intended domain of each (right).

Inuvialuit co-management bodies & domain	
Environmental Impact Screening Committee (EISC)	Environmental impact screening of proposed development
Environmental Impact Review Board (EIRB)	Environmental impact assessment & project review
Fisheries Joint Management Committee (FJMC)	Fisheries management (conservation)
Wildlife Management Advisory Council North Slope (WMAC (NS))	Wildlife management (conservation)
Wildlife Management Advisory Council Northwest Territories (WMAC (NWT))	Wildlife management (conservation)

Other management Acts

Inuvialuit input into decision-making processes is required in the MDR by two other legally binding documents: the Mackenzie Valley Resource Management Act (1988), and the Umbrella Final Agreement (1993). The Umbrella Final Agreement guarantees Indigenous participation in land use planning and in the development assessment process in the Yukon and NT (Government of Canada 1993). The Mackenzie Valley Resource Management Act contains legal mechanisms that ensure Indigenous peoples in the Mackenzie Valley will play a greater role in land and water management and protection. Specifically it calls for both scientific and traditional knowledge to be collected and used in cumulative environmental impact monitoring, as part of the impact assessment process (Government of Canada, 1998).

Table 1.3 Decision-making powers for each co-management body in the Inuvialuit Settlement Region, as established by the Inuvialuit Final Agreement. Co-management bodies include the Environmental Impact Screening Committee (EISC), the Environmental Impact Review Board (EIRB), The Wildlife Management Advisory Committee (North Slope) (WMAC(NS)), and the Wildlife Management Advisory Committee (Northwest Territories) (WMAC(NWT)).

	Inuvialuit Co-Management bodies & decision-making powers					
Decision-making powers found in the Inuvialuit Final Agreement		EISC	EIRB	FJMC	WMAC (NS)	WMAC (NWT)
	Issues or denies development permits	✓				
	Assists and advises management boards, commissions and others			✓	✓	✓
	Produces final reports		✓			
	Allocates Inuvialuit hunting quota			✓	✓	✓
	Includes TK and TEK in decision-making	✓	✓	✓	✓	✓
	Provides advice to the Minister	✓	✓	✓	✓	✓
	Supports research		✓	✓		
	Holds public hearings		✓			✓
	Creates management plans				✓	✓
	Facilitates cooperation between Inuvialuit and the government of Canada				✓	
	Issues land-access licences			✓		
	Supported by legal mechanisms ensuring Inuvialuit consultation before decisions are made by the Minister	✓		✓		
	Has legislative powers to make by-laws for internal management	✓		✓	✓	✓
	Holds conferences to promote public discussion about management coordination among aboriginals, government, and the private sector				✓	

Traditional ecological knowledge (TEK)

The ethnoecological literature is filled with a dizzying array of terms and definitions that, broadly speaking, refer to the environmental knowledge of Indigenous or local peoples

long resident to a particular place (Berkes 1999; Wenzel 1999, 2004; Usher, 2000; Ross *et al*. 2011). However, no common definition has emerged in the naming or definition of knowledge held by Indigenous experts (Berkes 1999; Huntington 2000; Usher 2000; Sillitoe, Bicker, & Pottier 2002; Bonny & Berkes 2008; Berkes 2009). For example, researchers in New Zealand have referred to the environmental knowledge of elders from the Te Whānau-ā-Apanui tribe as 'Māori environmental knowledge' (MEK) (King *et al.* 2008). Wohling (2009) uses the term 'Indigenous knowledge' (IK) because it is widely used in Australia. In North America the traditional ecological knowledge held by Inuit in Nunavut is now referred to as 'Inuit Qaujimajatuqangit' (IQ) (Dowsley 2009). 'Local ecological knowledge' (LEK) was used by Ballard *et al.* (2008) who defined it as "the local expertise of people who many not have a long-term relationship with the local environment compared with Indigenous people, but nevertheless have local wisdom, experience, and practices adapted to local ecosystems". Northern researchers have used the term 'Iñupiaq knowledge' (IK) to refer to the holders of traditional Iñupiaq knowledge from Alaska, U.S. (Eisner *et al*. 2009). The term 'Yup'ik knowledge' has been used to refer to the traditional knowledge held by Yup'ik knowledge holders from southwestern Alaska, U.S. (Fienup-Riordan and Carmack 2011). In the same region however, other researchers have referred to both Iñupiaq and Yup'ik sea ice knowledge as 'local Indigenous knowledge' (LIK) (Eicken, 2010).

The term 'TEK' has also been used widely to refer to all of these knowledge systems. In North America ecological and global environmental change researchers, and natural resource managers have used the term 'TEK'. Examples of references made to TEK

include: “knowledge about the environment derived from the experience and traditions of a particular group of people” (Usher 2000: 185), “TEK is ecological knowledge” (Hunn 1993: 13), and, *“the knowledge and insights acquired through extensive observation of an area or species. This may include knowledge passed down in an oral tradition, or shared among users of a resource. The holders of TEK need not be Indigenous…. [It] is used to understand and predict environmental events, upon which the livelihood or even survival of the individual depends”* (Huntington 2000: 1270). Although it is not an ideal term, because for some ‘traditional’ can mean old, static, or non-adaptive (Berkes 1999), the term ‘TEK’ is used by the Government of the Northwest Territories and is of interest to scholars, educators, environmental managers, policy makers, and Indigenous communities (Bonny & Berkes 2008).

In this research, we use Berkes’ (1999) definition, which describes TEK as: *“the cumulative body of knowledge, practice, and belief, 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 1999:8). It is important to note that traditional knowledge (TK) is not necessarily held exclusively by Indigenous peoples (Huntington 2000), although the terms ‘Indigenous knowledge’, ‘aboriginal traditional knowledge’, ‘local knowledge’, and permutations inducing ‘ecological’, have been frequently used to describe similar types of knowledge.

TEK is the term most commonly used term in the context of northern environmental assessment and management in northern Canada (Usher 2000), in areas with a history of

resource use (Menzies 2006). The Government of the Northwest Territories defines TK as "knowledge and values, which have been acquired through experience, observation, from the land or from spiritual teachings, and handed down from one generation to another" (Government of the Northwest Territories 2005). In 2005, the Mackenzie Valley Impact Review Board (MVIRB) issued the first guidelines for including TK in northern impact assessment. The MVIRB did not define TK in the guidelines, but described it as non-static wisdom, values, and knowledge about the environment, related to its use and management (MVRB 2005). Legislation requires the Government of the Northwest Territories is to incorporate TK into decision-making and actions when appropriate, and recognizes Indigenous knowledge as "a valid and essential source of information about the natural environment and its resources, the use of natural resources, and the relationship of people to the land and to each other" (Government of the Northwest Territories 2005:1).

In Arctic regions, TEK holders who spend extensive time on the land have extensive knowledge and are keenly aware of recent environmental change related to weather, seasons, wind, sea ice, and wildlife (animals and insects) (Huntington *et al.* 2005). Such knowledge is based on generations of experience while living in a particular area, and can be extremely important information for scientific research and decision-making (Nakashima 1993; Norton 2002; Gearheard *et al.* 2006; Laidler 2006; Eicken, Lovecraft, & Druckenmiller 2009; Eicken 2010; Kruipnik *et al.* 2010). TEK includes practical environmental knowledge with utility in environmental management, but this knowledge is inextricably linked with Indigenous culture and identity, worldview, ethics, and values.

TEK therefore, should not be compartmentalized as discrete content, but understood as a dynamic, learning, and knowledge-building process (Berkes 2009), or theory (Cruikshank 2001).

At the forefront of this research is a focus on collaboratively documenting the environmental observations and knowledge of the land held by Inuvialuit peoples with whom we worked. While we acknowledge that the environmental knowledge held by Inuvialuit peoples is indeed situated in a cultural context, our focus here is not on analysis of Inuvialuit 'culture' in and of itself. Highlighting the different focuses of TEK can help to demonstrate how it includes pragmatic and practical environmental knowledge with obvious utility in environmental management, but integrated in this knowledge is Indigenous culture and identity, distinct worldview, ethics, and values (Houde 2007).

The success, limitations, challenges, and complexity of collecting and using TEK with science and in natural resource management has been well documented and debated for decades (Agrawal 1994; Duerden 1998; Wenzel 1999; Huntington 2000; Usher 2000; Nadasdy 2005; Berkes 2009; Gagnon and Berteaux 2009; Wohling 2009). There are some important critiques of 'capturing' ethnoecological knowledge (TEK), and using it for natural resource management. For example, some research strategies have taken TEK out of its intended geographical context, and applied it at inappropriate scales (outside the TEK holder's immediate geography), which can abstract, misrepresent, or change the meaning of the knowledge (Duerden & Kuhn1998; Gangon & Berteaux 2009; Wohling, 2009). For example, some TEK research strategies have involved numerically coding

TEK and entering it into a scientific framework to make land-use decisions, effectively loosing the integrity (the meaning) of the knowledge (Duerden & Kuhn 1998). Such strategies are often a result of research championed by cultural outsiders (especially nonindigenous peoples) (Berteaux 2009; Wohling 2009). Other researchers have argued that the strategies used to collect and include TEK in natural resource management and decision-making are often highly political, and in some cases can lead to the bureaucratization and institutionalization of hunters and trappers, which can constrain the type of and way in which decisions can be made (Cruikshank 2001; Nadasdy 2003, 2005; Wohling 2009).

Many scientists and decision-makers have been sceptical of TEK (Huntington 2000; Cruikshank 2001; Berkes 2009). Berkes (2009) has highlighted that when TEK is used to help understand global climate change, some scientists have argued that global climate change is a new problem, outside of the cultural experience of elders' knowledge and tradition. Other reasons some researchers have had concerns with or resistance to using TEK include: loosing power of management or research decisions, inflexibility with working with non-scientists (Indigenous peoples) and/or, sharing or loosing control of data or information (Huntington 2000). The concerns and cultural dynamics that mediate such processes and relationships are complex and not limited to the simple recognition of the utility of TEK (Huntington 2000; Nadasdy 2003, 2005).

As such, there are several important questions to consider when using visual and web-based research methods to document share TEK among stakeholders in the context of

natural resource management, examples include: how do the methods change or compromise the value or meaning of the knowledge? Are the methods culturally appropriate? How do the methods change control and/or ownership of the knowledge? How do they affect misrepresentation or abstraction of the knowledge? Do the methods link well with other ongoing research efforts or existing structures that use or document TEK? Do the methods increase the risk of appropriation of the knowledge by others? As digital technologies rapidly advance, these questions must continue to be explored. Nevertheless, TEK has contributed to: environmental research and management (Berkes 1993, 1999; Reidlinger & Berkes 2001; Moller *et al.* 2004; Ellis 2005; Parlee, Berkes, & Gwich'in 2005; Dowsley 2009; Gagnon & Berteaux 2009), ecologically and socially resilient systems of management globally (Green & Raygorodetsky 2010), and to alternative resource management systems (Turner, Ignace, & Ignace 2000). It has also been acknowledged as an important aspect of the adaptive co-management learning process (Armitage 2007).

In recent years, there has been a shift in research methodologies away from separating the researcher from the participants of a study and towards more collaborative research. This is especially true in the Arctic, where Southern researchers have has a history of not returning to the communities where they conducted research (Sohng 1995, Huntington 2000, Gearheard 2006). Recent collaboration and research-partnerships between researchers and Inuit peoples has changed the culture of northern research, and showcased the value of meaningfully involving local people in all aspects of research (Gearheard 2006, Kruipnik *et al.* 2010). As such, we worked closely with the appropriate

Inuvialuit community organizations to collaboratively design the project goals and the methods used in this study. As discussed above, TEK was traditionally shared orally through cultural practices, passed on from one generation to the next over time. I wish to make clear, that the TEK held by knowledgeable land-users which was documented using our protocol, was represented and shared in a new and different way using visual, written, and spatial techniques. The protocol used in this study is in no way a replacement (and it is not attempting to be) for spending time on the land with knowledgeable land users, engaged in traditional activities, and learning by doing, which is how TEK has been transferred and shared through time.

Traditional use studies

Participatory and visual research methods have made an important contribution in the fields of traditional land use and occupancy mapping (Tobias 2009). Using participatory methods to map TEK (resource use, travel routes, and culturally important areas) onto clear plastic overlays over 1:250,000 scale maps (which are later digitized) is an increasingly popular technique for documenting and sharing Indigenous land use and knowledge (Keeping 1989). This knowledge can be important for land management purposes, sharing knowledge between generations, strengthening cultures, and securing land tenure for negotiating land claims (Chapin, Lamb, & Threlkeld 2005; Tobias 2000, 2009). This research project builds on and contributes to such techniques and ideas with a focus on continuous environmental monitoring. Key features of our PPM method that differentiate our methods from previous work include youth involvement in the monitoring protocol, an emphasis on photography, the incorporation of storytelling and

experiential (in situ) knowledge transfer, and the use of an open source and web-based mapping platform.

Using photography in research

Photography has been used in research in many different ways. Of particular concern to my thesis is the use of ground-based oblique photographs of landscapes, and to a lesser extent, oblique and vertical images taken from aircraft and satellite, which are commonly used in monitoring environmental change. The value of photography and the use of images in research to gather information is well established (Riley & Manias 2004). Photographs can tell interesting and important stories (Harp, Renouf, & Harp 2003), and contain valuable visual, spatial, and temporal information (Kuhnlein *et al.* 2006). They have become fundamental elements in the very construction of history (Martin 2004). Historical photographs can also provide a baseline against which to detect and calibrate changes in landscapes (Swetnam *et al.* 1999).

In this research project we define PPM as a method of documenting geo-referenced observations using the visual medium, and combining each observation with a participant narrative. This method is participatory because observers determine what and where to monitor and participants take their own photographs and add personal narratives. The observations are recorded using geo-referenced digital photographs (and other multi-media), and entered, stored, and shared among stakeholders using a web-based photo-map (web-based map).

Dennis *et al.* (2009) used the PPM method in the context of health and place research among urban youth. In their work they combined participant photography and GPS waypoints, photo-elicitation interview techniques, and participatory research protocols that enabled community-based partnerships to produce new knowledge (Dennis *et al.* 2009). They provided provide participants with cameras and GPS units to take photos of a chosen experience. Next, captured images became the focus of interviews in which individual and collective narratives were recorded about specific images. Subsequently, these images were organized into a GIS program, which was used to produce a map, which was then used to communicate the participants' experiences. In Madison, Wisconsin this method was used to inform neighbourhood action planning, which raised the profile of community issues and led to improvements in local parks and pedestrian infrastructure (Dennis *et al.* 2009).

Photography is a useful and accessible method to document observations of the environment. In the Canadian Arctic, photography has been used to assess wildlife habitat (Joynt, Millar, & Hoyt 2008), and estimate population sizes to inform wildlife management (Patterson, Olsen, & Joly 2004; Heard & Calef 2010). In some cases these studies involve collaborating with local community members to draw on TEK (Hall 2001; Hammill *et al.* 2004; Aswani & Lauer 2006; Munro *et al.* 2008). Changes in the environment or landscape can also be detected by comparing observed conditions against existing photographs (Noongwook, Huntington, & George 2007).

Repeat ground-based photography has many applications, and has been used to monitor small and large-scale changes going back more than 100 years (Nader *et al.* 1995; Skovlin & Thomas 1995). Scenes captured by painters over 100 years ago have also been re-photographed and compared (Pickard 2002). Repeat ground-based photography is often used to monitor and assess changes in natural and cultural landscapes (Rogers, Malde, & Turner 1984; Ahlstrom 1992; MacLaren, Higgs, & Zezulka-Mailloux 2005; Smith 2007; Higgs, Bartley, & Fisher 2009; Nyssen *et al.* 2009). Accurate repeat photography requires precise subject composition and camera placement. In contrast to precise repeat photography (generally associated with precision and detailed protocols regarding camera position, camera lens and settings, and aspect etc.), casual repeat photography involves capturing a scene similar to a photograph taken at another time without following a specific protocol. Although these images cannot typically be used to quantify change, they can allow for important qualitative comparisons (Ahlstrom 1992).

Summary

This review of additional background and contextual information introduced the Inuvialuit People, their history, and traditional culture. The impact of a variety of southern influences on the Inuvialuit was also discussed. Such information is important because it shaped the research design of this project. Specifically, it assisted with the development of a culturally appropriate monitoring protocol, which was tested in chapter 2.

The type and extent of the environmental change occurring in the study area, and how it is impacting northerners is described in detail in order to explain and justify the urgent need for a locally relevant and community-based environmental monitoring strategies. Cost effective, accurate, locally relevant, and up-to-date, monitoring is important for understanding, managing, and planning for northern environmental change.

The extent of the hydrocarbon discoveries in the study region, and the potential impacts that will result from the proposed developments were described. The introduction of the hydrocarbon discovery is fundamental information because it eventually led to the Berger Inquiry and the Inuvialuit Final Agreement, and the proposed oil and gas development will significantly change the region. The Inuvialuit co-management regime was reviewed because the legal framework for including Inuvialuit Traditional Knowledge in northern resource management and decision-making is central to this research. Finally, relevant photographic and participatory research efforts were discussed.

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Chapter 2

Participatory photo-mapping: a method for documenting, contextualizing, and sharing Indigenous observations of environmental conditions.

