

Briefing Note

The Polar Data Catalogue: A Vehicle for Collaboration, Northern Community Partnerships, & Policy-Making

Dana L. Church, Julie E. Friddell & Ellsworth F. LeDrew

In 1996, eight countries came together to form The Arctic Council, which is:

“ . . . the leading intergovernmental forum promoting cooperation, coordination, and interaction among the Arctic States, Arctic Indigenous communities, and other Arctic inhabitants on common Arctic issues, in particular on issues of sustainable development and environmental protection in the Arctic” (<http://www.arctic-council.org/index.php/en/about-us>).

The eight member countries of the Arctic Council are: Canada, the Kingdom of Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States. The Arctic Council also includes Permanent Participants, which are organizations representing Arctic Indigenous peoples, as well as Observers, which are non-Arctic states and other organizations wishing to participate. The work of the Arctic Council is mainly carried out by its six Working Groups, in the form of regular, scientific, comprehensive, cutting-edge assessments. These assessments cover diverse issues within the domains of environmental, ecological, and social sciences, and have strong influence on policy development. Due to the impact of these scientific assessments, the Arctic Council has been referred to as a “cognitive forerunner” (Nilsson, 2012). Indeed, a 2012 survey found that the Arctic Council’s scientific assessments by its Working

Groups were considered its most effective “products” (Kankaanpää & Young, 2012). Thus, although the Arctic Council may not have legal prowess, it has been influential through its “soft” power (Nilsson, 2012), which is “the ability to get what you want through attraction rather than through coercion” (Nye, 2004).

Around the same time that the Arctic Council was established, a number of researchers in Canada recognized the importance of storing and archiving Arctic data in accessible formats, rather than leaving the data to rest forever in the depths of personal filing cabinets or in outdated software programs. As a result, the Canadian Cryospheric Information Network (CCIN) was born. Spearheaded by Professor Ellsworth LeDrew at the University of Waterloo, Ontario, and in partnership with the Canadian Space Agency, Environment Canada (now Environment and Climate Change Canada), Natural Resources Canada, and Noetix Research Inc., the CCIN archived and publicly provided metadata and datasets contributed by cryospheric scientists associated with the CRYSYS (CRYosphere SYStem in Canada) program and other research programs in Canada. In addition to data archiving services, the CCIN has maintained an educational website for the public, scientists, and policy makers (www.ccin.ca) that includes snow water equivalent (SWE) maps for the Canadian Prairies and northern Canada, children’s games, photographs and videos, an “Ask an Expert” service, links to newsletters and publications, and interactive visualizations of SWE and lake ice data that have been developed in partnership with the Global Cryosphere Watch of the World Meteorological Organization. Content for the website is guided by a Scientific Advisory Council composed of experts in cryospheric research and data management (CCIN, 2015a). As will be discussed, over the years, the increased need for safe storage and accessibility of Arctic data led the CCIN to develop the Polar Data Catalogue (PDC).

The overlap between the Arctic Council—a forum for cooperation, coordination, and interaction among Arctic States, Arctic Indigenous communities, and other Arctic inhabitants—and the PDC—a “forum” for data availability, accessibility, and preservation—is the focus of this paper. We will show how the PDC can be a vehicle for collaboration, Northern community partnerships, and policy-making, which aligns with the objectives of the Arctic Council. The PDC has been, and continues to be, a valuable resource for the Arctic Council. There is opportunity to strengthen the relationship between the PDC and the Arctic Council, so that the PDC can support and further solidify the Arctic Council’s reputation as a “cognitive forerunner” in Arctic policy development.

History and Background of the PDC

When the CCIN was established in the mid-1990s, there was growing interest in Canada’s Arctic regions and, as a result, a wealth of Arctic data was beginning to accumulate. There was also growing acceptance of the concept of open access to data (Science International, 2015). Open access allows data to be explored and used in ways beyond that for which it was originally intended, and, in regards to Arctic data in particular, open data provides the opportunity to make new predictions, new discoveries, and hopefully new solutions to climate change and other challenges. The CCIN was a response to these two needs: the need to archive the increasing wealth of Arctic research data, and the need to make this data available to researchers, policy-makers, and the public—especially northern communities where the research was taking place.

The CCIN website and repository services had been in existence for almost a decade when the ArcticNet Network of Centres of Excellence of Canada was established in 2004. ArcticNet is a symbol of the gaining momentum of interest in the Arctic regions: it includes over 150 researchers, 1000 graduate students, postdoctoral fellows, research associates, technicians, and other specialists from 34 Canadian universities, 20 federal and provincial agencies and departments, and more than 150 partner organizations across 14 countries, all working toward the common goal of understanding the impacts of climate change and modernization in the coastal Canadian Arctic (www.arcticnet.ulaval.ca).

