Elevating Community-Based Water Monitoring in Canada

Context for a National Discussion

Final Recommendations

Featured Case Studies

Context for a National Discussion

Elevating Community-Based Water Monitoring in Canada

OTTAWA, ONTARIO - NOVEMBER 27-28, 2018

WWF

Living Lakes CANADA

THE GORDON FOUNDATION

Convening Team

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Executive Summary

Our freshwater systems – the very foundation of healthy, productive societies – are being affected in unprecedented ways by increasingly complex environmental changes. Indigenous and non-Indigenous communities across the country understand this and are taking to their watersheds to collect much-needed information to track and respond to changes as they happen. This groundswell in **Community-Based Water Monitoring (CBWM)** is a powerful way to achieve effective water management and stewardship practices that are tailored for local conditions and capable of keeping pace with rapid environmental change.

Opportunity for the Government of Canada

The growth of CBWM programs across Canada presents an opportunity for the Government of Canada to simultaneously advance a number of its core priorities, including those articulated in the following documents:

- **Mandate letters** relating to climate change, environmental law reform and open science
- **Truth and Reconciliation Commission** recommendations, including those related to strengthening nation-to-nation relations
- **United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)**
- **Canada's 2030 Agenda** to meet the **United Nations Sustainable Development Goal** #6 to ensure access to sustainable water management and sanitation for all

Importantly, the Government of Canada is already making significant investments in CBWM across the country through programming led by Environment and Climate Change Canada, the Department of Fisheries and Oceans, and Crown-Indigenous Relations and Northern Affairs Canada, among others. To make the most of these investments, efforts are needed to ensure programming across departments is well co-ordinated and effectively addresses community needs.

Draft Recommendations for the Government of Canada

The following draft recommendations for the Government of Canada aim to advance more strategic and sustained federal support for CBWM. These recommendations, developed collaboratively with diverse experts, including individuals with practical experience carrying out both Indigenous and non-Indigenous CBWM programs, were intended as a starting point for discussion at the National Roundtable on Community Based Water Monitoring held in Ottawa on November 27 and 28, 2018. **The aim of the roundtable was to revise, modify, add to, or remove from these recommendations based on the input of participants and outcomes of the collaborative discussion.**

Draft Recommendations for Discussion

1   **Capacity-building**

- Invest in partnership development
- Support knowledge co-production according to Indigenous protocols and policies

2   **Effective Monitoring**

- Where appropriate, participate in the co-design of strategic monitoring plans that fill critical data gaps while leveraging existing infrastructure or data collected under existing long-term monitoring programs
- Where desired and appropriate, support CBWM protocol design and review, as well as data analysis and interpretation
- Promote and support sharing of relevant protocols and equipment across CBWM programs within and between regions
- Support the development of standardized monitoring protocols, where appropriate

3   **Regional and National Collaboration**

- Be a part of the conversation: Participate in local, regional and national gatherings where CBWM organizations organically network, share ideas, and support one another
- Identify areas of overlapping interest to invest in strategic partnerships while avoiding forced collaboration
-

4 Data Management

- Extend "open by default" approach to federally-funded CBWM initiatives while upholding principles of data sovereignty as articulated by Indigenous nations
- Incubate and scale existing data management efforts
- Provide leadership on best practices and standards for managing data to promote interoperability

5 Data to Inform Decision-Making

- Coordinate federal support to strengthen CBWM through a cross-departmental CBWM strategy
- Better integrate CBWM data in decision-making at various levels (policy, planning and management)
- Promote knowledge sharing and best practices in government-funded research and science

6 Sustainable Funding

- Develop multi-year, core funding options
- Fund new and existing Indigenous Guardian Programs to improve Indigenous-Crown relationships and advance reconciliation through Indigenous-led programs
- Streamline and simplify federal funding processes
- Embed CBWM spending in federal water monitoring budgets
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Convening Team

The discussion paper and the National Roundtable were convened by Living Lakes Canada, WWF-Canada and The Gordon Foundation. All three organizations engage with CBWM in different ways and are committed to advancing collaborative and evidence-based water stewardship across Canada.

The convening team thanks the roundtable participants for their willingness to share their work, knowledge and expertise with the Government of Canada. We would also like to thank Environment and Climate Change Canada (ECCC) and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) for providing financial and in-kind support for this gathering and most importantly for their openness and willingness to work collaboratively towards achieving shared water stewardship objectives.

Acknowledgments

The organizing team thanks the many advisors, authors, and key reviewers whose insight and contributions made this discussion paper possible. Our advisory group provided strategic direction and guidance from the project's initiation through to the November event.

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Background

Freshwater systems are under increasing pressure from the impacts of climate change, development and other human-made stressors. There is, therefore, a need to focus on monitoring freshwater resources and aquatic ecosystems across Canada. To meet this growing need, there has been a proliferation of community-led efforts to generate critical data and information needed to understand, respond to, and plan for complex environmental challenges.

As a powerful means of achieving shared governance and sustainability objectives, **Community-Based Water Monitoring (CBWM)** is gaining momentum across Canada. To realize the full potential of this movement there is a need for strategic investment, collaboration and leadership across sectors, watersheds, and jurisdictional boundaries. This must include active integration of CBWM data into policy and decision-making.

About the Roundtable Discussion

Convened by The Gordon Foundation, Living Lakes Canada and WWF-Canada, the aim of the Roundtable Discussion was to support a collaborative dialogue around how the federal government can meaningfully and effectively engage with and support CBWM in Canada.

Key Objective: dentify actionable steps the federal government can take to show leadership and support in advancing community-based monitoring of freshwater ecosystems in Canada.

ROUNDTABLE OBJECTIVE

The Roundtable discussion presented a valuable opportunity for a growing community of practitioners to come together for the following purposes:

- Highlight the expansive, diverse nature and network of CBWM programs across the country
- Identify how CBWM programs and governments can collaborate, including to fill existing knowledge and data gaps
- Identify strategic opportunities for federal investment in promoting and leveraging CBWM

While acknowledging the leadership and contributions of community-based monitoring for terrestrial and marine ecosystems, the focus of the roundtable discussion was on environmental monitoring of freshwater.

To better understand priorities for advancing CBWM in Canada, the organizers sent out a national survey to CBWM practitioners in the winter of 2017/2018. The survey results confirmed considerable appetite for a collaborative national discussion on the topic of federal support for CBWM, and informed the key themes addressed in this discussion paper. More information about the survey can be found on the Atlantic DataStream website.

About this Paper

This discussion paper provides a brief overview of key areas where opportunities exist for the federal government to support CBWM. **This paper and the draft recommendations included in it have been intended as a starting point for discussion only** – the aim of the roundtable itself was to revise, modify, cut and add recommendations, based on the input of roundtable participants.

This discussion paper has been divided into the following key thematic areas of focus:

1. Capacity building
2. Effective monitoring
3. Regional and national collaboration
4. Data management
5. Data to inform decision making
6. Sustainable funding

Context for a National Discussion

Canada's commitment to environmental protection, reconciliation with Indigenous peoples, open data, and evidence-based decision making, along with a growing trend toward increased public engagement in environmental stewardship, presents a unique opportunity for the federal government to play a critical role in supporting and strengthening community-based water monitoring in Canada. However, without focused effort to build the capacity needed to sustain CBWM initiatives over the long-term as well as effective mechanisms to incorporate CBWM data into decision-making, there is a significant risk of wasting valuable resources and failing to mobilize the full potential of CBWM to support healthy communities and water in Canada.

Why Community-Based Water Monitoring?