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Keywords

Arctic; traditional ecological knowledge; Inuvialuit observations; web-based mapping; environmental monitoring; environmental change

Abstract

The Mackenzie Delta region of Northwestern Canada is a dynamic environment that is ecologically and culturally significant. This region is experiencing environmental change that is expected to worsen with continued climate warming and additional anthropogenic stressors. Knowledgeable land users are in a unique position to document changing environmental conditions in the region. In this project we developed and field-tested a monitoring program that used participatory photography to document TEK and observations. Working with local Hunter and Trapper Committees and the Inuvialuit Joint Secretariat, we adapted a participatory photo-mapping method to document Inuvialuit observations of environmental conditions. Observations were documented using digital cameras and GPS units. Subsequently, digital photographs and video became the focus of photo-elicitation interviews, which added a detailed narrative to each geo-referenced observation. Approximately 150 observations were then entered into a web-based map. Interviews with monitors and potential map users suggest that web-based mapping is an effective way to document and share the TEK, observations, and concerns related to the local environment held by the Inuvialuit TEK holders. Overall, this research highlights the effectiveness of using geo-referenced photos to document and share Inuvialuit observations and suggests that PPM monitoring programs can significantly improve capacity to detect the impacts of environmental change, and contribute to northern planning and decision-making.

Introduction

Indigenous peoples have an intimate understanding of their local environment, which they rely on for survival (Nuttal *et al.* 2005; Laidler *et al.* 2010). This knowledge can be extremely helpful for identifying environmental changes (Kokelj *et al.* In Press; Reidlinger & Berkes 2001; Huntington *et al.* 2005; Wolfe *et al.* 2011) and in contributing to environmental monitoring efforts in remote areas (Moller *et al.* 2004; Dyck 2009; Pearce *et al.* 2009; Gearheard *et al.* 2011). As such, there is a growing pressure to use this knowledge in environmental decision making and research (Wenzel 1999; Huntington 2000; Berkes 2009; Eisner *et al.* 2009; Pearce *et al.* 2009; Wohling 2009; Eicken 2010; Green & Raygorodetsky 2010; Lyver & others 2010). Local expertise and knowledge (TEK) is also useful for environmental assessment and resource management and is being used more frequently in this context (Armitage 2005; Menzies 2006; Armitage *et al.* 2011).

Resource management and environmental assessment is particularly difficult in Northern regions because the pace of environmental change is so rapid, and logistics in remote contexts are complex and costly (Serreze *et al.* 2000; Pearce *et al.* 2009; Pisaric *et al.* 2011; Kokelj *et al.* In Press). Indigenous land users who have an intimate understanding of the regional environment are particularly well suited to contribute to monitoring efforts aimed at identifying environmental change in remote regions (Riedlinger & Berkes 2001; Huntington *et al.* 2005). Many knowledge holders in these regions describe an urgent need to record TEK so it can be shared with the rest of the world (Krupnik & Jolly 2010). Indeed, many of the northern environmental changes that have

been the focus of recent scientific investigations were first noted by local land users (Nakashima, 1993; Weller *et al.* 2005; Menzies 2006; Krupnik & Jolly 2010).

Despite the potential for TEK to contribute to environmental assessment, monitoring, and management, there is little guidance available on how to effectively and appropriately use Indigenous knowledge in these contexts (Usher 2000). TEK holders have also struggled with how to effectively communicate their knowledge to other stakeholders involved in these processes (Bonny & Berkes 2008). Over many generations, northern Indigenous peoples have developed a detailed understanding of how to survive in Arctic regions. This multifaceted knowledge has been transmitted orally for thousands of years and includes: knowledge of travel and navigation strategies including stars, vegetation, weather, the range and distribution of wildlife, and hunting, fishing, and trapping techniques for each season (Cruikshank 2001; Alunik, Kolausok, & Morrison 2003; Aporta 2009; Inuvialuit Communications Society 2009; Bandringa & Inuvialuit Elders 2010; Lyons 2010). This traditional ecological knowledge (TEK) exists in specific and complex socio-cultural context, which is integral to its understanding and appropriate use (Cruikshank 2001; Berkes 2009). According to Berkes (2009: 151), adequately contextualizing TEK remains "one of the biggest challenges in Indigenous knowledge research". In many cases TEK has been inappropriately applied to scales outside of its intended use in ways that distort, abstract, or transform its original meaning (Wenzel 1999; Cruikshank 2001; Wohling 2009). The use of TEK in decision-making has also been criticized for lacking actual Indigenous

participation, which is required to prevent decontextualization of this knowledge (Mauro & Hardison 2000; Newton, Paci, & Ogden 2005; Dowsley 2009).

In the Inuvialuit Settlement Region (ISR), ongoing changes in temperature, natural disturbance regimes, and industrial development are anticipated to drive continued environmental change. In this region it is also a policy requirement that traditional knowledge be used in co-management and environmental decision-making (Keeping 1989; Usher 2000). The Inuvialuit Final Agreement (1984), the Mackenzie Valley Resource Management Act (1998), the Mackenzie Valley Joint Review Panel, and the McCrank Report to the Minister of Indian and Northern Affairs Canada also recommend that traditional knowledge be considered in decision-making, resource management and assessment (Keeping 1989; Government of Canada 2005; McCrank 2008; National Energy Board 2010). In this region there is a clear need for the development of an effective and locally relevant strategy for documenting and communicating observations of environmental conditions grounded in TEK. Such a monitoring strategy is essential because the impacts of change are affecting northerners in many ways, and it is required by Federal legislation. However, at this point in time there is no monitoring program explicitly focused on TEK.

The goal of this work was to develop a strategy for documenting and communicating TEK and observations related to local environmental conditions that is: 1) effective, 2) compatible with contemporary Inuvialuit culture, and 3) facilitates knowledge transfer within Inuvialuit communities. To accomplish this we used a modified version of

Dennis *et al's.* (2009) participatory-photo mapping (PPM) to record and communicate local observations of environmental conditions. Our modified method used observer photos, videos, audio, and interview transcripts, organized in a web-based map. This protocol was deployed during 13 outings with 16 Inuvialuit participants from three communities in the ISR: Inuvik, Aklavik, and Tuktoyaktuk. Nine Inuvialuit cultural experts evaluated the protocol in semi-structured interviews, and answered the following research question: can PPM effectively communicate and contextualize, Inuvialuit observations of environmental conditions in a manner consistent with contemporary Inuvialuit life?

To our knowledge this research is the one of the first efforts to engage Indigenous experts[5] and youth in participatory photo-mapping of environmental changes for the purpose of long-term environmental monitoring. As such, our protocol will record TEK, and contribute to knowledge co-production that will help facilitate decision-making at the community level.

Methods

To explore the potential of visual methods to record and communicate Inuvialuit observations of the environment we: 1) implemented a modified version of the PPM method described by Dennis *et al.* 2009, 2) created a web-based map to organize and

[5] Inuvialuit land users have a profound and intimate understanding of their environment and are referred to as experts throughout this thesis.

communicate participant observations, and 3) interviewed cultural specialists and program participants about the results of the pilot project.

Developing a PPM Protocol

In February 2009, researchers from the University of Victoria[6] (UVIC) and Aboriginal Affairs and Northern Development Canada (AANDC) met with the hunter and trapper committees (HTCs) in Inuvik, Aklavik, and Tuktoyaktuk to discuss a pilot project that would draw on Inuvialuit knowledge to monitor environmental conditions. At this time, a steering committee made up of HTC members and a representative from the Inuvialuit Joint Secretariat was established to guide these efforts. Following project initiatives in 2010, that included a meeting of knowledgeable Inuvialuit land users to discuss the issue of salt-kill in outer Mackenzie delta, and a land-based TEK workshop in the outer delta (Kokelj *et al.* In Press), we proposed a pilot project to explore the PPM procedure as a means of recording and communicating Inuvialuit observations. In our initial discussions about photo mapping with community members, they stressed that a pilot project to document TEK related to local environmental conditions should facilitate intergenerational knowledge transfer (traditional and technological) between local youth, Inuvialuit elders, experts and project researchers. To meet these goals we developed a protocol with a focus on elder-youth interactions on the land, which included digital tools training.

[6] Licenses obtained as a part of this research included: an Inuvialuit Land Use License (ILA10TN011), a Northwest Territories Scientific Research License (14795), a Yukon Scientists and Explorers Act License (10-61S&E), and a UVIC Human Research Ethics Board Certificate of Approval (10-259).

In planning meetings with the HTCs we identified 1) priority monitoring areas, and 2) local participants (Inuvialuit experts and youth) (Table 2.1). PPM outings took place in and around the communities of Inuvik, Aklavik, and Tuktoyaktuk, at sites identified by local experts out on the land in remote areas in the MDR, Northwest Territories (NWT). In 2010, the PPM method was deployed in a range of contexts. It was used primarily with pairs of participants (Inuvialuit experts and local youth), but other PPM outings involved groups of participants with multiple experts and youth, or a single expert. To facilitate the PPM procedure in this pilot project, we accompanied participants to all sites. At each observation site, Inuvialuit experts described their observations and shared detailed knowledge about the site. Youth participants worked with the expert to photo-document the observation with a digital camera (Olympus Stylus Tough HD6000). Landscape, mid-range, and close-up digital photographs were taken from a variety of angles to document the site. The digital cameras were set to take the highest quality JPEG photographs possible (10 megapixel). To encourage the youth to take photos and provide 'back-up' images, additional photos were taken with a Nikon D90 camera at each site. To obtain the location of each photo observation we used Garmin (GPSMAP 60CSx) GPS units to record a track log for the duration of the outing.

Photo-elicitation-interviews

Following each field outing, semi-structured photo-elicitation interviews were used to record detailed participant observations associated with each site. Participants reviewed the photos they had taken and were asked to select up to 60 key images. To provide a focal point for the interview these images were shown to the participants on a portable

computer. During interviews participants provided a detailed account (a photo narrative) to accompany each photograph. Questions asked in the photo-elicitation interviews are listed in Appendix 1. Interviews were recorded using a digital audio recording device (Zoom H2). Photo-elicitation interviews were conducted in two different settings: 1) with the expert in their home, after returning from the PPM outing, and 2) out on the land in the Aklavik Hunter and Trapper cabin with a group of four experts. In both cases photos were reviewed on a lap top computer. Participants were compensated for their time using locally established rates.

Table 2.1 Inuvialuit land users, youth and cultural experts who participated in the (2010) PPM pilot project.

Inuvialuk Participant	N.W.T. Community	Brief description	PPM Participant	Evaluated PPM protocol
Adam, Emmanuel	Tuktoyaktuk	Inuvialuk hunter & trapper, Preacher, former member of the Tuktoyaktuk Hunter & Trapper Committee (THTC)	✓	✓
Allen, Terrance	Aklavik	Inuvialuk youth	✓	
Amos, Jordan	Inuvik	Inuvialuk youth	✓	
Archie, Billy	Aklavik	Inuvialuk hunter & trapper, founding director of the Aklavik Hunter & Trapper Committee (AHTC), contractor	✓	
Arey, Joe	Aklavik	Inuvialuk elder, hunter & trapper	✓	
Arey, Nellie	Aklavik	Inuvialuk elder, hunter & trapper	✓	
Binder, Richard	Inuvik	Inuvialuk hunter & trapper, Inuvialuk Joint Secretariat		✓
Esagok, Douglas (Joe, Dougie)	Inuvik	Inuvialuk hunter & trapper, Inuvialuk Game Council Chair, Inuvik HTC, Northern Ranger	✓	
Felix, Cody	Inuvik	Inuvialuk youth, hunter & trapper	✓	
Felix, Cole	Inuvik	Inuvialuk youth, hunter & trapper	✓	
Felix, Dustin	Inuvik	Inuvialuk hunter & trapper	✓	
Gordon, Annie B.	Aklavik	Gwitch'in Elder, Interviewer for Arctic Borderlands Knowledge Co-op, language expert		✓
Gordon, Danny C.	Aklavik	Inuvialuk elder, AHTC member, Wildlife Management Advisory Council (Yukon, North Slope) member, hunter & trapper		✓
Gruben, Chucky	Tuktoyaktuk	Inuvialuk and user, former HTC member, contractor	✓	
James, Edward	Aklavik	Inuvialuk youth, hunter & trapper, traditional Inuvialuit drummer & dancer	✓	
Lennie, Edward	Inuvik	Inuvialuk elder, former member of the Inuvialuit Hunter & Trapper Committee (IHTC)	✓	
Lennie, Jeanie	Inuvik	Inuvialuit elder, and land user	✓	
Floyd, Kevin	Inuvik	Youth leadership coordinator, hunter & trapper		✓
Paul, William	Aklavik	Inuvialuk youth, hunter & trapper	✓	
Pokiak, Charles	Tuktoyaktuk	Inuvialuk, Inuvialuit hunter & trapper, THTC member, contractor		✓
Pokiak, Frank	Tuktoyaktuk	Inuvialuk hunter & trapper, Inuvialuit Game Council, former member of the THTC, hunter & trapper		✓
Storr, Evelyn	Aklavik	Inuvialuk, Inuvialuit Wildlife Management Advisory Council (Yukon North Slope & Northwest Territories), AHTC member		✓
Storr, Lyle	Aklavik	Inuvialuk youth	✓	
Wolki, Fred	Tuktoyaktuk	Inuvialuk elder, hunter & trapper		✓
Total	Aklavik (9) Inuvik (7) Tuktoyaktuk (8)	Youth (7) Elders (7) Experts (10)	16	9

Mapping participant observations

Each PPM outing produced a suite of observations that included digital photos, a photo-elicitation interview (digital audio file and a transcription), and a GPS track-log. A file naming convention was created for each PPM site to assist with file handling web-based mapping. In the fall of 2010, participant photos, video, and interview transcriptions were organized in a Drupal™ based geo-database and web-browser (Figure 2.1). Drupal™ is a web-based open source content management systems used in community-based mapping (Weiss & Lorenzi 2008). Drupal™ was chosen instead of a program such as ARCGIS 10™ because it is free and is highly customizable. In this project we used Drupal™ to overlay photos and associated text, over satellite imagery displayed in Google Earth™. This provided a simple means to store and share the mapped data with viewers (Fonseca & Vieira 2008). To add observations to the map, GPS track logs were downloaded and exported to GPS exchange format (.gpx) using MacGPS Pro™ computer software. Photos were geo-coded using HoudaGeo™. This software program estimates the geographic location of each image by linking the photo's time signature (found in its meta-data) with the coordinates from the corresponding time on GPS track-log. Subsequently, all the information collected as a part of the photo monitoring process was organized into Excel™ and then imported into a Drupal™ geo-database. Each 'data point' in this file consisted of a digital photo file name, latitude and longitude (X, Y coordinates of the image), author (observer), observation type (theme), description (verbatim text from the photo-elicitation interview), and a 'should this be mapped?' field. The 151 observations were organized into 33 different themes, or 'observation

types'. The excel document was added to the Drupal™ geo-database as a '.csv' (coma separated value) file.

Assessing the protocol

To assess the capacity of the protocol to situate Inuvialuit observations of environmental conditions in the context of Inuvialuit culture, we consulted 10 cultural experts (Table 2.1). Participants in these interviews were identified during the course of fieldwork and in consultation with local HTCs. Only one of these individuals participated in our 2010 fieldwork using the PPM method. Semi-structured interviews were conducted in the communities of Aklavik, Inuvik, and Tuktoyaktuk, NWT, and one interview was completed over the phone. Participants were asked to review the website (http://www.mapping.uvic.ca/mackenziedelta), read the brief project description on the home page, and navigate the observations recorded there. The basic layout of the map (geo-browser) and the functions of the map were described and demonstrated and then participants were asked to spend up to 15 minutes navigating the map of observations by zooming into particular areas of interest, visiting observation sites, and entering keywords of their choice into the search bar. Three interviews were conducted without Internet access. In these cases a standardized presentation including screen shots of key geo-browser features, functions, and examples of observations was shared with the participants.

After reviewing the map and its functions, participants were asked a series of questions pertaining to the utility of the map. Interview questions listed in Appendix 2 sought to

explore if and how the PPM method and web-based map could adequately contextualize Inuvialuit knowledge in a way that is useful for future generations of Inuvialuit. Interview participants were compensated for their time using locally established rates. Transcribed interviews were examined for recurrent themes using qualitative analysis software package (Nvivo 8). This information was used to identify the number of times thematic categories were referenced by participants. This information was then organized into an excel document sorted by the most frequently referenced thematic categories.

Results

Monitoring environmental conditions

In the summer and fall of 2010, 13 PPM outings with 16 Inuvialuit participants were conducted. These outings produced 151 observations, which were grouped into 33 thematic categories, and organized using a web-based geo-database (Figure 2.1). Two participants returned with video files. In some cases monitoring was conducted with a single expert, and in others we worked with teams of elders/experts and youth. Experts were all active land users, and many were active members of Inuvialuit co-management boards. Despite our intentions to work with an equal number of male and female participants, in the first year of this pilot project observers were mostly male.

Many participants focused their monitoring on environmental changes, including; shifts in wildlife and vegetation (range and distribution), drained lakes, thaw slumping,

landslides (Figure 2.2), river bank erosion (Figure 2.3), increased run-off, increased overflows, changes in permafrost, as well as increasingly hazardous travel conditions encountered while traveling or accessing hunting and harvesting areas (changes in water levels, and increased wave action). Many of the changing environmental conditions had damaged or threatened infrastructure (roads, cabins, camps, buildings), important historical sites (traditionally used camps, travel routes, grave sites), and harvesting areas. Harvesting of country foods such as plants, berries, fish, and waterfowl was documented using photos and video (Figure 2.4). Other participants described how Inuvialuit land users have adapted to changes in the environment (sea ice, water levels, drained lakes). The observations took place in only a portion of the MDR, and represent a subset of the environmental change occurring.