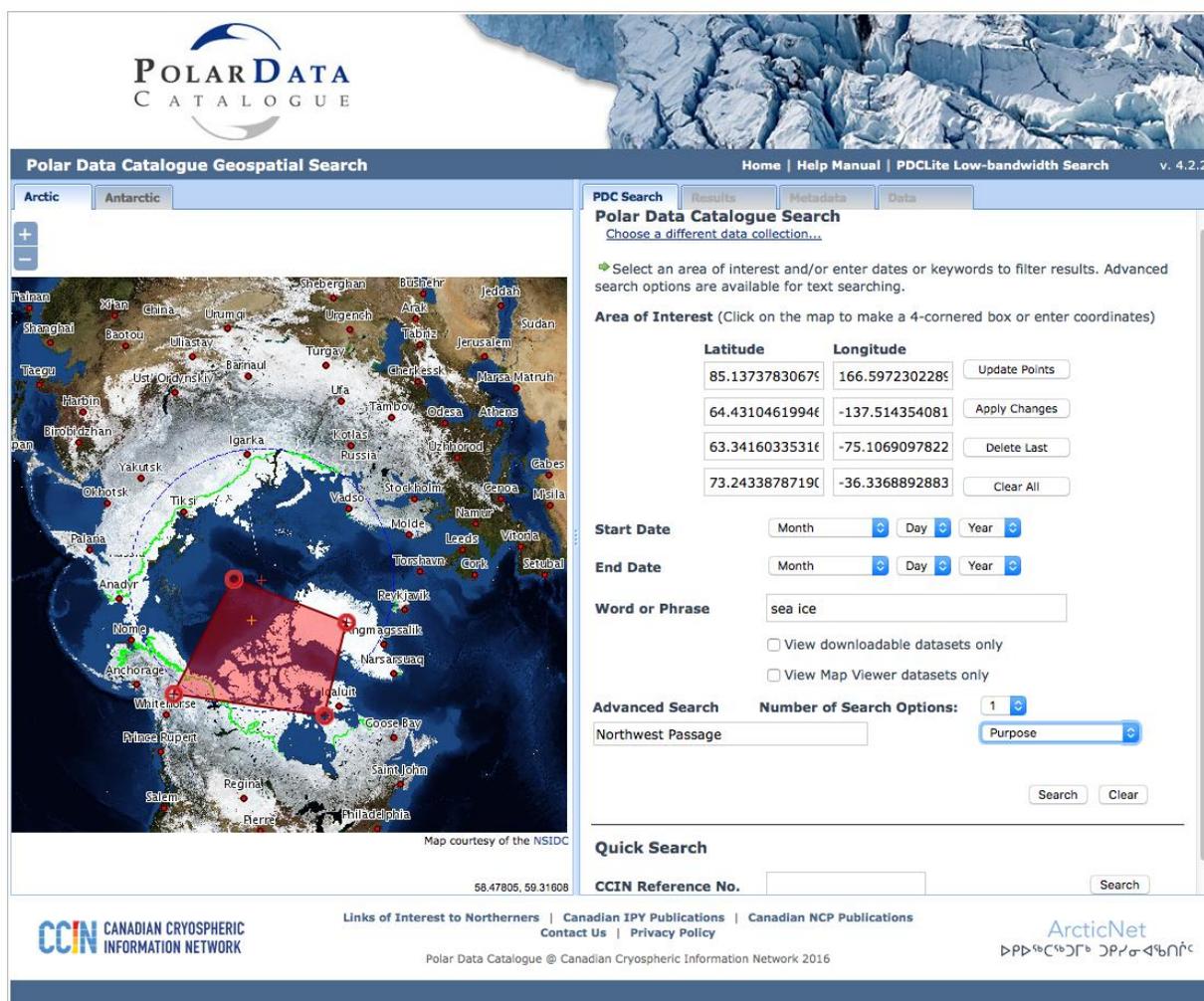
ArcticNet researchers recognized the necessity to provide an online data management system for scientists to archive information about their datasets, and to give the public a means to access them, especially northern residents where the research was occurring in their backyards. Up to this point the CCIN had been archiving data for cryospheric scientists associated with CRYSYS and other research programs in Canada. When ArcticNet identified the CCIN as a data repository for its multitudes of research projects, the CCIN needed to significantly upgrade its data management capabilities and infrastructure. This was eventually made possible by partnerships between the Government of Canada Program for International Polar Year, Noetix, and the Department of Fisheries and Oceans Canada. The resulting product was the Polar Data Catalogue (PDC; www.polardata.ca). Launched in 2007, the PDC was initially developed as a metadata-only “discovery portal” to allow for the exchange of information about datasets between researchers, Northern communities, international programs, decision makers, and the interested public (CCIN, 2015b). In 2011, functionality was added to archive and share data files to accompany the rapidly growing metadata collection. As of June 15, 2016, the number of metadata records in the PDC has reached 2,443. We also hold over 2.6 million data files, including almost 28,000 RADARSAT images of northern Canada and Antarctica. Partnering with ArcticNet also led to the addition of social science research into the catalogue, which is a collection that continues to grow today.