Why should communities be the ones to monitor water? Communities are closest to their watersheds and well-placed to identify and track the issues affecting them. CBWM is significantly expanding the spatial and temporal scales of freshwater monitoring, contributing to a more comprehensive picture of freshwater health in Canada, and is helping to build new, mutually beneficial relationships in Canada's water governance landscape (Buytaert et al., 2014). Through diverse programs across the country, CBWM is playing a critical role in mobilizing energy, engagement and knowledge from the ground up to protect the freshwater ecosystems on which we, and all life, ultimately depend.
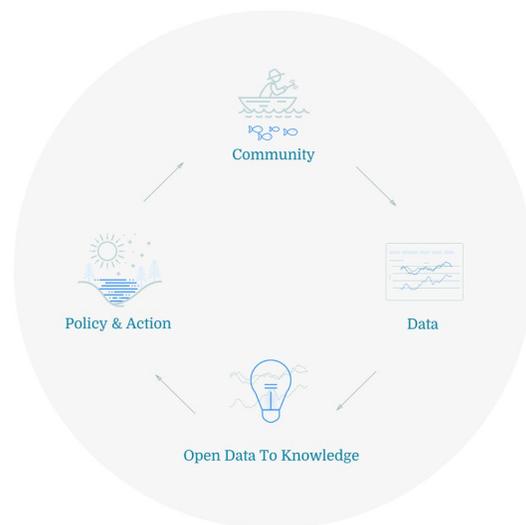
Figure 1. From data to policy and action through community-based monitoring. Image courtesy of The Gordon Foundation.

What do we mean by community-based water monitoring?

Community-Based Water Monitoring (CBWM), or citizen science, can be loosely defined as a "process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern" (Whitelaw, et al., p.410). CBWM is about all things water-related, such as monitoring quality, quantity and biodiversity in aquatic ecosystems. CBWM can be varied in its "nature and approach, ranging from volunteer monitoring programs to larger-scale, complex watershed management partnerships or councils" (Weston and Conrad, 2015, p. 1). In Indigenous contexts, CBWM further relates to Indigenous sovereignty and self-determination, and may be understood as "both a method for generating data useful for decision-making and an expression of governance itself, rooted in understandings of stewardship, kinship and responsibility" (Wilson, et al., 2018).

Indeed, despite recent iterations of CBWM, the concept is by no means new. From time immemorial, Indigenous peoples have maintained physical and spiritual connections to their lands marked by principles of community-based management. Though these connections have been affected by historic and ongoing legacies of colonialism, Indigenous peoples' observations, laws, and ways of knowing continue to inform governance of Indigenous lands and territories. Today, many Indigenous-led CBWM programs are conducted by employees of Indigenous governments and organizations, which differs from volunteer-based approaches typical of other citizen science monitoring initiatives. While Indigenous-led CBWM efforts can include western scientific indicators and methods, this monitoring may take place within larger governance processes and programs (e.g. Guardian programs) that are grounded in and seek to revitalize Indigenous ways of knowing, laws, cultures, languages and sovereignty.

Water: Sharing Responsibilities

ALL LIFE DEPENDS ON WATER; WE HAVE A SHARED RESPONSIBILITY TO PROTECT IT.

For freshwater ecosystems, the watershed is widely recognized as the most appropriate scale for most water planning and management functions (Parkes 2010; CCME 2016). Based on natural pathways of water flow, watershed boundaries do not follow political boundaries. This poses challenges because the complex distribution of responsibilities for water across orders

of government can result in an overlap in jurisdiction and, in some cases, an accountability gap (Swain, Louttit and Hrudey, 2006). This fragmentation of responsibility also poses challenges for monitoring and data management that can lead to gaps in information and disconnection between data and decision-making.w

Furthermore, prevailing approaches to water governance often exclude meaningful participation of Indigenous peoples, and systemic inequities constrain Indigenous peoples' access to water and ability to exercise inherent water rights and associated responsibilities (Craft, 2017; McGregor, 2014; Phare, 2009; Simms, 2016). Despite this, Indigenous peoples in Canada continue to assert their inherent rights and responsibilities to water, which flow from their relationships to their traditional territories and include the "power to make decisions, based upon [their] laws, customs, and traditional knowledge" (Phare, 2009, p. 46).

Fisheries
Navigation
Federal Lands
First Nation Reserves
International Relations
Co-Management

Federal Government*

Indigenous Governments*

Implement own laws based on inherent jurisdiction and traditional knowledge

WATER GOVERNANCE IN CANADA

Inuit Institutions of Public Government

Water conservation, Regulation and usage approvals, E.g. Nunavut Water Board

Water supply
Pollution Control
Hydroelectric development
Flow regulation
Authorization of water use

Provincial & Territorial Governments

Municipalities*

Provide drinking water
Wastewater treatment
Stormwater management

Figure 2. Governmental Responsibilities for Water

Current water governance in Canada is often described as a complex jurisdictional maze (Saunders and Wenig, 2007; Bakker and Cook, 2011). Under the Constitution Act (1867), responsibilities for various aspects of water law, policy, planning and management are shared among Indigenous peoples, municipal, provincial, territorial, and federal governments (see Figure 2).

Data Deficiencies

Limited availability of data and information about fresh water in Canada is a real and enduring barrier to making evidence-based decisions. As indicated in a 2010 audit by the Commissioner of the Environment and Sustainable Development, and echoed again in the WWF-Canada Watershed Reports of 2017, there is insufficient data collection and capacity within existing monitoring networks to fully understand long-term changes in water quality (WWF-Canada, 2017). These data gaps are a growing concern in the face of a rapidly warming climate, which is driving demand for robust and timely information needed to understand and adapt to more common and severe flood and drought, and to respond to increasingly complex threats to the health of freshwater resources and ecosystems.

A number of factors have led to this data deficiency. Some are more obvious, like persistent funding stress for long-term monitoring activities and the remoteness of many monitoring sites. Others, including a lack of co-ordination in monitoring efforts, poor communication among parties, and limited data sharing among government agencies, academia and other monitoring organizations may be more obscure but equally important. The wide range of protocols, indicators and metrics used to generate water quality data across watersheds further complicates integration of historical and newly acquired data to inform, for example, an understanding of cumulative effects on the state of freshwater resources and ecosystems.

Prime Minister Trudeau, June 2017
WWF-Canada Healthy Waters Summit

"We need to step up, all of us – public sector, different levels of government, private partners – and ensure that the data so many people are collecting in so many different ways gets aligned, gets collated and gets shared."

The Legislative Landscape and Opportunity to Support CBWM

For the federal government, strategic support for CBWM is an opportunity to build on existing momentum and a foundation of collaborative water monitoring. Under the Canada Water Act (1985) the federal government has the mandate to work with the provinces and territories on joint water management. This mandate is implemented in part through shared monitoring agreements with the provinces and territories (though not all have agreements in place) and in areas of national concern such as the Great Lakes, the Mackenzie River Basin, St. Lawrence

River, and Lake Winnipeg watershed. As it relates to hydrometric monitoring (i.e. water levels and flows), the federal government has maintained a successful 27-year collaborative relationship with the provinces and territories, housing data in a central, accessible online database (National Hydrometric Network led by Environment and Climate Change Canada.