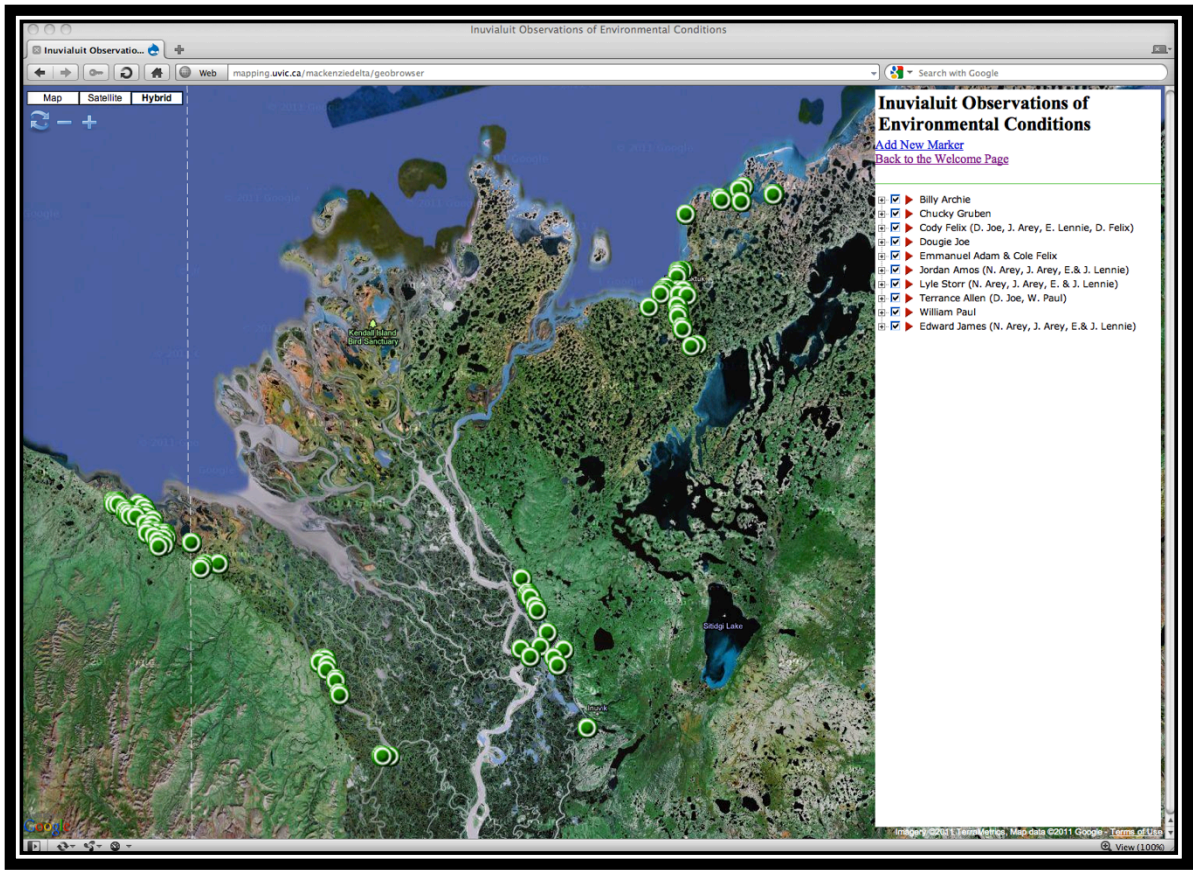

Figure 2.1 Screen shot of the geo-browser (http://mapping.uvic.ca/mackenziedelta/geobrowser) showing participatory photo-mapping (PPM) activity in the Mackenzie Delta Region in 2010. Green circles represent individual geo-referenced observations made during 2010 PPM activities in the Inuvialuit Settlement Region. Geo-referenced photographs were taken at sites chosen by Inuvialuit experts. On the right side of the web-browser the observations are organized according to the Inuvialuit experts who made each observation

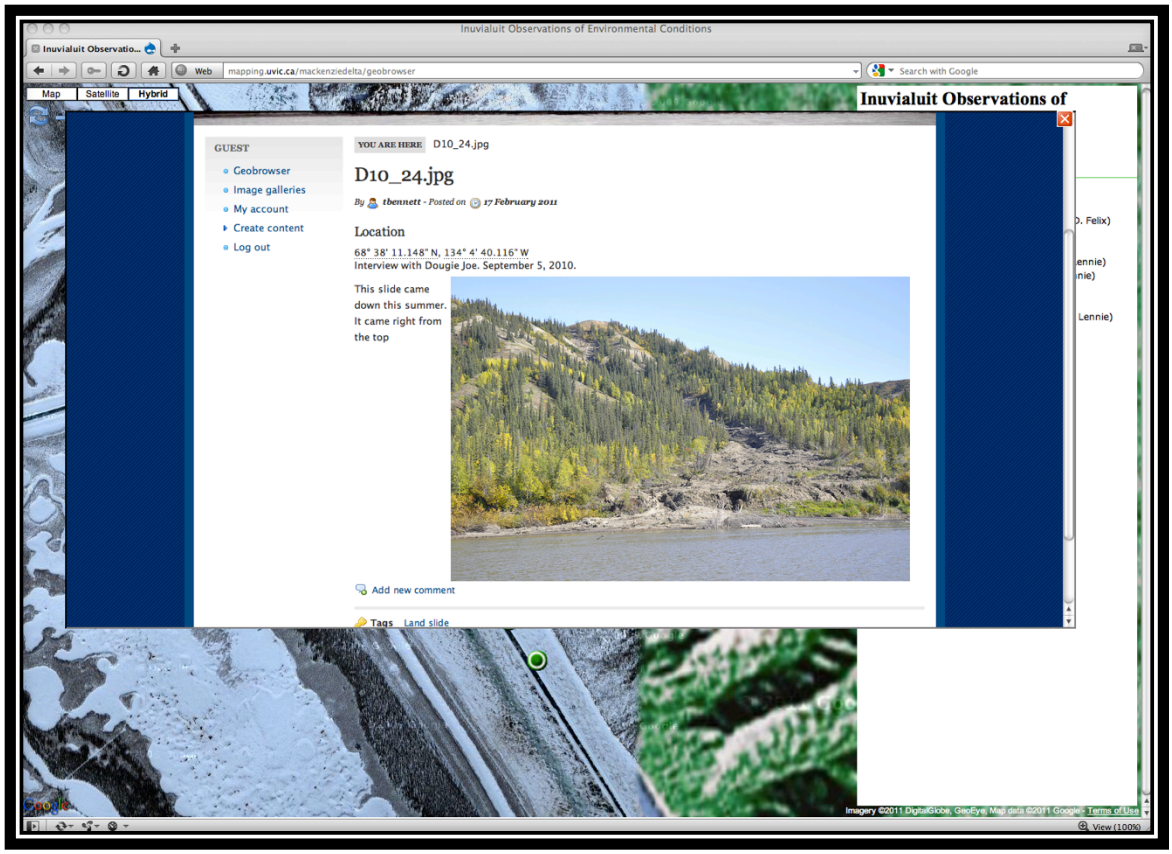

Figure 2.2 Screen shot from the geo-browser (http://mapping.uvic.ca/mackenziedelta/geobrowser) showing an observation of a landslide that occurred in 2010 in the Caribou Hills, north of Inuvik, NWT. Observations in the geo-browser include the GPS coordinates of the photo, the date, the name of the observer, and a direct quote from the photo-elicitation interview that corresponds to the photo.

Figure 2.3 Three photos taken by an Inuvialuk youth (Jordan Amos, Inuvik) were merged into a panoramic image. This photo documented riverbank erosion on the Mackenzie River near Inuvik. Inuvialuk expert Douglas Esagok noted that riverbank erosion is occurring at a rapid rate, requiring that that these cabins be moved every 2 years.

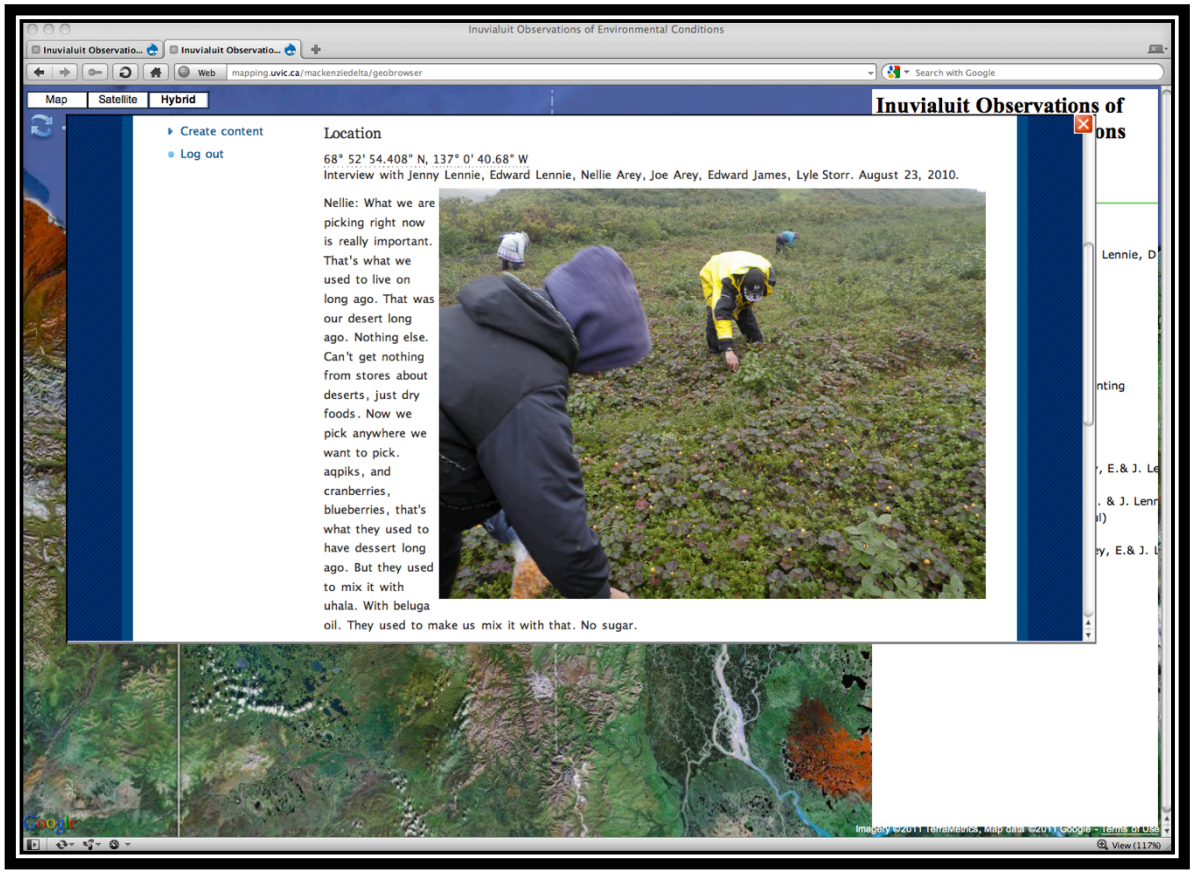

Figure 2.4 Geo-browser (http://mapping.uvic.ca/mackenziedelta/geobrowser) screen-shot showing an observation of an aqpik (*Rubus chamaemorus*) harvesting site on the Yukon North Slope. Berry harvesting continues to be an important Inuvialuit activity. In the text from the photo-elicitation interview (left of the photo), Nellie Arey describes the cultural importance of aqpiit harvesting and how these berries were traditionally mixed with uhala (beluga oil).

Documenting and communicating Inuvialuit TEK

PPM participants and cultural experts all agreed that the PPM protocol was a good strategy for documenting and communicating TEK, observations, and concerns. Interviews indicated that participants attributed the success of the protocol to the use of photography (the visual medium), the photo-interviews (story-telling), time spent on the land traveling and observing (in situ), and the pairing of local youth and elders/experts.

> "You got to be out there to see it. I mean if you stay in town, all you hear is stories about this happening and that happening. Until you finally see it for yourself, it becomes reality. You can say it's changing. Even from my own observations, from my own travels, things have really changed. And it's getting faster and faster because of the warming, because of the melt. Things are changing pretty fast now." Emmanuel Adam, Inuvialuk expert.

> "I think it's a good way. I think it's important that we start recording these observations from people who go out on the land." Frank Pokiak, Inuvialuk expert.

> "I think it's a good way because it's visual, if you have this and you can show the elders or the young people what has been collected by using this method, I think it becomes more real to them, then just having a document in a binder type form. It is a good approach, and with the technology today I think young people will have more interest in gathering information." Evelyn Storr, Inuvialuk expert.

Participants noted that organizing the documented environmental changes observed by land users on a web-based map of the region could help land users explain and communicate their observations to others.

> "I mean it's a good way [PPM method] because people can literally see the changes that do happen over time. It's real; you can see the evidence of it. To see the actual pictures … explaining it, it's so real." Emmanuel Adam, Inuvialuk expert.

> "If you had it on a website where people can actually look at it and see the changes that they are talking about, I think a lot of the time we really have a hard time trying to express

> ourselves and [describing] these changes, you know because you don't have any evidence of them." Frank Pokiak, Inuvialuk expert.

> "It may come in handy down the road, as we try to express ourselves as to why these areas are important to us. If people could take note of which areas they use for hunting and why, why it's important to us. Even for camping. I think it may be a good thing to do, especially with lots of pressure from oil and gas." Frank Pokiak, Inuvialuk expert.

> "I like seeing photos. That tells a lot of stories, when you can see photos and map where things are changing," Danny C. Gordon, Inuvialuk elder.

Many of the individuals who participated in monitoring were experienced photographers, or have used photography and video regularly to document travel, hunting, weather events, and camping activities for decades.

> "I've probably got 6,000 photos that I've taken along the coast, since the 1950s. Traveling, hunting, camping." Danny C. Gordon, Inuvialuk elder.

Many participants expressed concerns regarding the loss of TEK, stressing that it must be accurately documented and shared and highlighting the importance of knowledge about the land, environmental changes, and traditional hunting, trapping, camping, travel, and harvesting techniques. Local interest was also expressed in documenting and archiving such expert knowledge and facilitating its transfer to youth, and between northern communities.

> "I think it's a really good way to pass down information, we are going into a different technological era. 50 years ago we didn't have anything like this, and our youth are well into it, and they are going to be our future leaders." Richard Binder, Inuvialuk expert.

> "If we don't talk about it [our knowledge], we are going to lose it all." Annie B Gordon, Gwich'in elder.

> "You don't need 8 years of schooling to look at a photo, and also just to be able to get this information, this is great." Kevin Floyd, Inuvialuk land user.

> "We are a people that travel, and we are a people that observe and that use the land…Our culture is to observe and go places. Pass on the information to others who you know frequent these places. It's really important." Emmanuel Adam, Inuvialuk expert.

> "It's got to be shared. If there are changes like climate change happening … they are there to monitor what is really happening. Everybody has to share what's happening." Fred Wolki, Inuvialuk elder.

> "Over the years a lot of community members seem to have developed this fatigue to research and to supporting researchers." Kevin Floyd, Inuvialuk land user.

Several interview participants noted that the PPM might help to alleviate an experience they described as "research fatigue". By providing a more accessible form of information sharing, the web-based PPM can archive TEK, observations, and local concerns online, so that northern researchers can access information about the community prior to arriving in the communities.

> "There needs to be data sharing, and knowledge about what's going on [community concerns], and to me that's going to lessen the impact [time commitments] on the community." Richard Binder, Inuvialuk expert.

Effective PPM pairs

Our experience with the PPM pilot project suggests that PPM works better in some contexts than others. The most effective PPM outings occurred with small groups that included an engaged and eager youth, and a knowledgeable and interested elder or expert (Figure 2.5). Working with the same pair on multiple outings also increased their engagement in monitoring activities over time. In some cases working with a single expert observer was also very effective. Large groups were generally more difficult work with because of the increased complexity of travel logistics, and reduced opportunity for 'one-on-one' PPM facilitation. However, the group photo-elicitation interview was effective because when one person shared information or a story it sometimes helped others to remember stories and experiences, encouraging participation in the interview.

Figure 2.5 Emmanuel Adam and Cole Felix on a participatory photo-mapping (PPM) outing, photographing retrogressive thaw slumping, west of Tuktoyaktuk, NWT. In 2010 Inuvialuit experts and youth photo-mapped 151 observations of environmental conditions in the Mackenzie Delta Region. Photo: T. D. Bennett, 2010.

Sensitive observations

During photo elicitation interviews Inuvialuit experts identified some types of PPM observations as sensitive, and stressed that these observations should not be made public. For example, along a rapidly eroding portion of the Beaufort Coast, PPM monitors noted a recently exposed Inuvialuit gravesite that was about to be washed out to sea. The site was photographed from a distance. Participants acknowledged that while it is important to document the loss of historical sites to rapid coastal erosion, identifying the specific

locations of gravesites was problematic. Historically the Inuvialuit were buried with all of their possessions and these sites could become the sites of artifact theft. Similarly, other participants identified excellent harvesting sites (productive berry plots or fishing/hunting areas) as areas that are important to identify for planning purposes, but should not be identified on a public map.