The PDC as a Vehicle for Collaboration

Collaboration between the Arctic States is one of the main objectives of the Arctic Council. The Arctic Council addresses this objective by providing a forum for collaboration. When Arctic Council members convene to discuss issues such as sustainable development and environmental protection in the Arctic, information is key. Where and how they get their information is of utmost importance, for policy is only as good as the data upon which it is based.

The PDC promotes collaboration by being a publicly accessible metadata “discovery portal” upon which informed discussions and decisions about the Arctic can be based. Metadata records provide the description of research: the who, what, where, and when of the data. The records also include the funding program and the formal citation of the dataset for use by others (CCIN, 2015b). Figure 1 is a screenshot from the PDC of an example of a metadata record.

Figure 2: The PDC Geospatial Search application. The main search interface is shown with a sample search area (polygon) on the map.



Another PDC application, the PDC Lite Search, was developed in 2012 as a result of user feedback. A survey of northern Canadians, commissioned by ArcticNet, revealed that users with low-speed Internet connections—which are very common in northern Canada—often experienced long waiting times when using the full-featured PDC Search application. In response, PDC Lite is up to 90% faster than the full-featured PDC Search and has a different search interface focused on community-specific project investigation (see Figure 3). In the future we will continue to work with our northern partners and with northern community members to improve the PDC Lite to serve their specific needs for data and information (Friddell, LeDrew, & Vincent, 2014a; Friddell, LeDrew, & Vincent, 2014b).

The third PDC online application is PDC Input: a metadata and data entry application that scientists and research groups use to submit the metadata and data they have collected into the PDC. Figure 4 shows a screenshot of the new PDC Input front page that was launched in August 2016. Compared to the former PDC Input, the new PDC Input has been completely rebuilt using the latest web technologies and tools, features enhanced security for users, is fully mobile enabled, and the second version to be released later this year will be bilingual in English and French.



POLAR DATA CATALOGUE

Home Keywords Help Register for PDC Forgot Password Email Password Sign In

PDC Input

The PDC Data and Metadata Input application provides an interface for researchers in partner programs and organizations to upload and share data with other scientists and the general public. Log in above to submit your metadata and data to the PDC repository.

The Polar Data Catalogue is a searchable database of metadata and data that describes and provides access to data and information produced by Arctic and Antarctic researchers. Launched online in 2007, the PDC contains thousands of datasets, satellite images, and links to other polar data archives for use by scientists, decision makers, and the public. The PDC metadata records follow ISO 19115 (North American Profile) and Federal Geographic Data Committee (FGDC) standard formats to facilitate discovery and exchange with other data centres. The scope of the research in PDC covers a range of disciplines, from natural sciences to policy to health and social sciences.

METADATA: Metadata is data about data. Metadata provides the what, where, when of data and by whom it was collected, as well as its current location. Metadata facilitates the understanding, use, and management of data and is a tool for networking and collaboration. Standardized metadata allows automatic interoperability and sharing of information between polar data repositories around the world.

Background

The wealth of knowledge and data generated by polar research must be managed, to ensure and maximize the exchange and accessibility of relevant data, and to leave a lasting legacy. The Polar Data Catalogue was developed as a collaborative effort between the ArcticNet Network of Centres of Excellence, Aboriginal Affairs and Northern Development Canada, the Department of Fisheries and Oceans Canada (DFO), and the Canadian Cryospheric Information Network (CCIN) to facilitate exchange of information about the Canadian Arctic among researchers and other user groups, including northern communities and international programs. For more information about the organizations and agencies participating in PDC development, including programs which have contributed metadata and data to the PDC since 2007, click [HERE](#).