FEDERAL LEGISLATION	International Boundary Waters Treaty Act (1909)
	Fisheries Act, 1985*
	Canadian Environmental Protection Act, 1999 (CEPA)
	Federal Sustainable Development Act, 2008 (FDSA) & Strategy (2010)
	Canadian Environmental Assessment Act, 2012 (CEAA)*
	Great Lakes Water Quality Agreement (2012)

All include elements of water monitoring

*Note: Proposed amendments in Bills C-68 and C-69
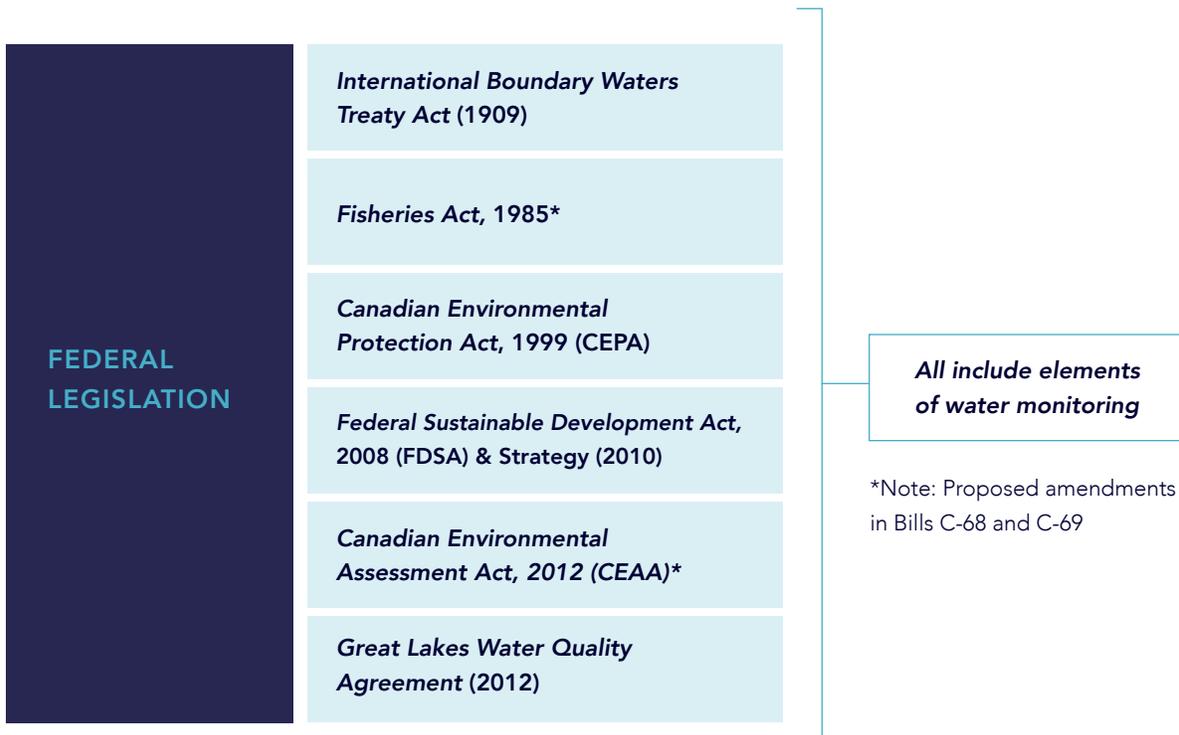
Figure 3. Federal Legislation Related to Water Management

A number of other federal laws also provide a basis for federal water monitoring (see Figure 3). Importantly, two Bills currently under review by the Senate will update the Fisheries Act (Bill C-68) and the Navigation Protection Act and environmental assessment legislation (Bill C-69) to require consideration of cumulative effects in decision making and establish a public registry to facilitate access to key information related to implementation of these laws. Implementation of these provisions would benefit greatly from the data and information developed through CBWM initiatives.

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[1] Five federal-provincial agreements are active today between Canada and the following jurisdictions: Quebec (1983); British Columbia (1985); Manitoba (1988); New Brunswick (1988/1995); Newfoundland and Labrador (1986); and Prince Edward Island (1989) (Canada. Environment and Climate Change Canada, 2017).

Indigenous Water Governance

Indigenous peoples in Canada have always had laws and governance systems that protected water and waterways. Despite the impacts of colonialism, Indigenous peoples continue to sustain, reclaim, and revitalize these forms of governance, which may be diverse across communities and Nations. Recent policy shifts have implications for the recognition of Indigenous water rights, responsibility and jurisdiction. In 2016, the Government of Canada endorsed the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), which is a comprehensive international instrument on Indigenous peoples' rights with implications for Indigenous water governance. More recently, the Principles Respecting the Government of Canada's Relationship with Indigenous Peoples marks a move to align federal policy with the provisions of UNDRIP, such as affirming self-determination and free, informed and prior consent (Canada. Department of Justice, 2018). While these policy moves express a political willingness, there remains much work to do to implement UNDRIP meaningfully with respect to fresh water issues (Askew et al., 2017).

Federal Support of CBWM

The benefits of collaborating with local monitoring groups have led governments at various levels to make considerable investments in CBWM. This has been accomplished through partnerships and support in the form of funding, training, equipment loans, data management, and project co-ordination. At the federal level, examples include long-standing programs such as the Canadian Aquatic Biomonitoring Network (CABIN) established through Environment and Climate Change Canada (ECCC), and the Aboriginal Aquatic Resource and Oceans Management Program (AAROM) housed at the Department of Fisheries and Oceans (DFO). The Northern Contaminants Program (NCP) is a long-standing example of collaborative monitoring conducted by northern communities and their partners at different levels of Indigenous and non-Indigenous government. At the federal government level, Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), Health Canada, ECCC and DFO are all involved in the NCP. The Nunavut, Northwest Territories, and Yukon territorial governments are also partners, as are Indigenous governments and organizations such as Inuit Tapiriit Kanatami (ITK), Inuit Circumpolar Council-Canada (ICC), Dene Nation and the Council of Yukon First Nations.

The federal government has also recently ramped up investments in monitoring through new and existing funding programs for which CBWM initiatives are eligible. Some notable examples include the following:

- **$44.84 million over 4 years: Great Lakes Protection Initiative**
  - Administered through ECCC under Budget 2017's $70.5 million allocation for freshwater protection: Swim Drink Fish received $1.8 million for recreational water quality monitoring
- **$31.4 million over 5 years: Indigenous Community-Based Climate Monitoring Program**
  - Announced in Budget 2017 and funded through CIRNAC
- **$25 million over 5 years: Indigenous Guardians Programs Announced in Budget 2017**
  - Administered through Parks Canada. Funding will support the launch of a national Indigenous Guardians Network.

Additional examples are listed in the Appendix. It should be noted that while federal supports for CBWM are the focus of this discussion, many Indigenous Nations, municipalities, provinces and territories provide significant supports for CBWM through leadership, collaboration, and resourcing.

Community-based water monitoring helps the Government of Canada meet the following commitments and responsibilities:

1. Advance whole-of-government priorities such as climate change and open science, as articulated in ministerial mandate letters (Canada. Prime Minister's Office, n.d.).

2. Strengthen nation-to-nation relationships and implementation recommendations of the Truth and Reconciliation Commission (TRC) that relate to the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and protection of the environment.

3. Measure Canada's performance in meeting biodiversity goals and targets through Canadian Environmental Sustainability Indicators (CESI).

4. Achieve Canada's 2030 Agenda to meet the United Nations Sustainable Development Goal # 6, which seeks to ensure availability and sustainable management of water and sanitation for all.

5. Implement terms of collaborative federal/provincial/territorial/ bilateral agreements on water quality monitoring across jurisdictional boundaries.

6. Ensure that decisions are based on evidence and principles of open government, and that they serve the public's interest.