Participant suggestions

Participants identified several ways that the PPM protocol could be expanded in the future. A number of individuals suggested that still photos should be augmented with video observations that can capture interactions, events, processes, and activities. Participants also suggested expanding the scope of the protocol to include other communities in the ISR, as well as areas outside of the ISR. Several participants suggested that the PPM could be integrated into school programs and into the Inuvialuit cultural resource center.

> "I think it would be excellent within the resource center, because with education now, and northern studies and the Aboriginal programs, if this is available, all the schools have computers and they have smart boards, you can just pull information if you have the site, you could show the kids. Say the youth that were involved, I mean that could be a real good show and tell project when they go back to school, and they can use something like this with their studies." Evelyn Storr, Inuvialuk.

> "You need to even start working with the schools. They have equipment there. They could do monitoring around the area. They can see it for themselves, it's something I've always tried

> to encourage. There are a lot of bright young kids there, and with the right tools for the science teacher it could have potential. You are combining what the local elders know about the area with science and that's the way to monitor impacts, especially climate change." Billy Archie, Inuvialuk.

Several senior participants identified computers and technology as a barrier. Most elders noted they were not familiar with computers and were not comfortable reviewing/navigating the web-based map, or with navigating the Internet generally. Others stated they were not familiar with GPS units, and suggested that they would require training.

Discussion

Monitoring environmental conditions

Our experience in this pilot project shows the PPM protocol was effective at engaging community members in recording TEK, observations of the environment, and local concerns. Inuvialuit participants documented 151 observations of environmental conditions. The majority of these were of recent environmental changes in areas important to Inuvialuit monitors from the communities of Aklavik, Inuvik, and Tuktoyaktuk. Some of the changes had visibly altered the landscape, often with serious implications for the safety of land users and the stability of infrastructure. Many observations were made along travel routes, at sites of traditional importance, in or near communities, or during harvesting activities. Organizing participant's observations

(digital photos, the verbatim photo-narrative, along with the observer's name, and the specific location and date of the observation) in an interactive web-based map was a successful way of communicating TEK held by local people to other interested parties. This approach also has potential to be used to archive TEK, and facilitate its transfer from local experts and elders to youth. As suggested by several participants, the PPM method could be integrated into local community-based monitoring initiatives and school programming such as annual youth canoe trips and integration into the local school programing for class credit.

Despite the enormous potential contribution of TEK, and the requirement that it be used in northern environmental planning and decision-making (Keeping 1989; Usher 2000), major gaps exist in the best practices for documenting and communicating TEK (Usher 2000; Bonny & Berkes 2008). The application of TEK in environmental decision-making and planning has often been criticized for abstracting knowledge from a broader cultural context (Basso 1996; Berkes 1999; Williamson *et al.* 2004; Castleden, Garvin, & others 2008; Thornton 2008; Berkes 2009; Wohling 2009). Other issues frequently associated with the applied use of TEK include marginalization, misuse (Cruikshank 2001), and misappropriation (Ross *et al.* 2010).

Our experience suggests that the PPM method may provide a partial solution to the problem of the decontextualiztaion of TEK. In this project, PPM was used to record the details of each TEK observation, and to explicitly include additional information that adds the context to each observation. Combining the date, location and author for each

observation, with an open-ended narrative about the location, allows users to include as much context as they deem appropriate. Narratives can include information such as place names, traditional use, stories, history, and perceptions of identified environmental change. For example, Emanuel Adam made an observation of thaw slumping near Tuktoyaktuk where, the eroded material had deposited silt into a water way making it more shallow, making a traditional travel route (important for avoiding open water during storms) impassable by boat. Other advantages of using participatory photography have been identified. Yamashita (2002) argued that the very act of framing a photo helps participants see everyday practices in new ways (Yamashita 2002). By having participants take photos, it "forces photographers to take on a contemplative 'quasi-outsider' role, which in turn invites deeper reflection and more meaningful interpretation of events and circumstances" (Dennis *et al.* 2009: 468).

Berkes (1999) points out that working closely with community members in ways that allow communities to ensure that their TEK is appropriately recorded and represented is the best practice for documenting TEK. Indigenous led projects are beginning to address concerns regarding cultural and intellectual appropriation in the use of TEK in research and management (Wenzel 1999). In developing the PPM protocol we consulted with the HTCs to develop community-specific research goals. The protocol was designed to include HTC recommendations, which included: local identification of priority-monitoring sites and experts, creation of opportunities for youth skill building and elder-youth interactions. The PPM pilot project highlights the potential for this method to provide a vehicle for other community interests & concerns.

Previous efforts to record Inuvialuit (and Gwitch'in) observations of environmental conditions in the MDR area have been based on interviews and surveys with local experts conducted through the Arctic Borderlands Ecological Knowledge Co-op (ABEKC) monitoring program (Gordon *et al.* 2007). These interviews are conducted by a single community monitor, and synthesized annually in a report. While it has recorded a wealth of general information characterizing environmental conditions, it has been criticized for being overly general, and not recording specific locations, dates, observers, or providing additional contextual information (Folliott, 2005). The PPM protocol has the potential to build on the success of the ABEKC by adding spatial accuracy, additional observer context, and increasing the accessibility of information.

TEK can also be used in collaborations to generate new knowledge and insights (Huntington, Gearheard, & Holm 2010). By facilitating communication among local land users and experts, researchers, educators, and decision-makers web-based maps of TEK can make an important contribution to a variety of programs and initiatives. Some examples include: Indigenous education programs (Pulsifer *et al.* 2010); resource management bodies (Usher 2000; Moller *et al.* 2004; Ballard, Fernandez-Gimenez, & Sturtevant 2008; Pulsifer *et al.* 2010; Fienup-Riordan & Carmack 2011); regional planning and scientific research (Kokelj *et al.* In Press; Hunn *et al.* 2003; Eisner *et al.* 2009); in support of land claims (Bonny & Berkes 2008), and in traditional use mapping (Tobias 2000, 2009). Our pilot project indicates that the PPM method can contribute to the application of TEK in these contexts. By promoting intergenerational knowledge

transfer, relationship building, time spent on the land, it can also build local capacity to monitor and understand environmental change.

Northern environmental change will impact northern livelihoods, infrastructure, wildlife habitat and, and many other components of northern ecosystems. The web-based map has the potential to be useful for researchers, decision-makers, and regulators who are working to track environmental change because it maps community concerns including: recent environmental change, geohazards, land use, and culturally important areas that are relevant to the northerners. While web-based PPM should never replace direct community consultation, it provides a valuable resource for local communities to share knowledge among themselves, across northern networks, and in meetings with researchers, regulators and decision-makers.

Inuvialuit knowledge is also of great interest to northern scientists focused on understanding environmental change (Kokelj *et al.* In Press; Pearce *et al*. 2011). Several recent examples demonstrate that partnerships among scientists and TEK holders are a vital component of northern environmental monitoring. By making TEK more widely accessible, a web based map increases the potential to rapidly detect recent changes, which could in turn be useful for planning local adaptation strategies.

The idea of collaborating with local experts who use GPS units and computers to develop maps (Perkins 2008) that document Indigenous knowledge (Aporta 2003), and facilitate geospatial cultural storytelling (Caquard *et al.* 2009), is not new. These

methods have been widely used in traditional use studies completed by many Indigenous groups (Tobias 2000, 2009; Brody 2010). In Canada, several recent efforts to document and map Indigenous observations related to the environment have utilized combinations of GPS, GIS, and web technologies. Maps and 'atlases' from these projects have been identified as being useful for local planning and management decision-making (Gearheard, Aipellee, & O'Keefe 2010). Recent examples of such projects include: the 2010 'Inuit Sea Ice Use and Occupancy Project' (Pulsifer *et al.* 2010), the 2010 'SIKU' Project (Kruipnik *et al.* 2010; Andrews 2011), the Igliniit Project (Gearheard *et al.* 2010), and the 'Cybercartographic Atlas of Indigenous Perspectives and Knowledge of the Great Lakes Region' (Caquard *et al.* 2009). These projects focused on documenting, and archiving local land use and knowledge, for the purpose of facilitating intergenerational knowledge transfer, and education. Our application of these technologies differs from these efforts because we focus on environmental monitoring that will provide an ongoing record of changing environmental conditions.

Communicating TEK

Our experience suggests that visual and multi-media techniques have great potential to assist with effective communication of Indigenous knowledge. PPM brings together observer photos, videos, and verbal observations in an interactive web-based map. This approach is particularly appropriate for efforts to document and communicate knowledge that is difficult to visualize and contextualize (Fox 2003; Bonny & Berkes 2008; Dennis *et al.* 2009). Our protocol is well suited to document Inuvialuit knowledge of environmental conditions, because photography provided a simple and effective focal

point for communication that could be easily combined with storytelling (photo-elicitation interviews), travel and time spent on the land, and geo-spatial information. However, regardless of the medium (oral, multi-media, text in a website, or in a book etc.), no single communication strategy can completely capture the oral knowledge deeply rooted in culture and experience (Bonny & Berkes 2008). Different types of knowledge can be communicated using a variety of mediums, and choosing the most appropriate medium is dependent upon the intended use of the knowledge, and the intended audience. Evidence from our interviews suggest that the combination of participatory photography, photo-narrative (photo-elicitation interviews), and maps (web-based PPM) are an effective strategy for documenting and communicating environmental observations because these approaches offer flexibility in communication strategies. The protocol allowed participants to communicate orally, (tell stories) visually (phototography), and spatially by mapping their observation (web-based map). We acknowledge our protocol may not be capable of documenting all types of observations. Future editions of the protocol may benefit from the inclusion of in situ video interviews.

In a 2005 study, Gearheard evaluated multimedia tools for documenting and communicating Inuit knowledge in Nunavut. Gearheard used photos, video, and audio to document Inuit knowledge of climate and environmental change, and shared the information on a CD-ROM. The study concluded that multimedia and other creative technologies such as the Internet have potential to be key communication tools that can assist Inuit communities in reaching their goals (Christensen 2003; Gearheard 2005). In

general, Inuit peoples have adopted media and technologies (Raymont 1983), and have used them to effectively document environmental knowledge (Gearheard & River 2005; Kruipnik *et al.* 2010; Kunuk & Mauro 2010). The visual and oral elements of digital multimedia fit well with Inuit culture, which is based on traditions of orally transmitting knowledge, and learning by watching and doing (Pulsifer *et al.* 2010). Gearheard noted that youth responded well to digital technologies, and that elders were less inclined (Gearheard 2005). Recoding observations at specific sites out on the land was also recommended by Tobias (2009) who explained that the richness of people's descriptions and memories of a particular place are enhanced when they are at a site, compared to asking people to recall such memory while in front of a map.

Our field experiences and interviews with cultural experts suggest that the protocol also fits well with contemporary Inuvialuit culture. Being out on the land has been a fundamental part of Inuvialuit culture and survival for thousands of years (Alunik *et al.* 2003; Inuvialuit Communications Society 2009). Integrating monitoring activities out on the land while traveling, observing, and orally sharing knowledge about the environment through story telling and experiential learning was an integral aspect of the monitoring protocol. We focused on visual and oral communication methods instead of written forms to document TEK, to encourage participation from participants, and avoid barriers associated with literacy or language. For participants in the PPM activities, the only reading and writing required in this research was the informed consent ethics form. Several senior participants could not read or write, and some youth were choosing not to attend high school. Such youth were interested and eager to take part in activities

involving the use of GPS and cameras out on the land. This is consistent with research by Gabhainn and Sixsmith (2006) who note that for some, writing can bring out feelings of self-consciousness can discourage participation (Gabhainn & Sixsmith 2006). This supports findings by Gearheard (2005) who suggested avoiding research methods that discourage participation when working with many Indigenous peoples, where language and knowledge has traditionally been transferred through oral histories, not through written communication.

The benefits of using visual and media technologies to communicate Inuit observations have been well established; however the use of photography in research is not without controversy. The use of photographs in research has been criticized because the meaning of images can be ambiguous and open to misinterpretation (Chaplin 2005). One strategy for navigating this issue is to use photography to complement other data collection methods such as interviews (Felton *et al.* 2009). When combined with an interview, photos can enable participants to remember, review, and reflect on a captured moment in time (Hurdley 2007), and provide key contextual information keep a photo and its meaning in its respective context (Akhbari *et al.* 2010). In our web-based PPM, each photo and video observation was linked with additional information including: verbatim text from the photo-interview with the observer, the observer's name, and other details such as the date, time, and exact location the observation was made. The additional information leaves little room for misinterpretation, or the possibility that information be taken out of its intended context.

Traditional knowledge and intellectual property

To ensure that TEK is not unfairly appropriated, misused, or exploited for profit without the consent of the knowledge holders it is vital that the issue of intellectual property rights is examined. Of particular concern is the possibility that TEK could be used for commercial benefit, or in a manner considered inappropriate by the knowledge holder. In this project TEK was documented, and stored in a web-based PPM with the intention of sharing the knowledge with various stakeholders. Most of the observations documented in this project are unlikely to be used in ways that are unrelated to environmental management and assessment. Observers in this project shared knowledge to inform others of the changes they are observing associated with environmental change. Other research initiatives to document Indigenous observations of changing climate conditions have also shared observations publically with wide audiences (Huntington *et al.* 2005; Krupnik *et al.* 2010; Kunuk & Mauro 2010).

In the context of intellectual property rights and TEK, there are a number of observations in this research that could be considered problematic: 1) the location of historic grave sites (often with artifacts) which may be of interest to collectors; 2) the identification of important hunting, or harvesting areas, which could become exploited (e.g. visited by an un-invited float plane of southern hunters/fishers). To address these issues in the web-based PPM, observations at gravesites were removed, and prior to entering the web-based PPM, users must agree to several terms of use, which were designed to protect the knowledge, and its holders. When users have agreed to the terms of use (check box), the site administrator provides them with a user name and password to use the web-based

map. A statement was also added to the website indicating that all knowledge, observations, and subsequent additions to the knowledge are the property of the observer and are managed by the Inuvialuit Joint Secretariat. It is clearly stated on the website, that the information in the web-based map is intended to communicate TEK of environmental changes to other northerners, and as not to be used for commercial purposes. In the future, observations deemed inappropriate for the public, as well as any with commercial applications, will not be shared publicly. This decision reflects our belief that the best way to protect culturally sensitive knowledge or knowledge with commercial value is to keep it out of the public domain.

As described above, there is excellent potential to use this method to record other cultural knowledge, and in these cases there is a need to proceed cautiously. For example, the PPM protocol could be used to organize and communicate: place names, traditional song and dances, traditional narratives, Indigenous language, and traditional skills and practices (Tobias 2000, 2009). Other examples include travel routes and the locations of lakes used for drinking water. Individuals and firms have patented, trademarked, and copyrighted knowledge and culture (herbal remedies and song and dance) held by Indigenous peoples in recent years (Munzer & Raustiala 2009; Brody 2010). If the PPM protocol is deployed to record these types of knowledge, communities will need to consider safe and secure information storage and user access.

The audience

As discussed above, the medium used to document certain types of TEK should be chosen based on the audience and the project goal. In the context of this research, there are two distinct audiences interested in Inuvialuit knowledge, each for different purposes. First is the audience with an interest in documenting knowledge for Inuvialuit education and culture. The second audience is interested in the knowledge for research, decision-making, and planning purposes. Depending on the purpose/audience for the knowledge, the ideal medium for communication is likely to be different. Using PPM to document knowledge for the purpose of education and preserving and promoting culture a mix of video, photography, audio recordings, and text might be best to capture such knowledge (Bonny & Berkes 2008). For the audience(s) interested in TEK and concerns for the purpose of decision-making, planning, and research; geo-referenced photos of local concerns, and evidence of environmental changes and impacts may become the most useful focus of PPM activities. In this case photos, text, and very short videos in English, all with accurate geo-spatial information may be the best fit. Our interviews suggest that PPM could also be deployed to monitor very specific things, in particular areas. For example thaw slump activity could be documented using PPM in a particular area.

While it is appropriate to share TEK using a web-based medium for multiple audiences, organizing knowledge within the geo-browser in different ways would increase its utility for different audiences. For example the current organization of observations in the geo-browser is by the observer (observer's name ie. Emmanuel Adam and Cole Felix). Other

audiences may be more interested in organizing the knowledge by standardized environmental indicators. For example the NWT CIMP project is interested in organizing the observations into the categories currently being used to monitor cumulative impacts called 'valued components' (VCs), VCs include: water, wildlife, birds and insects, plants, fish and marine life, air and climate, and people (AANDC 2010). The geo-browser could also be integrated with other GIS decision-making tools useful for the management of land-use permits for private lands in the ISR.