Our Sponsors

CCIN CANADIAN CRYOSPHERIC INFORMATION NETWORK

UNIVERSITY OF WATERLOO

ArcticNet

Noetix Research

Centre d'études nordiques

CSA ASC

IPY API International Polar Year / Année polaire internationale

Canada

Environment and Climate Change Canada

Environment and Climate Change Canada

Fisheries and Oceans Canada

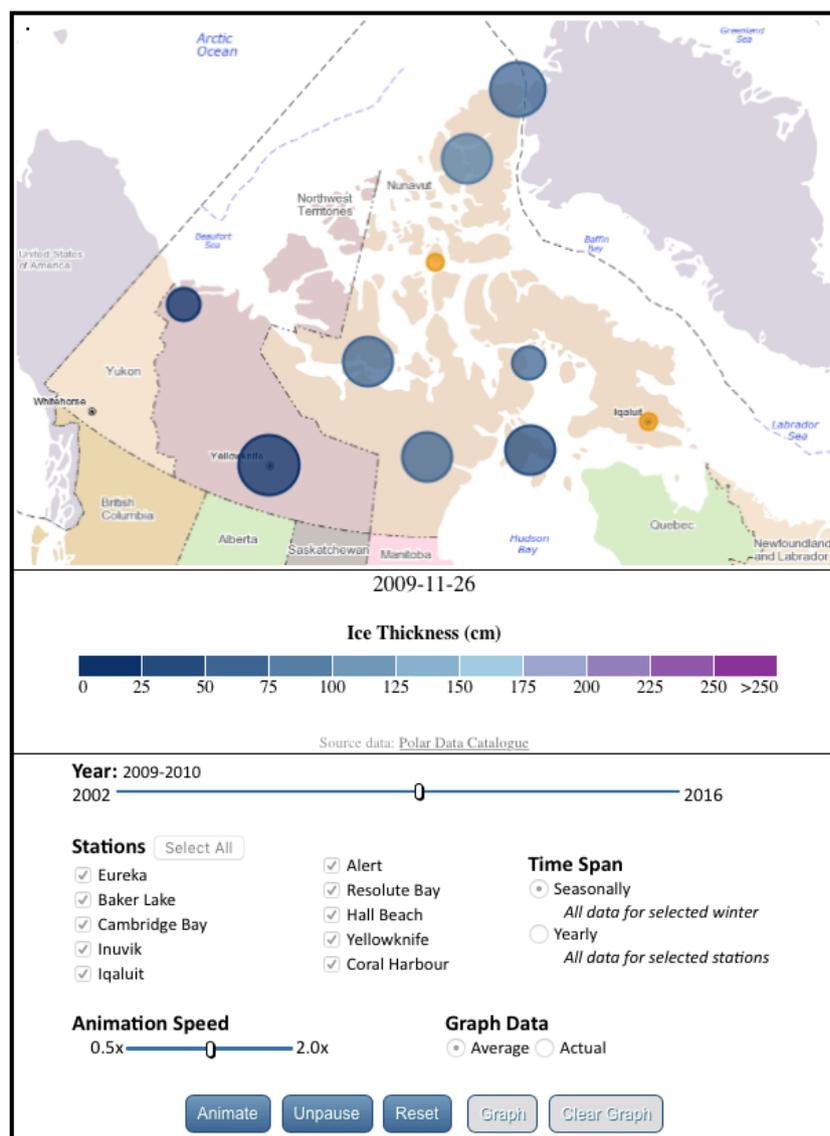
Niches of Oceans Canada

Aboriginal Affairs and Northern Development Canada

The Arctic and Antarctic metadata and data repository for Canada

A new data visualization tool in the PDC (<https://ccin.ca/home/ccw/seaice/current/thickness>) shows the Canadian Ice Service's (CIS) Ice Thickness Program Collection (ITCN) data (2002-present). The visualization of ITCN data displays sea and lake ice thickness graphically, via both an animation (where the stations on the map change color as ice thickness changes over the winter) and graphs (which provide a snapshot of thicknesses for all stations over a winter or over the full range of years). The animation (Figure 5) shows evolution of ice thickness over the winter, and the graphs provide a visual comparison of sea ice trends of different stations.

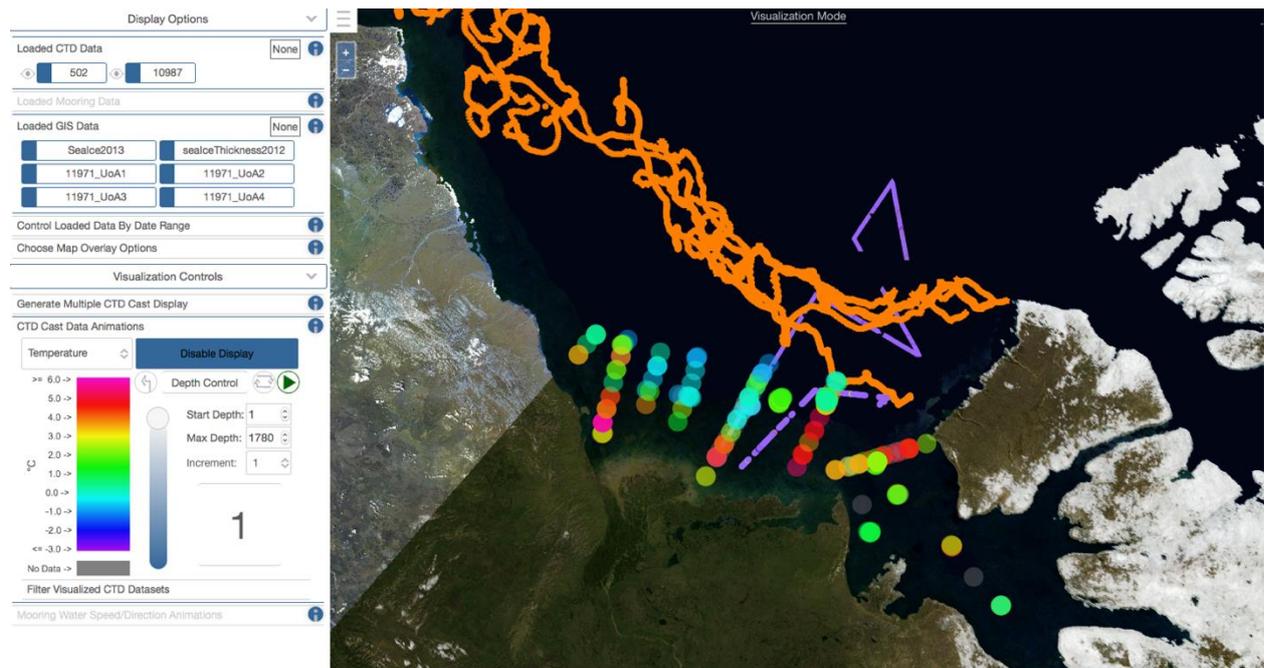
Figure 5: The Ice Thickness Program Collection data visualization tool. Shown is ice data with the animation paused.