7. Play a unifying role in ensuring the health of freshwater in Canada for Canadians as mandated in the Canada Water Act (1970).
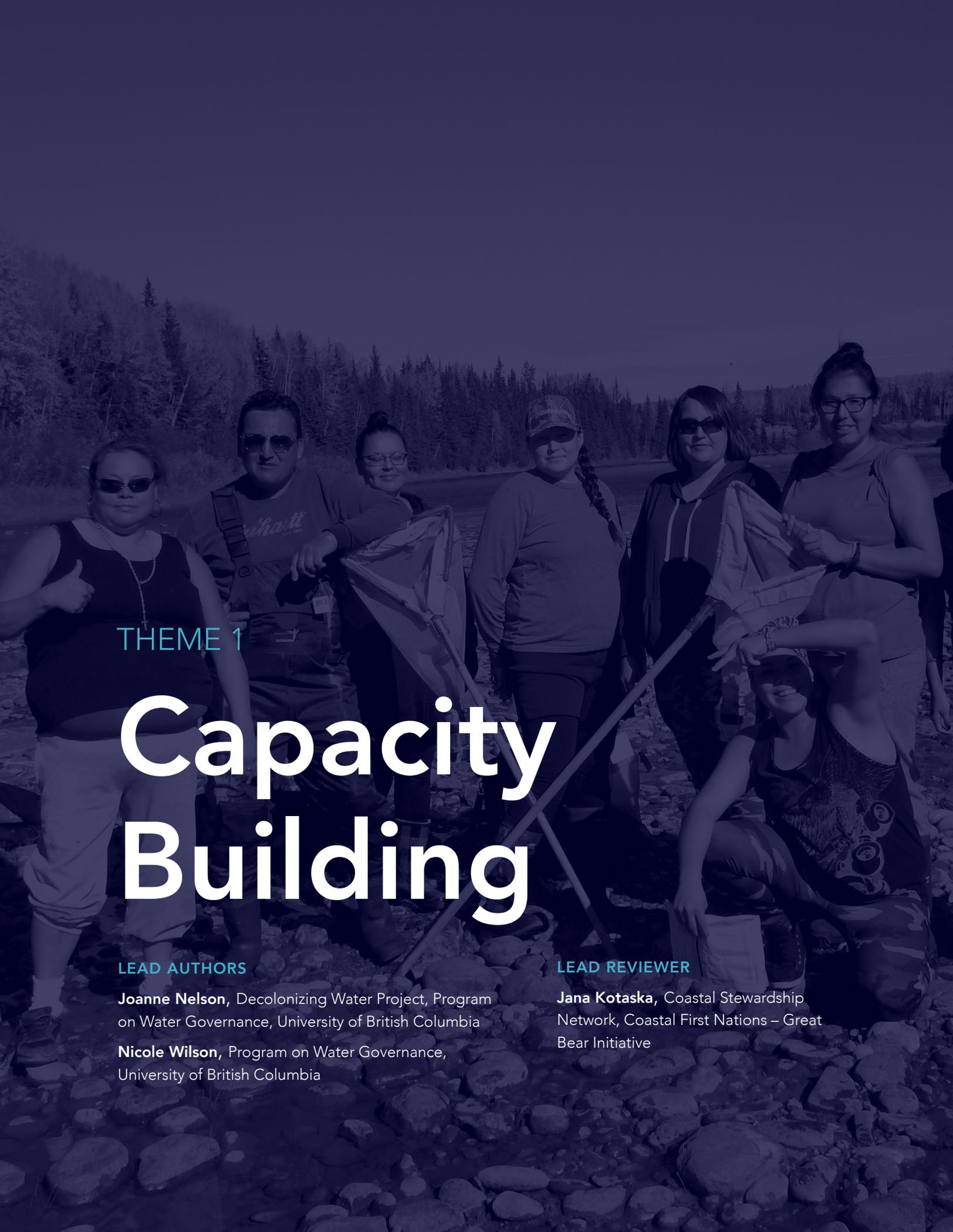
THEME 1

Capacity Building

LEAD AUTHORS

Joanne Nelson, Decolonizing Water Project, Program on Water Governance, University of British Columbia

Nicole Wilson, Program on Water Governance, University of British Columbia

LEAD REVIEWER

Jana Kotaska, Coastal Stewardship Network, Coastal First Nations – Great Bear Initiative

Overview

Capacity building has been identified as essential to the success of CBWM (Day and Litke, 1998; Conrad and Hilchey, 2010; Bellfield et al., 2015) and focuses on building the technical and institutional capacity to conduct monitoring that achieves identified objectives of a monitoring program, including the ability to collect high-quality data (CLEAR, n.d.; Bradshaw, 2003; Gouveia et al., 2004; Conrad and Daoust, 2007; Kearney et al., 2007; Conrad and Hilchey, 2010; Shelton, 2013; Danielsen et al., 2014; Buckland-Nicks, Castelden and Conrad, 2016; Jollymore et al., 2017; Herman-Mercer et al., 2018).

Challenges

The capacity- building challenges identified in this section apply to both Indigenous and non-Indigenous contexts. We acknowledge that Indigenous peoples face many more barriers as the result of ongoing and historical colonialism in Canada. There is a pressing need for a comprehensive analysis of the challenges and specific needs of Indigenous peoples related to CBWM. However, such an analysis is beyond the scope of this section.

SUSTAINABLE FUNDING

Sustainable funding is required to co-ordinate programs; train and retain qualified monitors; develop and maintain data management systems; support analysis, reporting and use of data; and retain institutional capacity, among other things (Carlson and Cohen, 2018; Conrad and Hilchey, 2011; Whitelaw et al., 2003.) The topic of funding is explored further in Section 6.

INSTITUTIONAL CAPACITY

A lack of sustained volunteer interest has been identified as one specific barrier to institutions conducting volunteer-based CBWM (Conrad and Daoust, 2007; Whitelaw et al., 2003). This may be influenced by several factors, including potential mismatches between volunteer interests and time, and monitoring program needs for engagement over the long-term. Likewise, complex or rigorous monitoring protocols such as the CABIN protocol; (see the case study at the end of this section) that require highly trained volunteers may be associated with costly certification programs that pose a financial barrier (Buckland-Nicks, Castleden and Conrad, 2016). For Indigenous governments and communities in particular, limits to institutional capacity mean being faced with the challenge of selecting priorities from among myriad pressing concerns.

POWER DYNAMICS

Mainstream approaches to capacity building tend to ignore the power dynamics that structure the context in which CBWM programs are being developed. Capacity building "ignores the fact that the very reason why some communities have difficulties in 'developing' is not their lack of capacity, but the structural, political and resource impediments in their way" (Kenny and Clark 2010, p. 8). Capacity building frequently fails to acknowledge the historic and ongoing effects of colonialism on Indigenous peoples in Canada associated with disruption of traditional laws, language and culture (Borrows, 2002; Napoleon, 2013). Mainstream approaches to capacity building have also ignored the need for non-Indigenous partners to build their capacity to work with Indigenous nations and within Indigenous territories, including increasing understanding of complex jurisdictional issues related to water governance, Indigenous ways of knowing and being, and traditional governance systems (Kotaska, 2013; Simms et al., 2016).

Opportunities

PARTNERSHIP DEVELOPMENT

Multi-stakeholder monitoring programs can increase the long-term organizational capacity and overall stability of CBWM programs by providing human and financial resources (Hunsberger, 2004). These partnerships can be used to leverage financial and other resources needed to support CBWM programs.

In Indigenous contexts, Indigenous-led bridging organizations have been key to building capacity for CBWM. These bridging organizations co-ordinate the efforts of multiple Indigenous governments, for example, Coastal First Nations or the Yukon River Inter-Tribal Watershed Council (YRITWC). At times, they also collaborate with external parties to leverage "networked capacity" while still acknowledging the authority of Indigenous governments to direct their own monitoring programs and engage in other self-determination activities that challenge current power dynamics. A good example of this is the international partnership model among Alaska Native Tribes and First Nations, the Yukon River Inter-Tribal Watershed Council (YRITWC), and the United States Geological Survey (USGS) (Wilson et al., 2018).

Opportunities exist for non-Indigenous groups to partner with and support Indigenous organizations that have monitoring programs to collect mutually beneficial data or collect data on a fee-for-service basis.

PROGRAM DESIGN THAT BALANCES SCIENTIFIC AND EDUCATIONAL GOALS

Where CBWM efforts are volunteer-based, integrated program designs that involve both adequate quality standards and engage volunteers are more apt to maximize resources and realize both scientific and educational goals, improving volunteer capacity and retention (Buckland-Nicks, Castleden and Conrad, 2016). To do this, programs must understand volunteer interests, motivation and skill level, and match monitoring design to this (Bliss et al., 2001; Whitelaw et al., 2003), while maintaining scientific credibility.