Education opportunities

The importance of sparking interest and creating opportunities to engage youth in land-based activities and education was identified as a community priority at the outset of this project. Our experience suggests that the PPM protocol may be particularly successful in this regard if it is integrated into local curricula. One of the most important aspects of the PPM method identified by the Inuvialuit cultural experts was the Elder-youth interaction on the land, and the opportunity for knowledge transfer and interaction in a culturally appropriate context. Participants noted that the combination of the 'hands on' outdoor approach and the focus on intergenerational knowledge transfer effectively facilitated youth engagement in Inuvialuit cultural activities. Billy Archie, Richard Binder, Kevin Floyd, and Evelyn Storr also suggested that the PPM method should go into school programing, where elders and youth could work together to document TEK, and the youth could earn class credits. School resources (teachers, funding, access to cameras, computers, 'smart boards' and GPS units) were also highlighted as having potential to help sustain PPM monitoring efforts. Several participants also suggested

ways in which PPM can contribute in other educational programs. Kevin Floyd noted that PPM could be important for youth because "*it gives [the youth] an investment, a very permanent and tangible connection to their future and what's at stake up here.*" Kevin Floyd (Inuvik, NWT) suggested deploying the PPM method with an Inuvialuit canoe trip program on the Horton River, a multi-day educational youth trip that occurs annually, where the same sites could be photographed annually.

Challenges

Despite the effectiveness of pairing youth and elders there were several challenges. At the outset of this research we hoped to have gender neutral participation. The engagement of female youth is important in the North because women have been poorly represented in formal decision-making bodies about natural resources (Williamson *et al,* 2004). Based on Inuvialuit cultural expert interviews, we learned that with having a greater number of females in the composition of the research working group, and more female elders involved in this project, Inuvialuit female youth would be more likely to participate.

Slow internet connection speeds, a complex web-based mapping interface, and technical demands of managing and organizing geo-referenced multi-media observations are key challenges that will need to be overcome before the PPM protocol can be implemented widely (this is discussed in more detail in chapter 3).

Conclusion

This research highlights the effectiveness of using visual and participatory methods to document, contextualize, and share Inuvialuit observations of the environment. Inuvialuit land users have an intimate and detailed understanding of changing conditions in the MDR, and are well suited to monitor environmental change.

The findings of this research suggest that the PPM protocol is effective because it is compatible with Inuvialuit culture and the traditions of storytelling, traveling, and observing the land. The combination of experiential, visual, oral, and spatial information can assist with the documentation and communication of TEK, and has potential to contribute to a range of community driven initiatives, including: facilitating knowledge transfer among northern communities and building local capacity to monitor, understand, and communicate environmental changes. Our work also indicates that PPM provides a web-based solution for archiving and sharing TEK in a standardized format. The greatest potential for PPM to be adopted and sustained in the North is within the local sphere. For northern community members, PPM could be comprehensively utilized in a certain geographical area, under the control and ownership of local peoples, sustained through integration with local school programming, and supported by effective research and community partnerships.

Ultimately, the success of a long-term PPM initiative will require community ownership of the process. The continued success of this project will require on-going and effective

collaboration between key community members, community organizations, and university researchers so that PPM remains consistent with community goals.

Acknowledgements

This project is collaboration between a variety of groups and individuals. The Hunter and Trapper Committees of Aklavik, Inuvik, and Tuktoyaktuk, with a special thanks to Michelle Gruben, Douglas Esagok, Emanuel Adam, Richard Binder and the Inuvialuit Joint Secretariat in Inuvik, and the Cumulative Impact Monitoring Program staff in Yellowknife Steve Kokelj, Claire Marchildon, and Stephan Goodman were extremely helpful in facilitating fieldwork.

This research was made possible by funding from the NWT Cumulative Impact Monitoring Program, MITACS Accelerate Internship, an NSERC Discovery Grant (TCL), Northern Scientific Training Award Program, Aurora Research Institute Fellowship, Dairyland Environmental Scholarships, and a University of Victoria Graduate Student Award.

Interview & PPM participants

Adam, Emmanuel (2010)
Allen, Terrance (2010)
Amos, Jordan (2010)
Archie, Billy (2010)
Arey, Joe (2010)
Arey, Nellie (2010)
Binder, Richard (2010)
Esagok, Douglas (Joe, Dougie) (2010)

Felix, Cody (2010)
Felix, Cole (2010)
Felix, Dustin (2010)
Gordon, Annie B (2010)
Gordon, Danny C (2010)
Gruben, Chucky (2010)
James, Edward (2010)
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Lennie, Jeanie (2010)
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Appendix 1
Photo-elicitation interview questions: Inuvialuit land and knowledge experts

Questions asked about individual photographs:

1. What is special about this photo?

2. Can you tell me about the features that are in this image?

3. What is significant about this area?

4. Is this a normal occurrence?

5. Do you recall when this happened?

Questions asked at the end of the interview

6. Am I asking the right type of questions?

7. If we could go out again, where would you want to go?

Appendix 2
Interview Questions: Inuvialuit cultural experts

1. Can you tell me a little bit about yourself?
2. Is this type of map, and the information it contains, a good way to record Inuvialuit observations?
3. Does the map and mapping protocol fit with Inuvialuit culture Inuvialuit, ways of knowing and understanding the land / spending time on the land? And if not why? How could the map be improved to overcome this?
4. How was knowledge shared in the past?

5. Q: Does this method of recording and documenting Inuvialuit observations of the land change the meaning of the knowledge? And if so, how might it be modified to overcome this?
6. How does looking at the map differ from being at the site where the observation was made?
7. Is the map an improvement on a text summary?
8. Could this method be applied by other programs such as the Beluga Whale monitoring program, wildlife monitor, environmental monitor etc. If not, why?
9. How could the photo-mapping program be improved?
10. Could this map fit in with Inuvialuit language programs?
11. Is the map user friendly enough? Is it difficult to navigate?
12. We will be sharing this map with scientists / resource managers / decision makers, do you see any issues that we should be aware of ? Perhaps about information that should not be made available, culturally sensitive information?
13. Who should have access to the map? Should it be made widely accessible? If not why?
14. Should the photo-mapping be part of Traditional Knowledge activities? TK camp? Take a kid trapping program?
15. Should there be a process to review mapped information for accuracy?
16. An Aklavik HTC member recommended setting up an elder advisory board for the program. Is this a good idea?
17. Who should do the photo-mapping? How should they be selected?
18. Should youth participation be a core part of this procedure?

19. How could the photo-mapping procedure be designed to engage youth?
20. How could the photo-mapping procedure be designed to engage female participants?
21. What should be the overall focus of the monitoring? (ecological, environmental, wildlife, etc.?)
22. When should the monitoring take place, for how much time?
23. Would expert video-interviews out on the land, at each observation site make the knowledge/observations more clear?
24. Can you recommend other cultural specialists I should interview about this.
25. What would it take for this photo-mapping program to run on its own?
26. Should there be a program coordinator? Who should that be?
27. Should monitors from each community by hired by the program? Should all land users be involved?

Chapter 3

A web-based map of Inuvialuit observations of the environment: A resource for environmental decision-making and research?

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Introduction

Traditional knowledge (TK) related to the environment (traditional ecological knowledge, or TEK) has been recognized as an important source of information for ecosystem management and decision-making (Hunn *et al.* 2003; Moller *et al.* 2004; Ballard, Fernandez-Gimenez, & Sturtevant 2008; Eisner *et al.* 2009; Lyver *et al.* 2010). This is particularly evident in northern environmental assessment and resource management decision-making where, in recent decades, there has been an increase in the number of policies that make reference to or require consideration of TEK (Usher 2000; Ellis 2005; MVRB 2005). In the Northwest Territories (NWT) there have been repeated calls for the development of monitoring programs that include TEK. Examples are found in the Mackenzie Valley Resource Management Act, the text of several aboriginal land agreements, the recommendations of the Mackenzie Valley Joint Review Panel, and in the McCrank Report to the Minister of Indian and Northern Affairs Canada (Joint Review Panel, 2010; McCrank, 2008). At this point in time there is no such monitoring program.

There are several factors that make monitoring programs grounded in TEK particularly appropriate in the North. Northern ecosystems in areas such as the Mackenzie Delta Region (MDR) are undergoing rapid environmental change that is expected to intensify (Cohen 1997; Pearce *et al.* 2009a, 2011). Examples of these changes include thinner ice that breaks up earlier, increasingly unpredictable and warmer weather, changes in the health of wildlife, the arrival of new species, increased intensity of the sun, terrestrial salinization, and an increased frequency and intensity of extreme weather events (Corell 2006; Parry 2007; Comiso *et al.* 2008; Graversen *et al.* 2008; Moline *et al.* 2008;

Perovich *et al.* 2008; Pearce *et al.* 2009a; Pisaric *et al.* 2011; Kokelj *et al.* In press). Increasing coastal erosion, rising sea levels, and permafrost thaw are also threatening the municipal infrastructure of coastal communities and coastal heritage sites (Lynch & Brunner, 2007; Couture & Pollard, 2007; Martin *et al.* 2007; Alessa *et al.* 2008; Larsen *et al.* 2008). In some areas, change is occurring so rapidly that conventional monitoring strategies cannot provide up-to-date information. The uncertainty associated with these changes affects local livelihoods and hinders regional planning (McGuire 2006; Pearce *et al.* 2011). Anticipated development is also expected to impact northern ecosystems and traditional livelihoods (Pearce *et al*. 2009a). Three areas in the Inuvialuit Settlement Region (ISR) are slated for oil and gas development (Holroyd *et al.* 2005; Voutier *et al.* 2009), of which the Inuvialuit have part-ownership. The impacts of constructing the pipeline and associated infrastructure (all-season roads, pumping and heating stations) include the loss of terrestrial habitat important for waterfowl and migratory birds, and changes to near shore vegetation due to inundation and increased overland flooding (National Energy Board 2009).

In the context of rapid environmental change and proposed development, TEK can make an important contribution to decision-making and research. Northern land users are particularly well suited to identify and monitor anomalous environmental change. While the integration of TEK into environmental decision-making can be meaningful and mutually beneficial, it is a complex undertaking (Huntington 2000; Cruikshank 2001; Moller *et al.* 2004; Nadasdy 2005; Newton *et al.* 2005; Fernandez-Gimenez, Huntington, & Frost 2006; Armitage 2007; Eisner *et al.* 2009; Wohling 2009; Berkes 2009b;

Armitage *et al.* 2011). Because TEK is embedded within a culture, it can be difficult to accurately document and communicate it to others while maintaining the integrity of the knowledge (Chapter 2). The complexity of such an undertaking can act as a barrier for monitoring programs that are required to use TEK (Cruikshank 1997; Ellis 2005; MVRB 2005; Bonny & Berkes 2008; Thornton 2008; Lauer & Aswani 2009). To use TEK effectively in environmental monitoring there is a need for approaches flexible enough to document a range of cultural knowledge associated with TEK. Employing flexible communication approaches can assist with facilitating effective communication of TEK among northern researchers, decision-makers, and the community in a manner that is consistent with contemporary Inuvialuit culture.

The ISR is located in the western Canadian Arctic, and was established by the Inuvialuit people and the Government of Canada in the Inuvialuit Final Agreement (1984) (the Agreement). The ISR is the ideal location to test a strategy of communicating TEK with decision-makers and researchers because the co-management regime established by the Agreement includes mechanisms intended to facilitate the inclusion of TEK in decision-making. Permanent Inuvialuit representation on the five regional co-management bodies, as established by the Agreement, ensures that interests and knowledge of the Inuvialuit are considered in decision-making and planning.

In this research we examined a web-based map of TEK related to local environmental conditions for its potential to contribute to environmental monitoring, research, and decision-making by interviewing northern ecosystem managers, decision-makers, and

researchers. The web-based map includes Inuvialuit observations and knowledge of environmental conditions in the MDR. It was created using a process known as participatory photo-mapping (PPM), which is described in more detail in Chapter 2. Ultimately, the goal of this research is to test the potential of the PPM method to contribute to the development of an effective community-driven environmental monitoring strategy focused on Inuvialuit knowledge and observations.

Methods

The study region

Field research for the PPM method was conducted primarily in the MDR, with additional fieldwork conducted on the Yukon North Slope and the Tuktoyaktuk peninsula. The MDR includes the large delta surrounding the Mackenzie River from Point Separation north to the Beaufort Sea, as well as areas of upland terrain to the east and west of the delta plain. The northern tree line cuts laterally across the MDR dividing subarctic boreal forest from northern tundra and coastal wetland ecosystems (Burn and Kokelj 2009). The MDR is ecologically rich and is capable of supporting a wide variety of life and a dense human population, unlike its surrounding environments, which are more barren, dry, and resource-poor (Alunik *et al.* 2003). The region has long cold winters (mean January temperature in Tuktoyaktuk is -27.2°C), and short cool summers (mean July temperature in Tuktoyaktuk is 10.9°C) (Johnstone & Kokelj 2008).

The MDR is experiencing rapid environmental change (Burn & Kokelj 2009, Parry *et al.* 2007), which includes some of the most rapid warming on Earth (Serreze *et al*. 2000). The MDR is underlain by ice-rich continuous permafrost, and reacts dramatically to warming that can drive landscape-scale changes to terrain (Burn & Kokelj 2009). In some cases coastlines are eroding and changing shape, inland erosion is altering rivers, and many areas have experienced increased thermokarst slumping (Burn & Kokelj, 2009; Lantz & Kokelj 2008).

The 2010 participatory photo-mapping pilot project

In 2010, we collaborated with the Inuvialuit Hunter and Trapper Committees (HTCs) of Inuvik, Aklavik, and Tuktoyaktuk, and the Inuvialuit Joint Secretariat to develop and test a protocol for Inuvialuit hunters and trappers to record environmental observations (Chapter 2). This pilot project used a PPM research method adapted from Denis *et al.* (2009), and paired Inuvialuit youth with knowledgeable local experts, who used visual and participatory methods to document TEK related to local environmental conditions. In 2010, we tested our PPM protocol by organizing field trips with knowledgeable Inuvialuit hunters and land users. Inuvialuit observations of environmental conditions were recorded using digital cameras and hand held GPS units. Subsequently, digital photographs and video became the focus of photo-elicitation interviews, which added a detailed narrative to each geo-referenced observation. Following fieldwork and interviews, geo-referenced photos, video, audio recordings, and associated text files were organized into a web-based map (Figure 3.1). In 2010, 151 observations were mapped and grouped into 33 themes (Figure 3.2; Chapter 2). The majority of PPM participants

documented and discussed examples of environmental changes (Figure 3.3). The PPM method is described in more detail in Chapter 2.

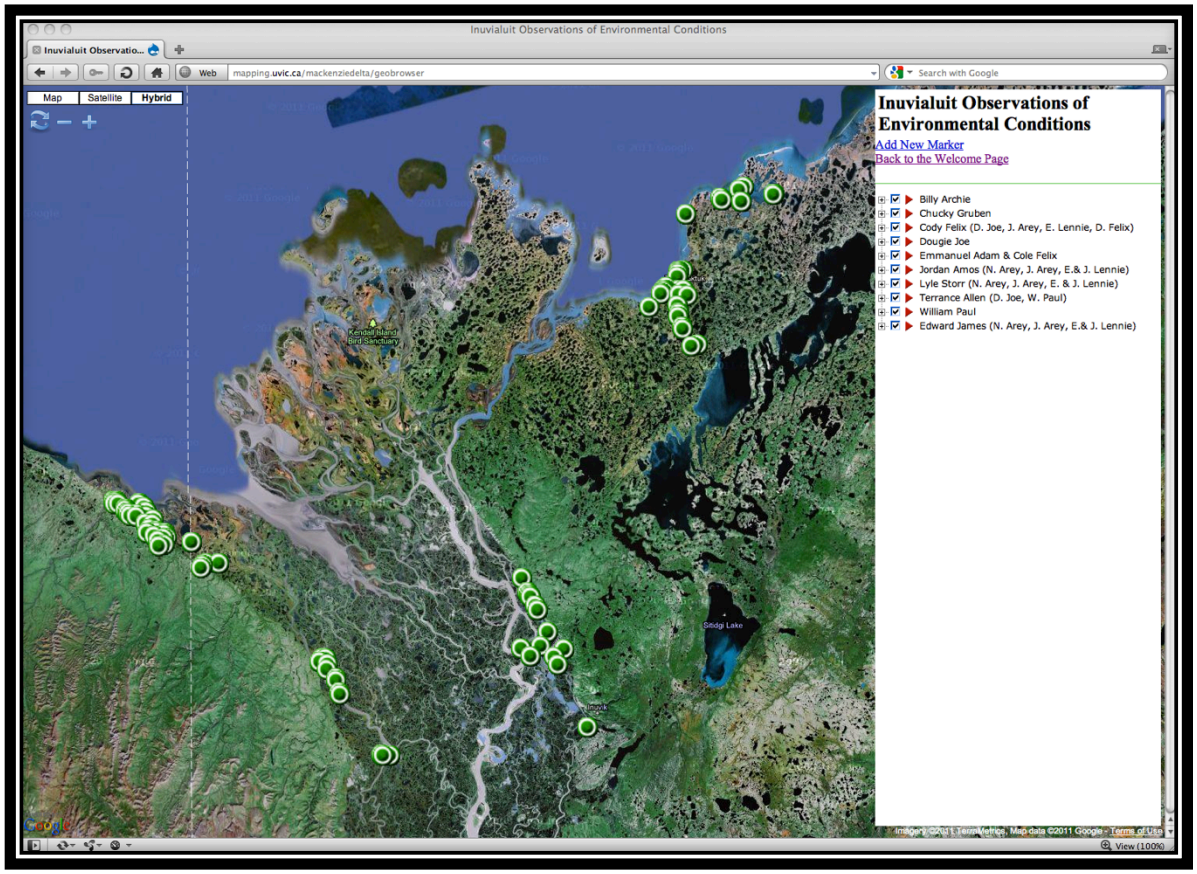

Figure 3.1 A screen shot of the geo-browser showing participatory photo-mapping (PPM) activity in the Mackenzie Delta Region (Western Canadian Arctic) in 2010. Green circles represent individual geo-referenced observations made during 2010 PPM activities. Geo-referenced photographs were taken at sites chosen by Inuvialuit experts. On the right side of the web-browser, the observations are organized by Inuvialuit experts.