A new Map Viewer data visualization graphically displays oceanic and sea ice data from the Arctic: https://www.polardata.ca/pdcsearch/PDC_ViewMapApp.ccin?ccin_datasets. This Map Viewer (Figure 6) is integrated into the PDC Search application and has recently been expanded to incorporate datasets of long-term oceanic observatories. Other data visualizations are easily accessible through the CCIN homepage, such as for snow water equivalent (SWE) and lake ice cover. We plan to continue developing visualizations of pertinent cryospheric data so that information about Canada's North can be more readily available to those who seek it.

It should be noted that the scientific assessments by the Arctic Council's Working Groups, such as the 2011 Snow, Water, Ice, and Permafrost ("SWIPA") report (AMAP, 2012), have the similar goal of making Arctic research and research findings more accessible to scientists, policy makers, and the public. These plain-language, illustrated reports are available online to whomever wishes to access them. Our online visualizations aligns with the work of the Arctic Council and can be used as supplementary information to that which is found in a number of their reports.

Figure 6: Screenshot of the Polar Data Catalogue's new Map Viewer data visualization, showing sea ice and oceanic data in the Beaufort Sea.



Another major focus of the PDC toward collaboration is through its linkages and interoperability with other data repositories around the world. One of the lessons learned from the International Polar Year (IPY), was that given the diversity of data needed to understand a system as complex as the Arctic, a “one-stop shop” data repository can become unwieldy and perhaps be impossible to implement. Instead, a “data bazaar” is preferable, in which a federation of specialized data systems and portals uses open web services to communicate and provide data to users (Mokrane & Parsons, 2014; Parsons et al., 2011). The PDC is one of these “vendors” in the online bazaar of polar data.

Interoperability is required for this online “bazaar” of polar data to be successful. Interoperability means that all the different “vendors” (i.e., data repositories or catalogues) must be able to network and work together: to communicate with each other, execute programs in common, and transfer metadata. If two data repositories are interoperable, this means that users can search for metadata in either repository and find the same result; each repository accesses the same metadata entry instead of each having to enter its own copy into its collection. Thus, standardization of metadata is important: users can expect the same type of information, labeling, and formatting of metadata entries regardless of the repository in which they are searching (Neiswender & Montgomery, 2009). The PDC conforms to international metadata standards and we require metadata and data contributors to abide by our Best Practices guidelines (Michaud & Friddell, 2011). Readers interested in more details about the standards and Best Practices are directed to Friddell, LeDrew, and Vincent (2014b).

The PDC’s metadata sharing efforts have focused on extending and solidifying linkages with polar data portals in Canada and abroad. At this time, PDC metadata are provided for harvesting by other repositories in three different internationally standardized web services protocols: OAI-PMH (Open Archives Initiative - Protocol for Metadata Harvesting), CSW (Catalog Service for the Web), and WMS (Web Map Service of the Open Geospatial Consortium). We have established one-way or two-way sharing links with the portals listed below:

- Northwest Territories Discovery Portal, Cumulative Impacts Monitoring Program
- Environment and Climate Change Canada
- Scholars Portal/Ontario Council of University Libraries
- Circumpolar Biodiversity Monitoring Program (CBMP), Conservation of Arctic Flora and Fauna (CAFF)
- Arctic Data Centre, Norwegian Meteorological Institute
- National Institute of Polar Research, Japan
- British Antarctic Survey
- National Snow and Ice Data Center (NSIDC), United States
- Arctic Data Explorer, NSIDC
- Alaska Ocean Observing System
- Global Cryosphere Watch portal
- Australian Antarctic Data Centre

The PDC metadata collection has also been registered with the Canadian federal government Open Data website and the GEO/GEOSS Component and Service Registry (a metadata brokering system). Finally, metadata from the PDC can be accessed through the Alaska Ocean Observing System (AOOS - www.aos.org).

To summarize, the PDC aligns with the Arctic Council's goal of collaboration through its online applications (PDC Geospatial Search, PDC Lite, and PDC Input), its online data visualizations, and its interoperability with an increasing number of Canadian and international data portals. The PDC's resources support informed discussions not only between members of the Arctic Council, but also between members of northern communities, the interested public, scientists, policy-makers, and other decision makers.