IN-KIND CONTRIBUTIONS

Non-monetary contributions are a valuable source of support for less-resourced CBWM groups. In-kind support may fall into the following areas:

- **Physical infrastructure**
    - Office space
    - Equipment such as monitoring kits, lab space, boat / car access
- **Technology**
    - Data management software
    - Access to servers and computers
- **Skills and time**
    - Volunteering
    - Training and technical expertise
    - Bookkeeping support
    - Fundraising including proposal writing
    - Networking (Weston and Conrad, 2015)

ENGAGING A KNOWLEDGE CO-PRODUCTION MODEL

Knowledge co-production conceptualizes capacity building in CBWM as a "mutual journey of discovery" (Kenny and Clarke, 2014, p. 10). Taking this concept further, community organizing emboldens leadership in communities to fight oppressive systems impeding their well-being (Kenny and Clarke, 2014, p. 18). In both non-Indigenous and Indigenous contexts, this means that capacity building should go beyond a narrow focus on technical capacity such as sampling protocols, and build institutional capacity for leadership, governance, and sustainability to maintain programs and use data in decision-making and other processes (Buckland-Nicks, Castleden and Conrad, 2016; Wilson, et al., 2018).

Draft Recommendations

The following actions can be taken by the federal government to build capacity for CBWM:

1. INVEST IN PARTNERSHIP DEVELOPMENT

- Develop partnerships with community institutions to conduct CBWM.
- In Indigenous monitoring contexts:
    - Develop partnerships with Indigenous bridging organizations to engage networked capacity (Wilson et al., 2018).
    - Focus capacity building efforts on developing partnerships that make Indigenous leadership and self-determination a high priority (Kotaska, 2013; Wilson et al., 2018). The federal government and other funders should be cautious about forcing unwanted or context-inappropriate partnerships.

2. SUPPORT KNOWLEDGE CO-PRODUCTION IN ACCORDANCE WITH INDIGENOUS PROTOCOLS AND POLICIES

- Create space for capacity building that is directed and led by Indigenous peoples for CBWM programs involving Indigenous peoples. To start:
    - Provide long-term funding for Indigenous Guardians and Indigenous-led CBWM programs
    - Include a mandate for federal water scientists and policymakers to recognize and make room for the role of ceremony and cultural connections to water and actively participating in these, where appropriate.
- Ensure that investment in CBWM in Indigenous contexts begins with acknowledging Indigenous self-determination and accounting for the broader political, economic, and jurisdictional challenges and inequities faced by Indigenous communities as a result of ongoing legacies of colonialism
- Challenge non-Indigenous partners to build their capacity to work with Indigenous peoples by genuinely investing in reconciliation and developing an improved understanding of Indigenous systems of knowledge, law, and governance.

Case Studies

ATLANTIC COASTAL ACTION PROGRAM (ACAP)

Between 1991 and 2009, ACAP was a federal government initiative operated by then Environment Canada. Its purpose was to help Atlantic Canadians restore and sustain local watersheds and adjacent coastal areas. Environment Canada and 15 ACAP groups (also known as the "ACAP family") worked together to develop environmental management plans, build awareness of local environmental issues, and advance scientific research to inform restoration efforts for freshwater systems, estuaries and Atlantic harbours.

Studies of ACAP's costs and benefits between 1997 and 2001 revealed that there were significant economic, social and ecological gains from the government's investment. A shift in the funding model in 2009 from providing core-funding to project-based funding through the Atlantic Ecosystem Initiative (AEI) has had a significant negative impact on the capacity of individual CBWM organizations to continue their monitoring activities, particularly smaller, less resourced groups.

For more information, see McNeil, Rousseau, and Hildebrand (2006).

THE INDIGENOUS OBSERVATION NETWORK (ION)

Organized through a partnership model among Alaska Native Tribes and First Nations, the Yukon River Inter-Tribal Watershed Council (YRITWC), and the United States Geological Survey (USGS), ION is the largest international, Indigenous-led monitoring initiative combining Indigenous Knowledge (IK) and western science to research, sustain and protect the Yukon River Basin (YRB). Since the program began, more than 300 community members have been trained to conduct sampling and analysis of water quality data. Over 1500 samples have been collected at more than 50 sites covering the entire 2,300-mile reach of the Yukon River (Herman-Mercer, 2016).

Strong collaborative relationships ensure that technical and financial capacities are fairly distributed within the network. Importantly, Indigenous leadership in CBWM within the YRB has been essential in developing a program that is designed to meet desired outcomes for Indigenous water rights and co-governance.

For more information, see the Yukon River Inter-Tribal Watershed Council website: http://www.yritwc.org/science.

THE COASTAL FIRST NATIONS REGIONAL MONITORING SYSTEM

Located in the North and Central Coasts of British Columbia, the Regional Monitoring System (RMS) was developed with the Coastal First Nations' Stewardship Offices and is administered by the Coastal Stewardship Network, a program of the Coastal First Nations-Great Bear Initiative. Guardian Watchmen play an important role in monitoring compliance with rules and regulations set out in ecosystem-based management plans and agreements such as the Marine Plan Partnership plans and Great Bear Rainforest Land Use Order, and are actively involved in education and outreach related to cultural and ecological values in the region. The water monitoring component of the RMS consists of stream surveys to collect water quality data, conduct salmon habitat assessments, and survey returning salmon to improve knowledge in priority watersheds.

With support from the Coastal Stewardship Network, member Nations of the RMS evaluate the system to ensure that it meets the changing needs of First Nations; keeps pace with advances in mobile technology; continues to collect data that will inform First Nations' land and marine use planning and management; and facilitates collaboration between Guardian Watchmen and non-Indigenous monitoring agencies (Kotaska, 2013).

The Coastal First Nations use a variety of sources of funding to support monitoring, including own-source revenue, government-to-government agreements, foundations, Coast Funds' conservation endowment, government funding programs, fee-for-service, and partnerships or agreements with academia, non-governmental organizations, government, and industry.

For more information, see the Coastal First Nations website:
http://coastalfirstnations.ca/our-environment/programs/regional-monitoring-system/

COLUMBIA BASIN WATERSHED NETWORK

Located in British Columbia's Columbia River Basin, Columbia Basin Watershed Network (CBWN) facilitates the sharing of knowledge and participates in water monitoring activities. The CBWN is led by a Board of Directors at the regional level and is publicly funded by the Columbia Basin Trust and key philanthropic granting sources. CBWN benefits from significant in-kind contributions from member groups and individuals.

CBWN promotes and supports collaboration at the sub-regional scale and works with members and partners to identify shared resource issues and to collaborate with partners to solve these at the Basin scale. As such, CBWN is well-placed to support and co-ordinate the efforts of sub-basin monitoring activities; to distribute knowledge; and to assist in the management of data through a regional Data Hub – a new initiative it is actively scoping.

For more information, see the Columbia Basin Watershed Network website: cbwn.ca

THEME 2

Effective
Monitoring

LEAD AUTHORS

Alexis Kanu, Lake Winnipeg Foundation

Michael Stainton, Lake Winnipeg Foundation

Chelsea Lobson, Lake Winnipeg Foundation

LEAD REVIEWER

Kelly Munkittrick, Cold Regions and
Water Initiatives, Wilfrid Laurier University

Overview

Despite the demonstrated benefits of CBWM, the credibility and utility of CBWM data has often been questioned. Data collected by CBWM programs may be viewed as inaccurate or of lesser quality given monitors' lack of traditional scientific training; such data may also be perceived as biased, if monitoring is motivated by specific citizen concerns. Data quality concerns may be further compounded by the short-term/stop-start nature of many CBWM programs. To address these concerns, CBWM programs can integrate the skills and experience of professional scientists with the commitment of trained community monitors (Kanu et al., 2016), matching tasks with the appropriate individuals and skills to leverage the unique capacity of all participants. Input from citizens and scientists alike drives an iterative program design that streamlines and simplifies data collection and interpretation to reduce error (Kosmala et al. 2016) and increase engagement.

CREDIBILITY OF CBWM DATA

Studies comparing water quality data collected by CBWM programs with those collected by professional scientists have found that statistical differences are not significant, and the data collected are of high quality (Shelton, 2013; Herman-Mercer et al., 2018). Diverse CBWM models exist and tailoring the approach of the program to desired objectives is key to ensuring that the data and information collected is fit for purpose. It should also be recognized that different knowledge systems have different methods and protocols for producing information that is considered valid within those systems.