TEK, northern decision-making, & research

To evaluate the potential of using the web-based map to inform environmental decision-making and research, semi-directive interviews were conducted with seven informants involved in northern ecosystem management and environmental research in northern Canada (Table 3.1).

Table 3.1 Informants who evaluated the PPM protocol by participating in semi-structured interviews.

Scientist/decision-maker	Position and Role in Northern Ecosystem Management
John Ondrack	Chair of the Inuvialuit Environmental Impact Screening Committee, former Mackenzie Valley Environmental Impact Review Board member
Dr. Kathleen Racher	Technical Director of the Wek'eezhii Land and Water Board
Lois Harwood	Marine mammal biologist, Department of Fisheries and Oceans
Mark Lange	Aboriginal Affairs and Northern Development Canada (AANDC) Cumulative Impacts Monitoring Program (CIMP) director
Dr. Steve Kokelj	Aboriginal Affairs and Northern Development Canada (AANDC) Cumulative Impacts Monitoring Program (CIMP) scientist
Nelson Perry	Parks Canada Ecosystem Scientist, formerly worked for the Inuvialuit Joint Secretariat, and the Inuvialuit Game Council
Norm Snow	Executive director of the Inuvialuit Joint Secretariat

In semi-directive interviews participants were given a descriptive introduction to the PPM protocol and a standardized presentation demonstrating the features and functionality of the web-based map. Informants were asked to navigate the map for up to 15 minutes, and were then asked to evaluate the utility of the web-based map by identifying advantages and disadvantages of the map in the context of northern environmental monitoring and decision-making. Five interviews were conducted in person in Inuvik, and Yellowknife, NWT, and two were conducted over the phone. Interviews were recorded using an audio recording device (Zoom H2). Interview questions are listed in Appendix 3.1.

Interview analysis

Using qualitative analysis software (NVIVO 8), interview transcriptions were organized into thematic categories based on reoccurring themes, and other salient information. NVIVO (8) generated reports for each thematic category, identifying the number of references to each. This information was used to create a spreadsheet using Microsoft Excel, which was used to sort the interview text into thematic categories and organize the interview data based on the frequency of references made to each thematic category.

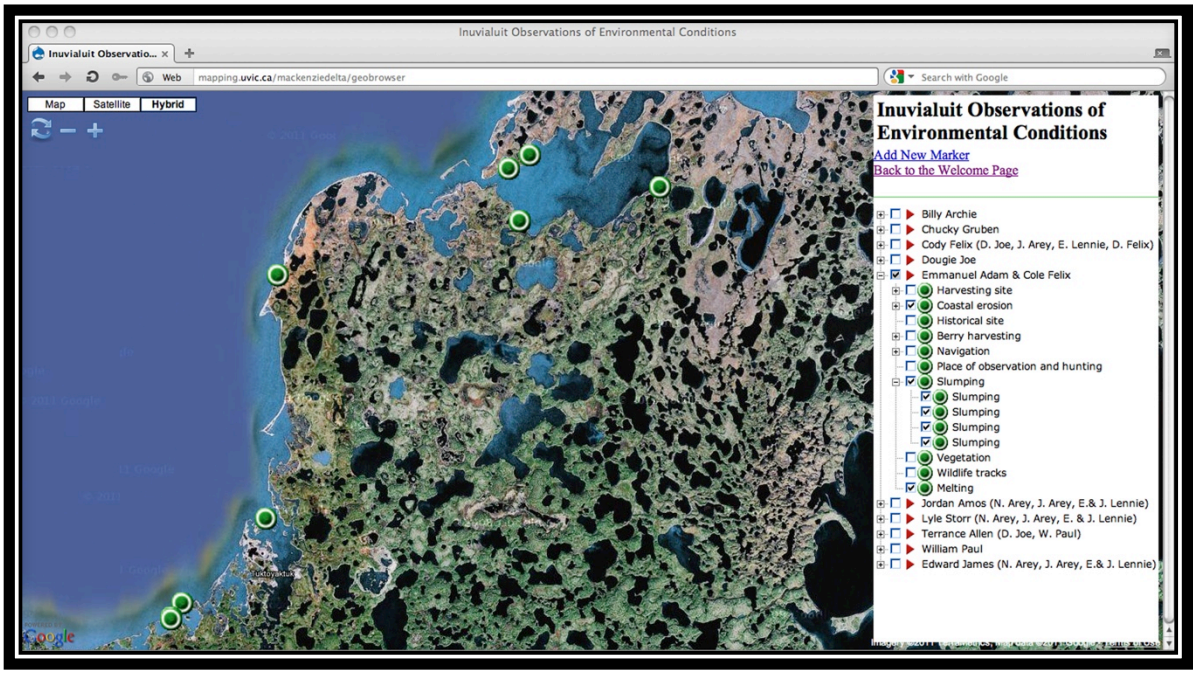

Figure 3.2 A screen shot captured from the web-based map of Inuvialuit observations of environmental conditions in the Inuvialuit Settlement Region, NWT [http://mapping.uvic.ca/mackenziedelta /geobrowser]. The green dots on the map correspond to checked boxes in the window on the right of the screen. The red triangles (right side) show the Inuvialuit experts who made each observation. In this image observations made by Emmanuel Adam and Cole Felix of 'slumping', 'coastal erosion', and 'melting' are visible.

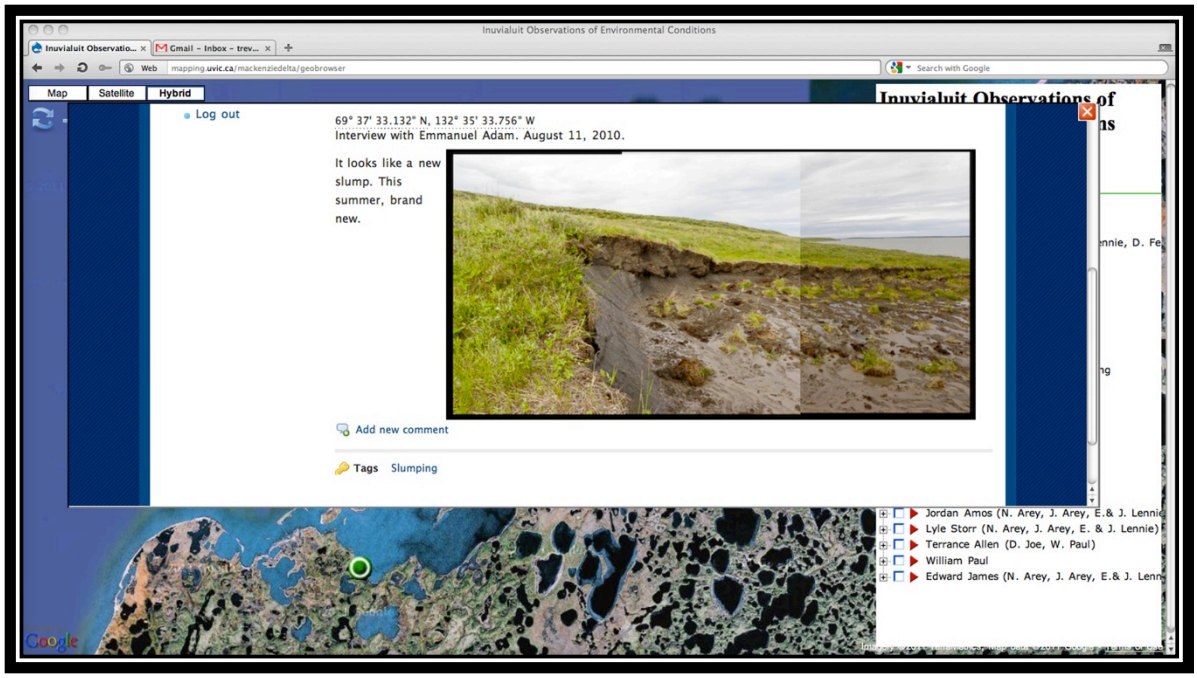

Figure 3.3 A screen shot captured from the web-based map of Inuvialuit observations of environmental conditions in the Inuvialuit Settlement Region, NWT [http://mapping.uvic.ca/mackenziedelta /geobrowser]. Emmanuel Adam and Cole Felix made this observation on August 11, 2010. It was categorized and tagged as an observation about 'slumping'. Each observation includes the GPS location, Inuvialuit expert's name, and verbatim text from photo-elicitation interviews conducted after returning from the field.

Results

Community consultation

Several participants stated that the PPM protocol and web-based map are useful tools for community consultation that could be used to communicate TEK about the cultural importance and traditional use of particular sites.

> *"A tool such as yours would be a really good way for us [the Wek'eezhii Land and Water Board] to know the importance of something. A specific example would be when you are deciding if a mine is going to go in a certain area, and they are going to be discharging*

affluent into a lake. We have to decide what level of waste can be put into this lake. … if this lake is really really important to people, and something that they are worried about and something they use all the time, then we might say you know the guideline values are not stringent enough. … I just automatically saw how useful this would be for the board to consider." Kathleen Racher

"I pop one [observation] open, it's got roads, slumping, and landslides. … I could go to this site and actually see the conditions on the ground with photos, so that's pretty nifty. I noticed on the very first photo I looked at was of evidence of slumping on a river bank, that is pretty common, a big issue for the pipeline project. … I could see that when a project is proposed in a sensitive area, on gravel bars or something like that, the raw evidence of when ice gets pushed against one of those things; the visual is huge. If you could actually find something that documented a condition that can occur, wash outs and that kind of thing, in the near area of where something [a development] is going to happen, then people [planners/decision-makers] are going to use it." John Ondrack

Participants also described the PPM method as an effective and valuable strategy for documenting and sharing TEK among stakeholders, indicating that method was effective because for participants it involved time on the land and focused on the visual medium (photography) for documentation.

"It seems like a very good step to actually documenting some of this local knowledge. Because over the years, working with all the people I have worked with, you hear a lot of comments about change, and about things being different. Changes about slumping or storms, or changes in vegetation, and changes in flow levels and all that, but it's very, … hard to summarize it and use it and put it together with science data because the two are such different approaches. It looks to me like it's a good mapping and geo-spatial analysis,

and a good idea to at least get the information from the people while they are available, and to get it into a consistent format where people can access it." Lois Harwood

"I can see from the community perspective, a lot of the value from this is even just archiving people's knowledge, it's a pretty neat way of retaining that." Steve Kokelj

"The fact that it's documented, having people talking and taking pictures, and having people talk about the past of a specific area, I found that very valuable, that documentation is something we are always looking for here [at the Wek'eezhii Land and Water Board]." Kathleen Racher

PPM was identified as a tool that could be useful for decision-makers and community environmental consultation. Interview participants explained that understanding community concerns, land-use practices, and the impact of management decisions on aboriginal rights (section 35 of the Constitution Act, 1982), are vital components of effective environmental consultation.

"Any time a decision-maker makes a decision, you have to look at the impact of that decision on aboriginal rights. … Well if there are a lot of slumps in the area, this project has an average to medium risk of causing slumps, then you know you are playing with aboriginal concerns. If you know some of the concerns are snow geese or that the geese are disappearing, you have already got a stressed component that Aboriginal have a first right to kill those geese and to use them for food. And then the decision-maker is like, oh well there is already some concerns there. … If there is a concern that you can match to the project, then you are already 5 steps ahead." Mark Lange

Participants described how regulators often seek local opinion on proposed development activities and suggested that the web-based map makes it easy to identify the knowledgeable experts in a specific area, and what their concerns are. Several participants also noted that organizing the observations by 'observer's names' makes it easier to know whom to contact regarding further investigation in certain remote areas.

> "*When we are deciding first of all if a development should happen in a certain area we have to have an indication of the importance of the area to people. There are some lakes on the tundra that are just another lake, and there are some lakes on the tundra that are of critical importance. Looking through the geobrowser, you automatically get a sense of people saying we fish here or so and so always came here, there's a cabin here. So it's an easy way to get a sense of how important is that region is. Do people use that region? What do they use the region for? Do they use it for drinking water? Is if for fishing? Is it for hunting? You can get a sense of the importance."* Kathleen Racher

> *"When we receive an application or some kind of management plan from the mine for example, we always send it out and get comments from anyone and everyone who might want to comment, and who might be effected in Federal departments, but also community members, members of the Band, or Band organizations etc. …[it's] a lot of sharing with everyone and asking everyone's opinion about the way things should be run in this particular management area. I guess that is where I am seeing how useful this is both for, your tool for example for the board. To be able to reference a tool such as this, so we can look it up ourselves, and so we can contact individuals if we wanted to, would be extremely valuable."* Kathleen Racher

> *"Locals have concerns, … and because they notice them it's easy to take a picture of. So you would see [in the map] clusters around industrial sites, clusters around hunting sites,*

> *clusters around where they travel, along travel routes. It captures concerns, and some of those concerns could be insults on the environment that are human in nature. … It's capturing what humans do best, which is notice things that are out of the ordinary when they travel somewhere and capturing it. … The more I think about this, this business of logging community concern is actually really powerful, it would re-map how we do business at INAC and with most decision-makers."* Mark Lange

Using TEK in northern decision-making

Decision-makers and regulators in northern Canada are required to facilitate effective community consultation and draw on a variety of information sources, including TEK. Several participants noted that using TEK in the context of northern decision-making has sometimes been seen as problematic. One participant suggested that combining spatially referenced photographs with the observer statements from photo-elicitation interviews could provide a form of evidence to support TEK holder's concerns in such a decision-making system.

> *"One of the problems that we have got, I mentioned the two organizations I've been working with [the Inuvialuit Environmental Impact Screening Committee, and the Mackenzie Valley Environmental Impact Review Board], they are administrative tribunals, that would be the equivalent of being a jury member in a court, we have to deal with factual evidence, and apply it to the circumstance before us. One of the challenges with traditional knowledge, is determining if the information given is factual or not, and therefore useful. We have a fair amount of leeway in that area, but it's still a big problem."* John Ondrack

Interview participants noted that the potential to use the web-based map as an archive of local information is particularly useful for community members who have concerns, but are unable to take part in community meetings with decision-makers, regulators, or researchers.

Lois Harwood noted that many TEK interviews have been recorded and archived, but because they only exist on cassette tapes in a library in Inuvik, they are inaccessible to many. A web-based map creates an opportunity for a land-user's concerns to be communicated in their absence, which is important for Inuvialuit hunter and trappers who are often out on the land for extended periods of time. By making local information and perspectives more accessible, it can potentially be valuable for sharing and retaining knowledge with future generations of Inuvialuit, for informing research questions about environmental management, and for generating new ideas, perspectives, understanding, ultimately leading to better decision-making.

> *"If you could actually get local people to actually start recording observations on this particular issue, it certainly would meet an immediate resource management question, and it would bring their knowledge to the table in a different way than soliciting it through a community meeting. … If you can actually get to the [decision-making] table where there are pictures and maps, its gets people thinking a lot more."* Steve Kokelj

> *"I have seen other science people with jobs similar to mine, but they don't live in the North, so they would have even a harder time accessing information, or knowing who to talk to, or where to go get it. So your approach might help focus people to see good people to contact."* Lois Harwood

Decision-making bodies in the MDR such as the Environmental Impact Screening Committee (EISC) and the Mackenzie Valley Environmental Impact Review Board (MVEIRB) are required to make decisions based on factual evidence. Participants stated that there is limited time available for conducting research to access such information. Consequently, information resources must be immediately accessible, relevant, and accurate. If information cannot be found easily, or if there is potential to become lost in an overwhelming quantity of information, the decision maker will lose interest in the resource. Participants highlighted the need for executive summaries, 'key word' searchable databases, and dependable evidence as guides to effective decision-making. Participants identified PPM and the web-based map as having potential to contribute to effective community consultation and communication of TEK.

> *"The folks that are making decisions are willing to invest an additional amount of time to make a better decision, but that additional amount of time is about this big [is very limited]. … They are willing to invest some time, but it's got to be pretty quick and digested – like sound bites - because someone is breathing down their back to make a decision. But the other way to look at it is you just digested 4 months worth of work and 10 or 15 people's worth of knowledge in a picture and a button, so there has been a lot digested already."* Mark Lange

Participants stated that the information in the web-based map was organized in a useful way because it allowed users to search for information at broad (regional) or fine (specific) spatial scales, by topic, and/or by individual people's observations.

> *"I like the way you have it listed by persons, but under each person you have all the different topics, and you can search by that. So you can search by the region. … If I was working on a site specific project, I would want to look at this place, but if you are looking for over all trends in erosion or harvesting etc. You can do it that way, on an issue specific basis."* Kathleen Racher

> *"This is potentially a useful tool for anyone that is looking at a project within proximity of the areas that you are monitoring. They could go to this map and see from the Inuvialuit users, how do they use that area, and their observations from that location, which is important information, especially if it's in an area that you are not already familiar with. … So you would be already that much further ahead, … you already know something before you start your consultation."* Nelson Perry

Informants expressed that the web-map could be beneficial for community members because it can help voice and support their perspectives and and/or concerns. Participants stated that if decision-makers or researchers could review the information in the web-based map prior to a community meeting, individuals could become more 'up-to speed' with the nature of TEK holder's concerns and observations. The map could also be used during a community meeting to help decision-makers understand TEK holder' and values and ultimately contribute to more informed decisions. This would effectively augment the information that is frequently solicited at community members' meetings. Additionally, PPM was highlighted as a means to eliminate frustrating redundancies associated with repetition of voicing the concerns of TEK holders at community meetings.