The PDC as a Vehicle for Northern Community Partnerships

The Arctic Council promotes cooperation, coordination, and interaction among the Arctic states and Arctic Indigenous communities. A primary target audience for the PDC is northern and Indigenous Canadians. Many of our partners in northern communities have expressed the desire to know more about the research being conducted in the north, usually by southern Canadians. Although the data and information that these researchers collect in the natural, social, and health sciences are extremely useful to Indigenous peoples, it is often difficult to find or access. It is the goal of the PDC to better serve the people in Canada's northern communities by making data and information more accessible and available. This is particularly important as northern communities experience environmental and social change. One example in which the PDC serves Indigenous and northern communities is production of the PDC Lite application, described earlier, which is designed for areas with slower Internet speed. The PDC Lite also allows the user to search according to specific northern communities.

Academic and institutional research is not the only source of Arctic data. Indigenous peoples have vast data and information resources in the form of Traditional or Local Knowledge (TLK).

In order for Arctic data management systems to be complete, they must be capable of preserving and sharing TLK. However, TLK may not fit comfortably within Western research regimes (Scassa, unpublished) or metadata standards. TLK is a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Defined in this way, TLK is not just a collection of discrete pieces of knowledge; it is a knowledge system. TLK may be acquired and used in ways that are very different from Western systems of knowledge. We cannot expect that what is archived as TLK is complete, does not need additional context or interpretation, and can be analyzed and quantified (Scassa, unpublished). Thus, the archiving and access requirements of all research involving TLK may be considered on a case-by-case basis.

A primary knowledge gap in the polar data management community is an understanding of the capacity, interest, and concerns of Indigenous people in preserving TLK. This information can be sensitive and may require additional protections. What appropriate protections are needed? Do Indigenous people want to preserve the TLK in local repositories? And is there capacity to do so? For data management systems to meet the needs of Indigenous peoples, and to preserve TLK for future generations, the concerns, requirements, and capabilities of all partners must be understood (Pulsifer, Laidler, Taylor & Hayes, 2011).

To facilitate dialogue and collaboration with Northern and Indigenous people and partners, in 2015, CCIN/PDC, in collaboration with numerous partners, co-led two major data management meetings in Canada: the *Canadian Polar Data Workshop* and the international *Polar Data Forum II*. Representatives from the Inuit Circumpolar Council (ICC), an organization with Permanent Participant status in the Arctic Council, participated in both of these events, and the CBMP data management team attended the Polar Data Forum II (CBMP, 2015).

The aim of the *Canadian Polar Data Workshop* was to coordinate the growing polar data community in Canada and to develop and implement best practices and sustainability in data stewardship, including the ability of Indigenous people to steward their own data resources, particularly TLK. The *Workshop* was held in Ottawa in May 2015 and was attended by 50 participants. Relevant outcomes of the Workshop included:

- Explicit acknowledgement that TLK and some other northern and Indigenous data and information will need to be exempted from expectations of open data sharing, due to confidentiality or other concerns of sensitivity.
- Stated interest by Indigenous and northern participants in the Workshop, as well as participants in the national online pre-Workshop consultation, to participate fully in the coordination exercise.
- Acknowledgement of the need to improve “human interoperability”: that relationships should be strengthened through more extensive collaboration with northern and Indigenous people and communities. This can be facilitated by attendance at meetings through provision of funding support for travel, as well as holding meetings in northern Canadian communities.

The second meeting held in 2015 was the *Polar Data Forum II: International Collaboration for Advancing Polar Data Access and Preservation* (www.polar-data-forum.org). This major international conference was held in October in Waterloo, Canada, and was attended by over 110 participants from 18 countries. This meeting aimed to build collaborations and systems for long-term

preservation and access to data and information from the Arctic and Antarctic. Funding was secured to bring six people from Indigenous and northern communities and organizations to the Forum, to ensure in-person participation and input on northern and Indigenous perspectives. The University of Waterloo Aboriginal Student Association opened the Forum with songs and drums, and an Aboriginal Evening event included a local women's drum circle, a smudging ceremony, and locally sourced Indigenous foods. Key outcomes of the Forum included:

- Recommendation that incorporation of Arctic Indigenous perspectives is critical to the success of international polar data management.
- This may be accomplished through support for Indigenous participation in polar data activities, including increasing capacity for self-management of Inuit data and TLK.

We plan to continue discussions on data management with Indigenous and northern peoples by hosting a second *Canadian Polar Data Workshop* in early 2017. Additional plans for enhancing future collaborations include:

- Seeking partnerships and funding to build systems for managing project tracking and research licensing in northern communities;
- Adding language support for Inuktitut to the online PDC tools;
- Writing articles and news items about the PDC, our services, and the motivations and benefits of proper data management;
- Increasing use of the CCIN/PDC websites and social media accounts to enhance outreach and education about northern Canada to students and the public and to reach northern Canadians who seek data and information related to their communities;
- Expansion of metadata sharing with northern organizations;
- Listening to our northern and Indigenous partners to understand their needs related to data management and access to information;
- Providing expertise and infrastructure, as needed and as feasible, to our northern and Indigenous partners; and
- Using surveys and other methods to receive feedback on our websites and services, including our Facebook and Twitter sites.