PROGRAM DESIGN

CBWM program design should be driven by the questions and concerns at hand, which in turn determine the methods, indicators of interest and the appropriate temporal and spatial resolution of sampling activities (Kanu et al., 2016). Capacity and resources available will also influence program design and scope. More data is not always better, if it does not address the overarching goals of the monitoring program or the concerns of participants.

TRAINING, EQUIPMENT AND MONITORING PROTOCOLS

For western scientific monitoring, protocols and equipment should be standardized and supported by appropriate quality assurance/quality control (QA/QC) measures to ensure consistency and replicability of data collection. Opportunities to standardize protocols and simplify sampling equipment, based on participant experience, can reduce sampler error and increase efficiency, and ensure consistency among samples. Field audits are a necessary component of QA/QC, and also provide collaborative opportunities to refine and clarify

sampling protocols. Automated data entry and detailed metadata record-keeping enables participants to trace and evaluate unexpected results. Comparability of lab performance is evaluated as necessary, particularly when CBWM is being used to augment existing agency monitoring programs. Sharing monitoring outcomes in accessible formats that provide appropriate context allows volunteers to understand the impact of their participation, supports long-term engagement and reinforces the credibility and utility of citizen-generated data.

Once CBWM data is shared, it must be evaluated by data users for validity like any other scientific dataset – by review of the methods, QA/QC measures, associated metadata, and replicability, etc. As with data collected by professional scientists, statistical analyses can identify bias, systematic error, or outliers in the data so that they can be addressed (Kosmala et al. 2016).

Draft Recommendations

The federal government can take the following actions to encourage effective monitoring:

1. Where appropriate, participate in the co-design of strategic monitoring plans that fill critical data gaps while leveraging existing infrastructure or data collected under existing long-term monitoring programs:

- Assist communities in determining what, when, how, and where to sample in order to answer the questions at hand.
- Identify opportunities where existing research infrastructure (e.g., HYDAT stations) or long-term datasets can be used to identify data gaps where CBWM efforts will be most valuable.
- Earmark resources and departmental staff time to work collaboratively with CBWM groups (e.g., through peer-reviewing of jointly developed monitoring plans).

2. Where desired and appropriate, support CBWM protocol design and review, as well as data analysis and interpretation:

- Work with experienced CBWM practitioners to develop a CBWM program design toolkit or checklist.
- Provide support and participate in sampling and lab comparison studies to evaluate data comparability.
- Provide access to lab space or in-kind support for lab analyses, as commercial labs can be cost-prohibitive.

3. Promote and support sharing of relevant protocols and equipment across CBWM programs within and between regions:

- Support regional coordination among CBWM programs with common objectives.
- Identify and support opportunities for resource-sharing (e.g. monitoring equipment loans, data management expertise, analysis expertise).

4. Support the development of standardized monitoring protocols, where appropriate:

- Invest in collective efforts to standardize protocols, including best practices to ensure spatial, temporal, and methodological consistency.
- Following principles of open government, ensure protocols are openly shared and accessible.

Case Studies

LAKE WINNIPEG COMMUNITY-BASED MONITORING NETWORK

Located in the Lake Winnipeg watershed, Lake Winnipeg Community-Based Monitoring Network (LWCBMN) increases the spatial and temporal resolution of phosphorus monitoring. This network mobilizes citizens across the watershed to generate useful and credible water quality data to identify phosphorus hotspots: areas that contribute a disproportionately high phosphorus load to local waterways. LWCBMN volunteers follow scientifically-vetted sampling protocols that are compatible with provincial and federal water-quality monitoring initiatives, meaning LWCBMN data can be easily integrated into decision-making processes, and can guide the development of evidence-based policies and practices. LWCBMN is guided by the expertise of LWF's Science Advisory Council, composed of nationally recognized freshwater scientists from across the country.

Annual funding is received from multiple private and public foundations. Recently, the network received a four-year federal funding commitment from ECCC. LWCBMN data is currently being used to inform decision-making by watershed district managers, and has been acknowledged as increasing provincial capacity to target phosphorus load reductions and improve water quality across Manitoba.

For more information, see the Lake Winnipeg Community-Based Monitoring Network website: http://www.lakewinnipegfoundation.org/lake-winnipeg-community-based-monitoring-network

MIKISEW CREE FIRST NATION-COMMUNITY BASED MONITORING PROGRAM (MCFN-CBM)

Based in the Peace Athabasca Delta of northern Alberta, Mikisew Cree First Nation-Community Based Monitoring Program (MCFN-CBM) program uses scientific methods and local IK and wisdom passed down by Elders to watch, listen, understand and report on activities that may cause harm to their traditional lands and resources in the delta. The results of their studies are used to inform community members about the state of the traditional territory, to assist the leadership in establishment of Indigenous policies, and to inform consultation processes surrounding the impacts of resource development.

The programs measure water depth and navigation, water quality, ice thickness and snow depth, and CBM staff collaborate with other Indigenous, federal, provincial, territorial and University researchers in examining contaminants in wildlife and fish. MCFN CBM Guardians also respond to emergencies such as the October 2013 Obed spill.

For more information see the Mikisew Cree First Nation-Community Based Monitoring Program website: http://mikisewgir.com/cbm/

Regional & National Collaboration

LEAD AUTHOR

Emma Wattie, Atlantic Water Network

LEAD REVIEWERS

Alice Cohen, Acadia University

Edda Mutter, Yukon River Inter-Tribal Watershed Council

Overview

Countless watershed-focused monitoring organizations exist across Canada and many of these rely on robust partnerships among Indigenous and non-Indigenous CBWM participants and different levels of government. Examples of such partnerships are the PEI Watershed Alliance, the NWT-wide CBM Program, and the Indigenous Observation Network Case Studies. Despite successful examples of collaboration, many actors in the water monitoring and management landscape continue to operate in silos, focusing on one lake, beach or river without looking at the entire system. Regional collaboration more readily mobilizes knowledge within communities, enhances the inclusion of decision-makers, fosters peer-to-peer learning, and can leverage funding well beyond original investments (Weston and Conrad 2015, McNeil et al., 2006, Whitelaw et al. 2003).

Challenges

COMPLEX INTER-JURISDICTIONAL AND CROSS-SECTORAL RELATIONSHIPS

Organizations operating at the local and municipal level often face issues of concern that may fall under provincial, federal, Indigenous or even international jurisdiction. While many CBWM funding programs are administered by the federal government, the projects themselves may require multi-sectoral collaboration. This can lead to confusion over who does what. For example, when groups undertake a watershed connectivity project to improve fish passage or flow, provincial departments of transportation may be required for project approval, but DFO also has jurisdiction and responsibilities relating to fish habitat. Information about these responsibilities may be difficult for CBWM groups to access, or there may not be an obvious point person for groups to contact in each department.

ESTABLISHING TRUST AMONG ACTORS

Efforts towards collaboration must overcome existing mistrust among different groups. In Indigenous contexts, careful thought must go into ensuring that cultural knowledge and practices are respected in order to foster mutually respectful collaboration with Indigenous-led monitoring programs.

Opportunities

The federal government is well-placed to support strategic collaboration where it is appropriate, desired and brings value. Over the past few decades a number of federal funding programs have facilitated regional collaboration among CBWM initiatives such as the following:

- **Ecological Monitoring and Assessment Network (EMAN)** was a national citizen science program that was co-founded by Environment Canada and discontinued in 2010 (see the case study at the end of this section);

- **Atlantic Coastal Action Program (ACAP)** was operated by Environment Canada from the mid 90s to mid-2010. ACAP's model clearly demonstrated the environmental, economic, and social potential of a CBWM program (see the case study in Theme 1: Capacity Building). EC held annual gatherings of ACAP Directors, which led to strong program development and natural partnerships that exist to this day;

- **Atlantic Ecosystem Initiative (AEI)** provides funding through ECCC (2015-present). It encourages the inclusion of multiple types of partnerships in proposals;

- **Aboriginal Aquatics Resources and Oceans Management (AAROM)** organizations and the **Community Aquatic Monitoring Program (CAMP)** are ongoing programs run by DFO;

- **Great Lakes Protection Initiative:** Citizen Science Stream was announced in 2018 and will run until 2022. Funding will be allocated to programs that enhance public knowledge and awareness around Great Lakes water quality and ecosystem health;

- **Great Lakes Protection Initiative:** Indigenous stream has the aim of increasing Indigenous participation in restoration and monitoring efforts throughout the Great Lakes Region.