"From a consultative perspective … there is a lot of redundancy in venues where the community concerns are raised over and over again. The community gets frustrated, both sides kind of get frustrated.... This [the web-map] is an accumulation of those concerns in a graphic format.... You know, the worst part is hearing people say, you know what we have said this so many times and you guys still aren't listening ... Or the certain person who has the concern doesn't show up for the group to a meeting, and that doesn't mean that the concern isn't there, but it's just that it's kind of a way of accumulating the community's concerns." Steve Kokelj

"I like the fact that it's capturing the state of the environment in some way, and that it's giving voice to average community folks," Mark Lange

"Even better than putting a workshop together, is to give a bunch of folks who use that area this [PPM] tool and say, collectively this is what we are interested in, here's the [PPM protocol and tools], … and send them out." Steve Kokelj

PPM: successes and challenges

Several informants identified the combination of visual methods, the web-based map, and land-based monitoring as key strengths of the approach. Participants suggested that engaging observers out on the land increased the likelihood that important details would be recorded.

"If you go to a meeting with local people and you say tell me what you know about this or that, or traditional knowledge, … it doesn't really come out in a meeting or even in a living room over a cup of tea necessarily. But if you are out there on the land then you having a fighting chance at accessing some of the information." Lois Harwood

This sentiment was echoed by Inuvialuit experts who evaluated the protocol (Chapter 2). Participants also described the geo-browser as a better strategy of presenting and storing information than in printed form because of ease of accessibility. Several individuals recommended that digital video also be integrated into future developments of the PPM protocol because it is a potentially beneficial strategy for knowledge-transfer between elders to youth.

> *"To me, it's way more powerful: having a map, and pictures, and a description, it's way more powerful than a one page summary. ... To the point where it's going to be beneficial to the community, you know pictures speak a thousand words."* Steve Kokelj

> *"It's better than a piece of paper in a binder on a shelf in somebody's office for sure. Or tapes that are in an archive that are difficult to get at."* Lois Harwood

> *"If there hadn't been a picture, I think that every observation would be just a little less interesting"* Kathleen Racher

Participants identified one of the highlights of the web-based interface to be the function allowing for the addition of text to any existing observation using a web-browser connected to the Internet. This feature was built into the design of the Drupal geo-browser (highlighted in Figure 3.4), and was identified as a potentially valuable strategy for gaining ongoing community input regarding local concerns. Harwood observed that elders are unlikely to review other's observations, but that they may be inclined to add additional information based on their own experiences.

"I think this is interesting because it is an easy place for people to blog a concern or an observation." Mark Lange

"... I see that you can add a new comment, and I can think of how cool that would be if other people could add comments, it would be the equivalent of a peer review system. .... There is no way that anyone of us is going to go in and interview just the right people at just the right time, on just the right topic, in just the right way, and get the truth. It's only going to be a bunch of statements that you can evaluate together. So it would be great to have people add comments that would be pretty fabulous." Kathleen Racher

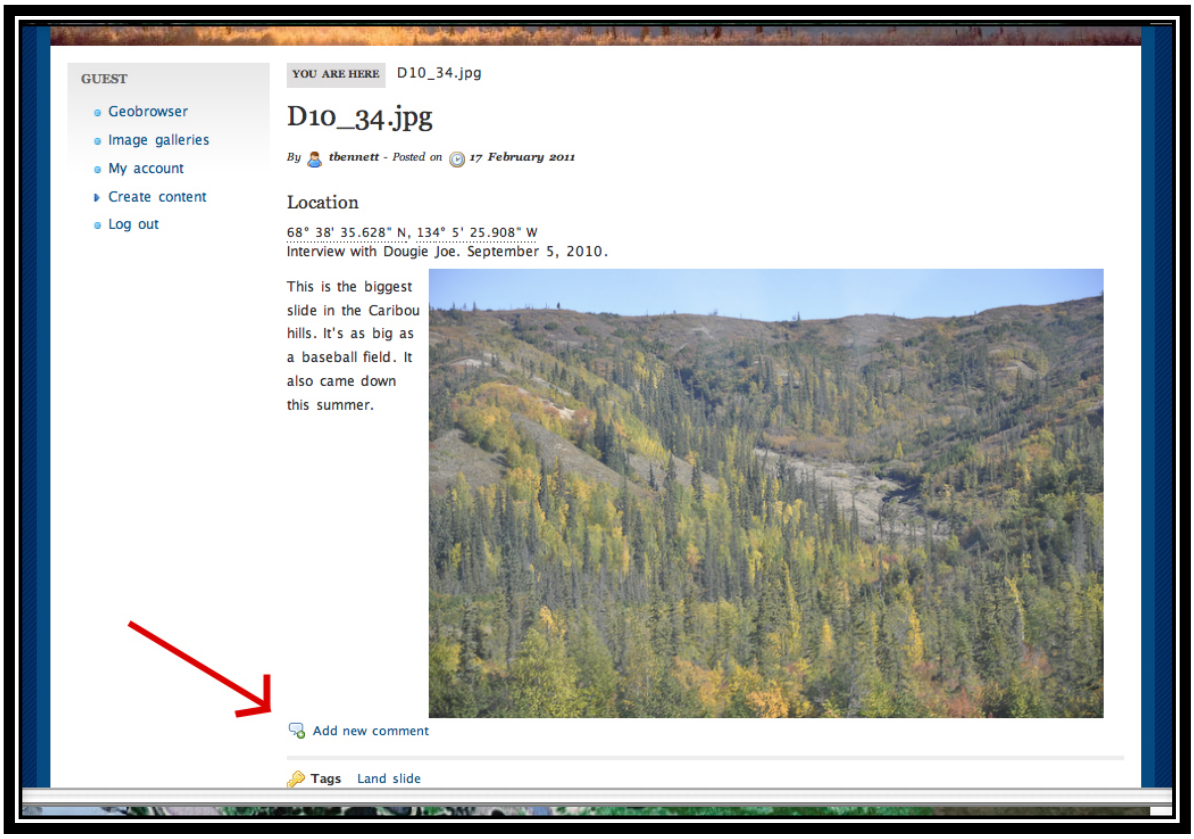

Figure 3.4 Screen shot of the geobrowser showing Inuvialuk observation number D10_34 of a recent landslide in the Caribou Hills, South of Reindeer Station, NWT. Douglas Esagok (Dougie Joe) made this observation in 2010. The red arrow identifies a link where users can "add a new comment". By clicking on this link a new dialog box will appear and users can contribute additional information to the post.

Several participants highlighted that the map is not likely to ever capture all community observations or concerns. Others noted that some individual's concerns, observations, or knowledge might be difficult to photograph, describe, or track with a GPS. The technical and resource requirements related to NWT-wide implementation of the PPM protocol and map were also mentioned as barriers to implementation.

> *"I guess you have to be careful, you're not going to capture everything, that's the hard part. Say this part of your map that you didn't get to with someone, and then an oil company wants to go explore there. You just don't want to give the impression in your tool there that you captured everything."* Lois Harwood

> *"Are you taking away, or limiting observations if you are now saying it's only valid if you show me? It [the web-map] could be criticized for what it is lacking [areas in the map that do not have observations], … if you haven't seen it, [if a concern is not mapped] it doesn't exist."* Mark Lange

Interviews with informants revealed that the information required for environmental assessment, consultation, and resource management is often dependent on the scale of inquiry (local/regional/territorial). Regulators want both broad and specific types of information, depending on the decisions being made. For example, if a decision-maker were interested in the sites of local importance in close proximity to a proposed development site, the PPM protocol should be deployed to document information from local experts about that particular area. Examples of relevant observations include environmental disturbances, culturally important sites, harvesting sites, and bear dens.

Participants identified the PPM pilot protocol as having potential to inform all scales, but stressed that the greater the size of the area, the more observations would be required to characterize key issues in a given area.

> *"We can't anticipate what all the cumulative effects questions or all the regulatory questions are going to be, we just can't. … Sometimes the regulator wants to know the broad picture, but sometimes they want to know the specific needs. If we just collect data everywhere, about everything, that's to probably answer very general questions… But let's just say the question is what are Inuvialuit observations with respect to infrastructure, or what are their perceptions, then maybe, … the tool could be used to do very specific things as well."* Steve Kokelj

Interview participants noted that if the map was made publicly available, certain types of PPM observations could raise unanticipated issues for the local community, the Inuvialuit, or the monitoring framework.

> *"I can imagine if this is implemented five years from now you will get shots of shot-up moose, or 5 caribou on the ice, or pictures of guts as they cut them up. And they might say, you know that was a good moose hunting spot; I don't want that on the map."* Mark Lange

Finally, although Internet access in northern regions is increasingly available, for any web-based resource designed for northern use, Internet connection access and speed is going to be a challenge, and a drawback.

"If the communities are going to be using it, they are going to need a good Internet connection. Every community has internet, but depending on how fast it is. Even here in the Parks Canada office in Inuvik, the speed is very, very slow some days." Nelson Perry

Discussion

Our research shows that the PPM method fills a critical gap in monitoring protocols for remote areas. Although this method presents some challenges, our interviews with northern decision-makers, regulators, and researchers highlight PPMs utility as a tool to collect local information and contribute to and complement strategies that monitor environmental change, inform adaptation strategies, research, and contribute to community consultation and co-management strategies.

The use of PPM in environmental monitoring

Monitoring environmental conditions with adequate sampling frequency and broad-scale coverage is particularly difficult in remote areas because of cost and complex logistics. This problem is compounded by the accelerated pace of change in the Arctic (Dowsley 2009).

An effective monitoring program needs to document change rapidly and accurately, employ effective communications strategies, be cost effective, and be accessible to all stakeholders. An observation network established by individuals who spend extensive periods of time on the land can clearly make a significant contribution to the regional monitoring efforts. PPM can be used to monitor and document observations in specific

locations (fine-scale) and, if it is implemented widely, a regional picture may emerge (broad-scale). However, the MDR is a huge area, the observations in the map represent only a small subset of the TEK, observations, and concerns in the region. It is unlikely that the map will ever be exhaustive, large areas were not visited in the study region. The potential to provide up to date information recorded by local monitors on the state of the environment was highlighted as key strength of the program.

Combined with TEK, accessible collections of geo-referenced photos in areas undergoing environmental change are likely to be useful in monitoring and assessing change in the future. Research using repeat photography also suggests that the photographs captured by participants could be used to track long-term change (Rogers, Malde, & Turner 1984; Ahlstrom 1992; Smith 2007; Nyssen *et al.* 2009; Anderson *et al.* 2009; Cerney 2010). Since the goals of monitoring are likely to change as environmental conditions evolve over time, the flexible nature of the PPM protocol, and its potential to be adapted, are also a key strength.

Information collected using the PPM protocol

In northern regions, long-term collaborative efforts to monitor environmental conditions and resource use can be mutually beneficial for both local communities and researchers (Danielsen, Burgess, & Balmford 2005). They are beneficial because environmental monitoring strategies that involve local people are timelier at influencing decisions than research projects executed by scientists alone, and often address more locally relevant

needs and concerns (Danielsen *et al.* 2010). Such collaborations also help to offset the high cost and logistical constraints associated with Arctic research (Dyck 2009).

The use of PPM in community adaptation

Indigenous land users also need to mitigate vulnerabilities associated with environmental change. Historically Indigenous peoples have been adept navigators of environmental change. However, recent environmental change (often unprecedented in cultural memory) is occurring so rapidly, that new adaptations are required (Newton *et al.* 2005; Armirage *et al.* 2011). For northern peoples managing rapid environmental change means developing strategies to adapt and reduce exposure to vulnerabilities such as environmental hazards and take advantage of new opportunities (Smit *et al.* 2008; Ford *et al.* 2010; Andrachuck & Pearce 2010; Pearce *et al.* 2011).

Since the food systems of northern Indigenous peoples are impacted by environmental conditions, ongoing changes are likely to increase their vulnerability (Furgal & Seguin 2006; Smit, Hovelsrud, & Wandel 2008; Andrachuk & Pearce 2010; Ford & Pearce 2010; Green & Raygorodetsky 2010; Pearce *et al.* 2010). In the MDR, human disturbances associated with oil and gas development, such as drilling mud sumps, drilling pads, and access roads have a lasting effect on surrounding vegetation, which is particularly slow to recover from disturbance (Johnstone & Kokelj 2008). Increasingly frequent natural disturbance has similar effects (Lantz *et al.* 2009; Kokelj *et al.* In Press). Because the PPM protocol can provide up to date information about local environmental

conditions it can make an important contribution to adapting to the impacts of environmental change.

Several examples of disrupted travel routes due to changing environmental conditions were documented using PPM. In one case a series of protected waterways used for boat travel had recently become impassable by boat due to increasingly shallow water. The waterways (protected from wind and waves) were traditionally used as alternative passageways to access harvesting areas or camps when open water was too rough for safe travel. Since this protected travel route is now too shallow to navigate, travelers must face increased risk in the rough water or must postpone their travel. Alternative travel routes or access to larger boats, are examples of potential adaptive strategies.

TEK and northern research

TEK held by Indigenous northerners has been valued in Arctic research for nearly 50 years (Wenzel 1999). TEK holders have detailed and intimate information about their environment, based on generations of experience interacting daily with northern ecosystems. In Arctic regions, TEK includes information related to: weather, seasons, wind, sea ice, and wildlife (Huntington *et al.* 2005a). This wealth of knowledge can be extremely important information for scientific research and decision-making (Nakashima 1993; Norton 2002; Gearheard *et al.* 2006; Laidler 2006; Eicken, Lovecraft, & Druckenmiller 2009; Eicken 2010; Krupnik *et al.* 2010). Examples of effective research collaborations between researchers and Indigenous communities include work that has described ocean characteristics (snow and ice characteristics, and fish abundance)

(Carmack & Macdonald 2008), guided geophysical and biological research (Eisner *et al.* 2009; Eicken 2010), and monitored populations and co-managed sustainable wildlife harvests (Moller *et al.* 2004)

Our research demonstrates that PPM has the potential to facilitate knowledge transfer between local land user experts and other researchers. In many instances, TEK can lead to more detailed multidisciplinary investigations. Kokelj *et al.* (In Press) used Inuvialuit TEK, obtained through interviews at a Traditional Knowledge workshop, to better understand the cause of a significant vegetation disturbance that occurred in the outer Mackenzie Delta. The Inuvialuit experts identified that a storm surge that occurred in 1999, that had inundated the disturbed area with salt water. Further investigation was conducted to better understand the environmental disturbance, which involved remote sensing, hydrometric, meteorological, and permafrost studies. On the North Slope of Alaska, Eisner *et al.* (2009) worked with Iñupiaq TEK holders to identify changes in environmental conditions associated with lakes. The TEK was also corroborated with scientific investigations, in this case using areal and remote sensing time series to identify the details of the change. In both examples, TEK provided additional information important for local and the scientific communities' understanding of northern environmental change.

Our findings indicate the PPM protocol provides a mechanism to facilitate effective communication between local community organizations and researchers, improving research partnerships. Effective communication from community organizations in

research partnerships can help local communities meet locally established goals. Effective collaboration and local partnerships can result in meaningful and coherent research based on trust and mutual understanding (Huntington *et al.* 2005; Wolfe *et al*. 2011), which can also yield new insights into environmental processes, changes, and impacts at local and regional scales (Huntington, Gearheard, & Holm 2010; Kokelj *et al.* In Press).

PPM in consultation & co-management

In the NWT, effective community consultation is a key aspect of environmental assessment and management (Usher, 2000). Ongoing community consultation is a fundamental aspect of the PPM protocol, used to identify priority regions to monitor, and the community's most knowledgeable persons to work with. The web-based map of TEK also provides a useful tool for community organizations because it archives TEK (observations, and concerns) that could help local community organizations effectively communicate TEK with other stakeholders.

TEK has been used in co-management in Arctic research in a variety of ways. Some examples include: monitoring and management of bowhead whales (Freeman, Wein, & Keith 1992; Koski *et al.* 2005; Noongwook, Huntington, & George 2007), population assessment and the management of beluga whales (Adams, Frost, & Harwood 1993; Harwood *et al.* 2002; Hammill *et al.* 2004; Fernandez-Gimenez *et al.* 2006; Carter & Nielsen 2011), estimating herd size, and monitoring caribou herd health (Ferguson, Williamson, & Messier 1998; Kruse *et al.* 1998; Thorpe, Hakongak, & Eyegetok 2002),

monitoring changes in sea ice cover and thickness (Gearheard *et al.* 2006; Laidler 2006; Huntington *et al.* 2009; Kruipnik *et al.* 2010; Laidler *et al.* 2010; Pulsifer *et al.* 2010; Andrews 2011; Gearheard *et al.* 2011).