We value the input of our northern and Indigenous partners and look forward to further feedback to ensure we are addressing northern needs through the PDC.

The PDC as a Vehicle for Policy-Making

Given the influence of the Arctic Council on policy, we seek to show here how the PDC directly contributes to the Arctic Council. The direct relationship between the PDC and the Arctic Council begins with the ABDS, the Arctic Biodiversity Data Service (ABDS - www.abds.is), which is a publicly searchable database. Included in this database is research conducted by CAFF, one of the Arctic Council's six Working Groups. CCIN has an ongoing, long-standing partnership with CAFF. The PDC stores metadata for the Circumpolar Biodiversity Monitoring Programme (CBMP), which is one of CAFF's programs (CBMP, 2015). As of May 2016, the PDC holds 189 metadata for the CBMP's Marine Group project inventory and 305 metadata for the CBMP Terrestrial Group. The ABDS actively harvests CBMP metadata from the PDC. In order to be housed at the PDC, this metadata must pass the specific standards outlined previously; thus, the PDC acts not only as a repository of metadata for CAFF but also as metadata quality control.

CAFF has produced a number of comprehensive, cutting-edge reports based on data housed in the ABDS, and thus harvested from the PDC. We are currently working to strengthen the PDC's existing relationship with CAFF as well as foster new relationships with the other Working Groups of the Arctic Council.

The PDC can be regarded as a vehicle for developing consistent policy between northern countries. Currently we are writing guidelines on data management requirements for a set of northern research and monitoring programs in Canada, and we are learning much from this exercise regarding unifying data management practice and expectations across programs. It will simplify work for researchers and data managers in all countries by making metadata and data requirements consistent. This same approach of consistent data policy could be applied across Arctic Council Working Groups and member states.

Summary, Recommendations, and Opportunities

The mid-1990s saw the birth of two “forums”: The Arctic Council, as a forum to promote cooperation, coordination, and interaction among the Arctic States, Indigenous communities and other northern inhabitants; and the CCIN—along with its later product, the PDC—as a “forum” for polar data stewardship, management, and access. The PDC has become a vehicle for collaboration, developing and strengthening northern community partnerships, and for policy-making, all in alignment with the objectives of the Arctic Council. The PDC is a vehicle for collaboration by providing open access to Arctic research metadata and data, data visualizations, and through interoperability with other data portals around the world. The PDC's network of interoperability and partnerships continues to grow, and opportunities exist for the PDC to serve other Arctic Council Working Groups, Task Forces, and Expert Groups. The PDC is a vehicle for policy-making, as evidenced by the archival of data used by CAFF, one of the Arctic Council Working Groups. Finally, the PDC strives to cooperate, coordinate, and interact with northern and Indigenous communities to discuss, discover, and address their data and information needs. Face-to-face dialogue was fostered through the *Canadian Polar Data Workshop* and the *Polar Data Forum II*, and work continues to develop a more “Indigenist” data management system (Pulsifer et al., 2011) that can adequately accommodate and preserve TLK and Indigenous science.

The Arctic Council has been described as a “cognitive forerunner,” in reference to its comprehensive, cutting-edge scientific assessments of Arctic issues that have been used for policy development and decision-making (Nilsson, 2012). In order for the Arctic Council to maintain this status, data management must be a priority. Indeed, a report released by CAFF (2015) entitled “Actions for Arctic Biodiversity” highlights the following future goals:

- “Develop tools for data sharing in order that data collected can be used by a wide range of people engaged in Arctic biodiversity science, policy, and management” (7).
- “Advance and sustain the Arctic Biodiversity Data Service (ABDS)” (11).
- “Establish the Arctic Biodiversity Data Service (ABDS) as the supporting framework to facilitate long-term data sharing and as a source of data for modeling and ecosystem-based management” (12).

Based on the PDC's successful archiving of metadata and data from CAFF and numerous other partners, there is opportunity for the PDC to assist the Arctic Council in fulfilling these goals, as well as opportunity to host data from other Arctic Council Working Groups, Task Forces, and

Expert Groups. Given that Canada is a Member State of the Arctic Council, and that the PDC is Canada's primary repository for polar data, the PDC is a viable option for providing future and enhanced access to relevant data for the Arctic Council's scientific assessment work. Further, given the maturing expectations of open access to data and the development of data stewardship requirements and policies around the world (Science International, 2015), the PDC is positioned to support the Arctic Council to ensure implementation of effective and consistent data policy across the Member States. Finally, as described earlier, efforts of the PDC, including providing access to information about research in northern communities and/or providing face-to-face meetings on polar data issues, provide a forum in which to increase the role of northern and Indigenous peoples in data management and decision-making. Of course, there are other organizations which are similarly positioned to provide service to the Arctic Council, and may already be doing so, with whom the PDC could form a coordinated network.