As federal interest in CBWM grows, it is imperative that federal department staff be empowered to actively engage with community-led initiatives. For example, the ACAP structure enabled regional ECCC staff or "EC Windows" to co-ordinate networking opportunities and facilitate cross-jurisdictional connections (Weston and Conrad, 2015). An international example is the New Jersey Department of Environmental Protection which has a Volunteer Monitoring Coordinator.

Several non-governmental organizations and networks are also actively facilitating regional collaboration in Canada. Organizations such as the Atlantic Water Network, the Lake Winnipeg Foundation, Swim Drink Fish, and the Coastal Stewardship Network support local CBWM efforts in their respective regions. "By joining wider networks and linking to other monitoring and scientific research initiatives, community members gain a sense of being a part of a wider collective, and gain access to new ideas and approaches that can improve techniques and lead to new discoveries" (Johnson et al., 2015 pg. 35).

Draft Recommendations

The federal government can take the following actions to promote regional and national collaboration:

1. Be a part of the conversation: Participate in local, regional and national gatherings where organizations organically network, share ideas, and support one another.

- Attend local and regional non-governmental CBWM gatherings and water management meetings to enhance federal awareness of the scope of CBWM work across watersheds and stay abreast of opportunities to collaborate;

- Invest staff time and resources in projects that are designed to bring local actors together to address practical issues of common concern.

2. Where desired and appropriate, support CBWM protocol design and review, as well as data analysis and interpretation:

- Support non-governmental organizations and platforms that are well-positioned to facilitate regional collaboration.

- Seek opportunities to co-design and manage water monitoring through mechanisms that promote cross-sectoral collaboration between environmental non-governmental organizations (ENGOs), multiple levels of government, Indigenous nations, academia, and industry (an ongoing example of this collaboration can be seen in the Columbia Basin Framework on Water Monitoring, see case study in Theme 1: Capacity Building).

- Avoid forced collaborations through funding programs where partnerships might not make sense.

Case Studies

ATLANTIC WATER NETWORK

The core mission of the Atlantic Water Network (AWN) is to build capacity among stewardship and watershed organizations by providing access to water monitoring and conservation resources such as standardized training via WET-Pro water monitoring kits, a secure and open access data hub (Atlantic DataStream), and the free use of an Environmental Monitoring Equipment Bank.

By sharing resources, AWN has contributed to the development of a standardized approach to water quality monitoring across Atlantic Canada through its online database, WET-Pro training and toolkit. AWN facilitates collaborative networking among member organizations and supports educational outreach efforts with the broader public. Importantly, AWN facilitates dialogue among relevant stakeholders about how to share water quality data and information products to facilitate uptake in decision-making. Collaboration with academic research has helped measure and communicate the credibility of CBWM data to other audiences (Shelton, 2013).

For more information see the Atlantic Water Network website: http://atlwaternetwork.ca

PRINCE EDWARD ISLAND WATERSHED ALLIANCE

Focusing on the Inland waters of Prince Edward Island, Prince Edward Island Watershed Alliance (PEIWA) supports the development of new and existing inland Watershed Groups in meeting their objectives to improve and protect the environmental quality of their watersheds. The Alliance serves as the main voice for all of the groups, which together account for water stewardship activities covering approximately 95% of the island. The provincial government of PEI provides multi-year core funding to members of the Alliance through a Watershed Management Fund (WMF). As well, PEIWA was successful in securing large-scale, multi-year funding from the federal government worth approximately $2 million.

Brokered through the PEIWA, partnerships established with local farmers, woodlot owners, and community organizations have helped minimize the impacts of local industries on freshwater health. Often this involves tree and shrub plantings in the riparian zone, taking marginal lands out of crop production, and educating industries about provincial incentive programs (e.g., ALUS, NAPA, etc.). The Alliance has also been instrumental in the development of a Watershed Strategy and has provided input into recently drafted provincial legislation, the Water Act.

For more information see the Prince Edward Island Watershed Alliance website:
http://www.peiwatershedalliance.org

Case Studies

ECOLOGICAL MONITORING AND ASSESSMENT NETWORK (EMAN)

No longer in operation, EMAN was funded by Environment Canada from 1994 to 2010. Operating at the national level, EMAN was a network of organizations involved in ecological monitoring in Canada to better detect, describe, and report on ecosystem changes. EMAN promoted the integration of long-term, multidisciplinary ecosystem research projects and their results across Canada, and helped to standardize protocols and contributed to making data accessible. Many conservation professionals and citizen scientists continue to monitor using these protocols.

During its existence, EMAN effectively demonstrated the importance of connecting different stakeholders, including citizen scientists, through their shared goal of monitoring ecosystem change across Canada using standardized protocols. EMAN also demonstrated the importance of secured funding and a leadership role through a Coordinating Office to strengthen the network. However, relying solely on a single source of funding, particularly government funding, is risky with budget cuts. A model with more distributed authority in terms of governance and funding would have increased the resiliency of the network.

For more information, see the archived ECCC website for EMAN:
http://www.ec.gc.ca/faunescience-wildlifescience/default.asp?n=E19163B6-1

ARCTICONNEXION, POND INLET COMMUNITY-BASED WATER MONITORING

Located in Pond Inlet, Nunavut and working in adjacent watersheds, ARCTIConnexion's objectives are to implement a novel research framework based on community leadership, cultural relevance, and youth skills development for advancing scientifically rigorous water research capacity in Nunavut. Local watershed monitoring employs field- and satellite-based data to integrate various measures:
- climate (weather)
- landscape parameters (vegetation, soils, permafrost)
- hydrological conditions (stream flow, water level)
- water quality measures (DO, pH, conductivity, bacterial, benthic invertebrates)

Additionally, participatory mapping and traditional knowledge is used to guide the research locations and questions.

The program's focus on community-led research with scientific mentorship builds research capacity in a decolonizing and empowering spirit of truth and reconciliation. The program has seen progress in reframing the position of Inuit traditional knowledge and scientific knowledge in Arctic research settings and has already been successful in establishing community laboratory infrastructure in Arctic communities. The Project is expanding with water quality projects in the communities of Arviat, Baker Lake, and Taloyoak, Nunavut. **For more information, see the ARCTIConnexion website:**
http://arcticconnexion.ca/project/pond-inlet/

Data
Management

LEAD AUTHOR

Carolyn DuBois, Water Program,
The Gordon Foundation

LEAD REVIEWERS

Claire Herbert, Canadian Watershed Information Network

Gabrielle Parent-Doliner, Swim Guide, Swim Drink Fish

Peter Pulsifer, Exchange for Local Observations and
Knowledge of the Arctic (ELOKA), University of Colorado

Overview

Among the most frequently cited motivations for collecting water quality data through CBWM is the hope that the information generated will inform water stewardship decisions and policy. And, while CBWM groups are collecting data that could be used in this way, it often doesn't reach decision-making tables (Weston and Conrad, 2015; Vines et al., 2014; Kanu et al., 2016). One of the barriers to this is the limited capacity and infrastructure that communities have to manage the data they collect (Pulsifer and McNeave, 2014; Michener, 2015). The end result is that when CBWM data is available, it is often scattered and inconsistent, making it difficult for communities and other end-users to interpret and use them for decision-making.