Interviews with potential map users indicate that the PPM method could facilitate additional uses of TEK in co-management. In the ISR, co-management boards with Inuvialuit representation [Fisheries Joint Management Committee (FJMC), and the Wildlife Management Advisory Council (WMAC) etc.], are tasked with using both Science and Inuvialuit TEK in decision-making. In this process, the ability of Inuvialuit hunter and trappers to influence decisions is dependent on the effective communication of Inuvialuit participants at the co-management board meetings. Inuvialuit cultural experts (Chapter 2) and participants in this research stated that the PPM method provides a powerful tool that HTC members, and Inuvialuit Game Council members could use to communicate TEK at various co-management board meetings. Several interview participants mentioned the web-based map could potentially be used to identify areas where development projects should be avoided.

The following hypothetical scenario is intended to demonstrate the how the PPM method and web-based map could be used to share TEK in the co-management process. Upon returning from a hunting trip, an Inuvialuik hunter from Inuvik informs a member of the Inuvik HTC (IHTC) about a landslide that the hunter noticed during his time on the land, noting its large size, its recent origin, and proximity to some cabins. Following up, the IHTC office sends a knowledgeable expert and youth to the site to document the observation using the PPM protocol. Once the observation has been documented, the

digital tools get returned to the IHTC office, and the observers are interviewed by the IHTC community liaison. Student researchers at the University of Victoria and Aurora College (Inuvik) transcribe the interviews, geo-reference the photos, attach the observer narrative (interview text) and organize the observations using to the web-based map [http://mapping.uvic.ca/mackenziedelta].

Later, at a workshop in Inuvik, the map is projected onto a wall using a digital projector, and HTC members, northern scientists, and local land users review the mapped observations. At this time priority observations, (such as the landslide) are identified and discussed. Priority observations are then presented to the relevant co-management groups, who share the web-based map with other researchers, and decision-makers. By making the web-based map accessible, co-management group members could also review the map prior to the meeting. Decisions could then be made about conducting additional research, or developing adaptation/mitigation strategies. Community HTCs have regular monthly meetings, and the Inuvialuit Game Council, and the five co-management groups have meetings no less than 4 times a year (Snow 2011). This creates the potential to have TEK presented to decision-makers in a timely manner.

To increase the utility of TEK in environmental decision-making there is a need for more effective cross-cultural communication (Prober, O'Connor, & Walsh 2011). Our experience with the PPM protocol suggests that it has the potential to facilitate effective communication between Inuvialuit land users and other northern environmental stakeholders.

In environmental management frameworks, adaptive feedback process that include sharing information among stakeholders can facilitate adaptation to local and specific circumstances, making management more effective over time (Berkes 2007). The adaptive feedback process that allows for institutional learning in several of the Inuvialuit co-management bodies have been recognized as an important part of the co-management framework (Berkes *et al.* 2007). Our findings indicate that a key strength of the PPM method is the flexibility of the PPM protocol, allowing for it to be adapted to meet dynamic and community-specific goals.

Challenges and successes

Overall, our findings indicate that the PPM method is useful for northern research and decision-making. However, both interview participants and our field experience suggest that several important challenges must be overcome before PPM can be deployed more widely.

151 observations were recorded during the PPM pilot, representing only small subset of the region, and local experts. Extensive areas of the research area were not included for sampling, and the mapped observations are by no means comprehensive. One of the long-term goals of the project is to increase the sample size of observations over time, and return to visit previously documented sites to compare conditions.

A key challenge in ensuring the long-term sustainability of a PPM monitoring program is ongoing financial support. In the ISR continued monitoring would require a dedicated project coordinator to facilitate training for monitors, organize field outings, manage digital media, and maintain the web-based map. Additional funding would also be required for compensating local monitors, and to maintain ongoing and effective community participation in project planning and implementation.

While every effort was made to document and communicate TEK as clearly and explicitly as possible, there always remains the chance that the knowledge is misrepresented. As discussed above, accurately documenting, representing, and communicating TEK is a complex task. Once the TEK is documented and uploaded into the web-based map, it is important that the TEK is used at the appropriate and intended scale. As described above, every effort was made for users of the web-based map to understand that the TEK in the map is inextricably linked in the Inuvialuit cultural and geographical context. If used outside of this geographic or cultural context, value and meaning (integrity) of the TEK can become abstracted or misrepresented (Wohling, 2009). This is a risk when making such a web-based knowledge sources public and widely available. We acknowledge that some types of TEK are not easily documented with photographs even when combined with a photo narrative. Aporta (2010) noted that by singling out one aspect of Indigenous knowledge (in our case observations and knowledge of environmental conditions) programs could fragment a more comprehensive understanding of life or reality. Based on interviews with cultural experts (Chapter 2), we believe that by employing visual, oral, and spatial communication methods and

focusing on communicating environmental observations, we were able to accurately document TEK. Future monitoring using the protocol will integrate video interviews of knowledge holders speaking to observations in situ. The addition of video interviews may also help to document observations not easily documented with still photography. Digital multimedia has been highlighted as a valuable addition to a communication strategy because these media can add contextual information, that is particularly useful with Indigenous groups who have a strong oral culture and traditions of experiential learning (Aporta 2009; Pulsifer *et al.* 2010).

Other challenges associated with the web based-map that should be addressed include simplifying the complex user web-mapping interface, and slow and inconsistent northern Internet connections. Current manual data management practices (organizing and geo-referencing observations, transcribing interviews, editing digital media, etc.) are time intensive. Streamlining and simplifying these processes will likely be required to sustain ongoing monitoring. Finally, intellectual property rights protection of TEK is another key issue that needs to be addressed. This is discussed in more detail in Chapter 2.

In this research we examined the potential of the PPM method to contribute to northern research and decision-making. Our findings indicate that the PPM protocol and web-based map can facilitate community consultation, knowledge transfer, and contribute to environmental impact assessment. This research is timely. With growing impacts from environmental change and development, access to accurate and useful information is extremely important in environmental decision-making, research, and monitoring.

Study interview participants

Ondrack, John (2011)
Racher, Kathleen (2011)
Harwood, Lois (2011)
Lange, Mark (2011)
Kokelj, Steve (2011)
Perry, Nelson (2011)
Snow, Norm (2011)

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Appendix 1
Interview questions: Northern researchers & decision-makers

1. Can you please tell me a little about yourself?
2. To what extent is this type of map, and the information it contains, useful for northern ecosystem/resource management? Why or why not? PICK examples from the map - slumping - roads? erosion - community planning? drained lakes? for harvest management plans?
3. Are there issues that make the broad-scale application of this information problematic? [Is there enough information? How do we know it is reliable? Is it systematic?]
4. How might these issues be overcome?
5. What would it take for this mapping strategy to inform northern policy and decision-making?
6. Could this map be integrated with other forms of knowledge? (Ex. GIS data about wildlife, water quality info, etc.?)
7. What are the maps shortcomings. [Web-interface? Web-speed? Integration with existing geo-databases?] How might these be overcome?
8. What would it take for this monitoring protocol to be adopted by used in other context - FJMC, WMAC's , Environmental Assessment's etc? (Environmental impact screening committee, environmental impact review board, fisheries joint management committee, wildlife management advisory council (NS), wildlife management advisory council (NT). etc)
9. Could others in government contribute to this initiative (INAC inspectors, field biologists, other scientists, etc.)?

10. Are the observations in the web-based map organized in a useful way? How could it be made better?
11. How should ownership and access to this type of knowledge be managed?
12. Who else should I consult with about these questions? Northern decision makers?

Chapter 4

Conclusions

Introduction

In remote northern regions, knowledgeable land users are in a unique position to assess changes in regional environmental conditions, inventory cumulative impacts, and make a valuable contribution to northern planning. This research took place in and around the Mackenzie Delta Region (MDR) in the Northwest Territories. It is well documented that like many other Arctic regions, the MDR is undergoing environmental change, the pace of which expected to quicken with ongoing climate change and increased infrastructure development (Weller *et al.* 2005; Burn & Kokelj 2009; Prowse *et al.* 2009; Pearce *et al*. 2011). The rate and scale of these changes create significant uncertainty regarding the future of northern livelihoods, traditional lifeways, and the ecological integrity of the MDR. To navigate this uncertain future, it is essential that effective environmental monitoring and research strategies be used to inform good decision-making and planning.

In the MDR, federal legislation requires that TEK be considered in northern ecosystem management and decision-making. At this point in time there is no systematic strategy to document or communicate TEK. The overall goals of this research were to 1) contribute to the development of a systematic and long-term strategy for recording, documenting, and communicating TEK related to local environmental change, and 2) to develop a tool that is useful for northern planning, decision-making, and research. To do this we collaborated with the Hunter and Trapper Committees of Inuvik, Aklavik, and

Tuktoyaktuk and the NWT Cumulative Impacts Monitoring Program (CIMP) to develop and test an environmental monitoring program based on Inuvialuit TEK. This chapter brings together key findings from the two research papers contained in this thesis (Chapters 2 & 3), discusses the future of the PPM method in the MDR, and presents conclusions of the project as a whole.

The participatory photo-mapping pilot project

In Chapter 2 of this thesis the participatory photo mapping (PPM) method was field-tested and evaluated by 16 Inuvialuit participants for its ability to document and communicate Inuvialuit environmental observations in a culturally appropriate manner. The findings of this research indicate that the PPM protocol is compatible with contemporary Inuvialuit culture, and is capable of documenting, sharing, and contextualizing Inuvialuit TEK. Participants identified that a key strength of the monitoring protocol was its compatibility with the Inuvialuit cultural activities and traditions of storytelling, travelling, and teaching. Overall, this research highlights the effectiveness of using visual and participatory research methods to document and communicate TEK. The PPM method was also successful at engaging Inuvialuit experts and youth in land-based environmental monitoring. The PPM method was designed to incorporate community-established goals such skills development, getting people out on the land together, and knowledge transfer to northern youth from elders and experts. We worked collaboratively towards these goals, which contributed to the success of the monitoring method. To our knowledge this project represents the first effort to engage

local youth and experts in the use of participatory photography and mapping as a strategy for long-term environmental monitoring.

The PPM monitoring program described in this thesis has enormous potential to assist with the documentation and communication of TEK and contribute to a range of community driven initiatives. This work also shows that the method can also contribute to the development of local capacity to monitor, understand, and communicate environmental changes among stakeholders.

Focusing on TEK in northern natural resource management

Chapter 3 explored the potential of the PPM method to contribute to northern environmental decision-making, research, and management. To this end, the PPM method was evaluated by seven key informants. Based on this work we conclude that PPM method can: 1) contribute to northern decision-making, 2) facilitate knowledge transfer among northern stakeholders, 3) facilitate community consultation, 4) contribute to environmental impact assessment strategies, and 5) monitor environmental change.

Research in Chapter 3 also identified several challenges and limitations that need to be overcome before the monitoring protocol could be implemented widely, specifically: 1) simplifying the web-based mapping interface, 2) intellectual property rights issues need to be addressed, and 3) long-term project funding needs to be secured.

In the Northwest Territories, there are rules and regulations governing research, and all research must be licenced. One of the regulations requires that TEK researchers consult with the local Hunter and Trapper Committees (HTCs). As such, the PPM protocol testing and development involved close consultation with the Mackenzie Delta CIMP steering committee, and the local HTCs, the members of which recommend participants to work with, and local environmental conditions and/or concerns do document. Both organizations are male dominated, which may have contributed to the skewed gender representation (mostly male) of participants in the study. Participant selection and the environmental observations documented in this research were influenced and limited by the members of the HTCs and the Mackenzie Delta CIMP steering committee. The influence of this, and other political and cultural factors, on the information recorded by the PPM protocol should be examined in more detail in future research.

Overall, based on the interviews conducted, we found that the PPM method was culturally appropriate, and that it was able to communicate complicated knowledge and observations among multiple stakeholders. Chapter 3 of this research highlights that the PPM method fits well and could contribute to ongoing research efforts and existing structures that use or document TEK in the MDR. The methods tested in this project were cautiously designed through a consultative process with the appropriate community representatives, with the intention of accurately documenting TEK, while simultaneously protecting and respecting the TEK, and its holders. However, important questions related to the web-based mapping of the observations remain unresolved, and should to be the focus of further investigation, specifically: will the safeguards put in place to protect the

TEK and its holders? Compromise the control, ownership, or use of the TEK or observations? And do the methods increase the risk of appropriation of the TEK by others?

Future of the PPM method

Based on the results of this pilot study, project partners have committed to continue using the PPM method to monitor environmental change using TEK. Funding support from CIMP in 2012, allowed the project to conduct the first winter monitoring using this protocol (Figure 4.1). Issues identified for winter monitoring by the project steering committee include: extreme weather, landscape change impacting infrastructure, wildlife, and travel. Specific examples include: more severe and unusual winter windstorms damaging cabins around Kugmallit Bay. Winter sea-ice push-up damage has been reported at several islands in the outer delta. Slumping of the East Channel of the Mackenzie River near the proposed pipeline crossing north of Swimming Point has also been identified. Several drained lakes in the delta lowlands near Aklavik, are thought to be driving changing ice conditions that are impacting fur-bearers. In the spring and summer of 2012/2013 monitors will investigate thaw slump erosion and decreasing water levels in the Husky Lakes and Parsons Lake, and the dramatic environmental change taking place along the north shore of the Tuktoyaktuk Peninsula. Changes to this landscape, including the erosion of important landmarks, have increased the difficulty and danger associated with travel in the region. These changes are also threatening several culturally important sites.

In 2012, monitoring efforts will have an increased emphasis on conducting video interviews with elders and experts while on the land. The addition of video may be useful for documenting observations not easily captured with still photography, and for documenting elders speaking in Inuvialuktun. Such observations could be useful for educational purposes for local community members, other northerners, and other researchers (anthropologists, ethnoecologists, ethnomusicologists, social geographers, etc.) (Sakakibara 2009). The addition of video to PPM however, could significantly increase the demands on time and resources for editing and media management, and be increasingly difficult to upload and stream (view) with slow or inconsistent Internet connection speeds. In addition to these observations of environmental conditions, we hope to document other land-based activities such as travel and navigation using PPM. We also hope to include traditional place names in future editions of the web based-map.

A long-term goal of this project that was suggested by participants in Chapter 2 is the integration of the PPM method into ongoing northern outdoor education activities (such as the annual Horton River paddle trip) and into northern high school and collage curriculum. This would involve working closely with northern education administrators and instructors. Collaborations with the Aurora Collage in Inuvik could also be possible because a certificate program in environmental monitoring is offered.

Figure 4.1 Winter participatory photo-mapping is scheduled to take place in the Mackenzie Delta Region in March, 2012. In this photo the Garmin (GPSMap 60cx) GPS units are being tested in winter conditions near Inuvik, NWT. Photo: T. D. Bennett, 2012.

In November 2011, Chapter 2 of this thesis was presented at an ELOKA workshop (Exchange of Local Observations and Knowledge of the Arctic) in Boulder, Colorado, USA. At the ELOKA workshop researchers and northern Indigenous peoples met to discuss strategies for documenting local observations, sharing knowledge, and the creation of networks that link local experts with scientists and global experts. The organizers of the ELOKA workshop have organized a special issue of Polar Geography to publish the papers delivered at this workshop. Chapter 2 of this thesis was submitted to the Polar Geography Journal for peer review in March 2012. At the same time, this research was also presented at a symposium in Yellowknife examining the successes and challenges associated with community-based monitoring in the Arctic (Lantz, Bennett,

and Esagok 2012). The results of this symposium are being summarized in an AANDC discussion paper. In April 2012, I will present research from Chapter 3 in a session entitled 'From Knowledge to Action' at the IPY (International Polar Year) conference in Montreal, Que. These presentations have generated considerable interest from other northern communities, government, and academic researchers interested in pursuing similar monitoring.

Crossroads

The primary focus of this work was to explore a method of documenting TEK related to environmental observations with the intention of informing northern resource and ecosystem management (impact monitoring), environmental change research, and planning. However, this research also makes it clear that PPM method can be used for other applications. Many of the participant observations relate to traditional Inuvialuit culture. As such, there is also potential to integrate PPM activities into northern education and cultural programs, focused on recording and archiving cultural practices, techniques, traditional language, place names, and land use practices. While the most comprehensive information is likely to come from a program that pursues these objectives simultaneously, each objective may demand a different organization and communication strategy (Bonny & Berkes 2008. Decision-makers and planners are interested in quickly accessing information that can inform decision-making. Conversely, when documenting cultural knowledge for educational purposes it is likely more appropriate to use video interviews to document activities, practices, and stories spoken in Inuvialuktun.

Ultimately, the greatest potential for PPM activity to be sustained in the North is for it to be adopted by local community-based organizations. In this setting, there is potential for PPM to be used comprehensively in areas of local importance under the control and ownership of local peoples. In the spring of 2012, we began another pilot effort, which consisted of providing PPM kits (camera, GPS unit, and instructions) to each hunter and trapper committee (Inuvik, Aklavik, and Tuktoyaktuk). Inuvialuit land users who document observations of the environment on the land using the provided tools will be provided with financial compensation for fuel. Our work with Inuvialuit cultural experts shows that PPM efforts could be sustained through integration into local school curriculum, and supported by effective research and community partnerships. In this context PPM shows great promise.

Overall, this research has generated considerable interest and our pilot protocol has been very well received as an effective way of drawing on TEK in environmental monitoring. Ultimately, the flexibility of the PPM method will allow communities to employ it as they see fit, balancing the emphasis on environmental and broader cultural knowledge.

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