Recently there have been suggestions in the literature that the Arctic Council undergo various degrees of structural organization (Conley & Melino, 2016; Wilson, 2016). To our knowledge, the potential effects of reorganization on data availability and accessibility for the Working Groups, should it occur, have not been addressed. If the data management services of the PDC continue to be used by the Arctic Council, the intention of the PDC is to hold polar data in perpetuity, providing a safe and secure archive for data, regardless of the organizational structure or existence of the data contributor(s).

This paper has discussed how the PDC embodies the same goals as the Arctic Council. However, from the opposite angle, the Arctic Council can also be a vehicle for data stewardship, by providing a transformative opportunity for the views, needs, and information of its northern and Indigenous partners to be served by the technical advances in modern data management.

Science International (2015) has stated that, "Openness and transparency have formed the bedrock on which the progress of science in the modern era has been based" (4). Yet it is not enough to simply make data "open," or accessible. Data should be "intelligently open," which requires that data are discoverable, accessible, intelligible, assessable, and usable (Science International, 2015). This paper demonstrates that the PDC satisfies these requirements for intelligently open data. With its experience, capacity, and expertise, the PDC can support the Arctic Council in remaining a "cognitive forerunner" on issues of sustainable development and environmental protection in the Arctic.

References

- AMAP. (2012). Arctic Climate Issues 2011: Changes in Arctic Snow, Water, Ice, and Permafrost. SWIPA 2011 Overview Report.
- CAFF. (2015). *Actions for Arctic Biodiversity, 2013-2021: Implementing the recommendations of the Arctic Biodiversity Assessment*. Conservation of Arctic Flora and Fauna, Akureyri, Iceland. ISBN: 978-9935-431-41-7.
- CBMP. (2015, Spring). e-CBMP Newsletter. 9(1). Retrieved from: <http://archive.constantcontact.com/fs150/1102157694644/archive/1120991966569.html#PDF>
- CCIN. (2015a). *About us*. Retrieved from: <https://ccin.ca/home/about>

- CCIN. (2015b). *The Polar Data Catalogue*. Retrieved from: <https://ccin.ca/home/aboutpdc>
- Conley, H. A., & Melino, M. (February, 2016). *An Arctic redesign: Recommendations to rejuvenate the Arctic Council*. A Report of the Center for Strategic & International Studies (CSIS) Europe Program. Washington: CSIS.
- Friddell, J. E., LeDrew, E. F., & Vincent, W. F. (2014a). The Polar Data Catalogue: Data management for polar and cryospheric science. *70th Eastern Snow Conference, Huntsville, Ontario, Canada*, 113-126.
- Friddell, J. E., LeDrew, E. F., & Vincent, W. F. (2014b, 30 October). The Polar Data Catalogue: Best practices for sharing and archiving Canada's polar data. *Data Science Journal*, 13: PDA1-PDA7.
- Kankaanpää, P., & Young, O. R. (2012). The effectiveness of the Arctic Council. *Polar Research*, 31, 171-76. Available at: <http://dx.doi.org/10.3402/polar.v31i0.17176>
- Michaud, J., & Friddell, J. (Eds.). (2011). Best practices for sharing and archiving datasets. Retrieved from: https://polardata.ca/pdcinput/public/PDC_Best_Practices_FULLL.pdf
- Mokrane, M., & Parsons, M. A. (2014, 30 October). Learning from the International Polar Year to build the future of polar data management. *Data Science Journal*, 13: PDA88-PDA93.
- Neiswender, C., & Montgomery, E. (2009). Metadata interoperability: What is it, and why is it important? In: *The MMI Guides: Navigating the World of Marine Metadata*. Retrieved from: <http://marinemetadata.org/guides/mdataintro/mdatainteroperability>
- Nilsson, A. E. (2012). *Chapter 7: Knowing the Arctic: The Arctic Council as a cognitive forerunner*. Originally presented during *The Arctic Council: Its place in the future of Arctic governance*, January 17-18, 2012, Munk-Gordon Arctic Security Program and the University of Lapland. ISBN # 978-0-9737651-5-1.
- Nye, J. Jr. (2004). *Bound to lead: The changing nature of American power*. Public Affairs: New York.
- Parsons, M. A., Øystein, G., LeDrew, E., de Bruin, T. F., Danis, B., Tomlinson, S., & Carlson, D. (2011). A conceptual framework for managing very diverse data for complex, interdisciplinary science. *Journal of Information Science*, 37(6): 555-569.
- Pulsifer, P. L., Laidler, G. J., Taylor, D. R. F., & Hayes, A. (2011). Towards an Indigenist data management program: Reflections on experiences developing an atlas of sea ice knowledge and use. *The Canadian Geographer*, 55(1): 108-124.
- Scassa, T. (unpublished). Intellectual property and research data: Key issues and challenges in the Canadian North (draft paper).
- Science International (2015). *Open data in a big data world*. Paris: International Council for Science (ICSU), International Social Science Council (ISSC), The World Academy of Sciences (IWAS), InterAcademy Partnership (IAP).
- Wilson, P. (2016). Society, steward or security actor? Three visions of the Arctic Council. *Cooperation and Conflict*, 51(1): 55-74.