The impact of this is well-illustrated in the challenges WWF Canada encountered in producing its Watershed Health Assessments. This nation-wide assessment could not obtain sufficient data to calculate health scores for 65% of watersheds, despite the existence of comprehensive CBWM programs in some of these places. Though WWF did an extensive search for any data available, CBWM data was, quite literally, not on the map (WWF-Canada, 2017).

Challenges

The following challenges are common to CBWM data management:

- Data is stored in formats that are difficult to use in an analytical environment (such as in PDF or even paper format), not open (in formats that require the purchase of software), or difficult to aggregate with other datasets (i.e., "non-interoperable");

- Concerns exist about data sharing and how this impacts data security, ownership and control; this includes ensuring that data and its management can support decolonization efforts and avoid reintroducing colonial concepts and patterns.

- Data management infrastructure can be costly and cumbersome to develop and maintain. This is particularly true for groups seeking to adapt existing data management systems to new data models;

- There is a lack of financial and human resources to manage data once it is collected (Kanu et al., 2016).

Additional challenges, particularly relating to research and monitoring conducted by or with Indigenous communities, relate to processes around the treatment of sensitive data such as health data, or Indigenous knowledge about places with cultural or sacred significance (Johnson et al., 2015).

Opportunities

While communities do face real challenges managing their data, these are not intractable issues. Thanks to a combination of both technological advances and sociocultural shifts across disciplines and sectors, the data management issues of CBWM are arguably more solvable than they have ever been (Patterson et al., 2017; Cantor et al., 2018).

The advent of computer and web-based technologies alone presents tremendous opportunities to amplify the impacts of CBM initiatives. When datasets are well-managed, are available in formats that permit re-use, and when they are accompanied by detailed metadata (information that describes how, why and by whom the data were collected), there are considerable benefits including: protection against data loss; establishing baseline conditions; efficiency in research; and scaling up impacts from the community to a broader watershed or basin scale (DuBois as cited in Kanu et al., 2016, p.18).

Solutions to CBWM data management challenges do exist but navigating the vast landscape of tools, standards and platforms is a daunting challenge for both the data collectors who are seeking to manage and share data, as well as for the data users seeking to glean insights from that data to inform a complete picture of watershed health. This is where strategic support and leadership are needed from multiple partners including the federal government.

Data Management Principles

1. ETHICALLY OPEN ACCESS

Provide ethically open[2], accessible and understandable data. Open access datasets are distributed freely online without costs or other barriers (i.e. requiring login).

2. CLARITY ON INTELLECTUAL PROPERTY

Follow practices that support privacy, intellectual property rights, and sovereignty (Pulsifer and McNeave, 2014). It should be clear to contributors and end users who owns and has rights to data.Sustainability: Developing a data management plan that considers governance, financing, architecture, and long-term maintenance and operations can help ensure that data management practices are sustainable.

3. PERMANENT IDENTIFIER

Assigning permanent identifiers to datasets increases accessibility, enables clear citation, and identifies licensing terms, thus reducing chances of misuse. Digital Object Identifiers (DOIs) are the most common but others might include Uniform Resource Identifiers (URIs) and the Handle System (hdl).

4. DATA QUALITY

It is not always necessary to have access to high-quality data but rather to always know the quality of the data available. This can be achieved through use of robust documentation and metadata: the "who, what, where, when, and how of the data collection, or in other words, data about the data" (Pulsifer and McNeave, 2014)

5. STANDARDIZATION AND INTEROPERABILITY

Standardization ensures data is available in consistent, predictable, machine readable and internationally-recognized formats. This promotes "interoperability" in which an ecosystem of specialized hubs can connect in dynamic ways to match user needs and questions.

6. SUSTAINABILITY

Developing a data management plan that considers governance, financing, architecture, and long-term maintenance and operations can help ensure that data management practices are sustainable.

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[2] Open data accounts for the need to appropriately manage the sensitive nature of some forms of data, such as. health records. (Pulsifer et al., 2013)

Draft Recommendations

The federal government can help improve CBWM data management by taking the following actions:

1. Extend "open by default" approach to federally-funded CBWM while upholding principles of data sovereignty as articulated by Indigenous peoples.

- Lead by example by making the federal CABIN database open access.

- Extend the federal government's "Open by Default" policy to the CBWM groups it supports by making open sharing of data a requirement of receiving federal funding (though note that exemptions should be made for any sensitive data or knowledge).

- Within Indigenous contexts, nation-to-nation relationships and principles of data sovereignty should be respected and implemented. The OCAP® principles[3] (ownership, control, access and possession) set useful standards for how to conduct research with First Nations, including how to approach data management (First Nations Information Governance Centre, n.d.).

2. Incubate and scale existing data management efforts.

- Take stock of where CBWM data is currently housed and shared.

- Provide long-term support for existing independent data sharing platforms such as DataStream, CanWIN and Swim Guide so that they can serve the needs of CBWM groups.

- Encourage CBWM groups funded through federal programs to use existing platforms wherever possible rather than building new systems from scratch.

3. Build CBWM data management capacity.

- Tie CBWM funding to data management-related activities, that is, require that fundees provide a data management plan. This could include releasing final payment only once groups can demonstrate how and where data is being managed and, where appropriate, made open to the public.

- Support communities in developing data management expertise.

- Recognize that a data system includes social and organizational components such as policy, access models, legal and ethical dimensions and other facets related to the human context.

- Invest in "data rescue" by supporting initiatives to digitize and manage historical CBWM data.

4. Support the development of standardized monitoring protocols, where appropriate:

- Invest in collective efforts to standardize protocols, including best practices to ensure spatial, temporal, and methodological consistency.

- Following principles of open government, ensure protocols are openly shared and accessible.

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[3] OCAP® is a registered trademark of the First Nations Information Governance Centre (FNIGC)

Case Studies

DATASTREAM

Currently operating in the Mackenzie River Basin, Atlantic Canada, and the Lake Winnipeg watershed, DataStream provides the infrastructure to support open sharing of water quality data across multiple monitoring programs and jurisdictions. Led by the Gordon Foundation at the national level, DataStream's regional partners include the Government of the Northwest Territories (GNWT) in the Mackenzie River Basin; the Atlantic Water Network (AWN) in Atlantic Canada; and the Lake Winnipeg Foundation in the Lake Winnipeg watershed. Data Stewards, or contributors, include watershed groups, Indigenous Guardian programs, governments and researchers.

DataStream employs a strong partnership model across regional hubs. All activities are carried out in collaboration with leading organizations across the country that are well-placed to effect change at the right levels. As well, DataStream is free and open for anyone to use. This approach has an embedded economy of scale, meaning that with each new iteration and improvement to the system, every monitoring organization, contributor, and user benefits.

For more information see the Gordon Foundation website: http://gordonfoundation.ca/ initiatives/datastream/

CANADIAN WATERSHED INFORMATION NETWORK

Focused on the Lake Winnipeg Basin, the Canadian Watershed Information Network (CanWIN) is a web-based collaborative platform hosted at the University of Manitoba (UM) and supports research, education, management, policy and evidence-based decision-making about nutrient- and climate-related issues. CanWIN (formerly the Lake Winnipeg Basin Information Network) was created by Environment Canada as part of the Lake Winnipeg Basin Initiative under Canada's Action Plan on Clean Water and was transferred in 2012 to UM, where it benefits from a core funding model.

CanWIN currently hosts many different types of data, from community-based monitoring to historical and active research programs. CanWIN provides support to users on managing the complete data lifecycle, from project conception to data sharing. By working with multiple data managers, users and subject matter experts, CanWIN is working towards national and international standards for a common vocabulary and metadata, which increases the interoperability and therefore usability of the data. This harmonizing of disparate data and language enables users to ask new research questions by giving them the ability to analyze complex, multi-themed watershed issues across broad spatial and temporal extents.

For more information see the University of Manitoba website: lwbi.cc.umanitoba.ca

EXCHANGE FOR LOCAL OBSERVATIONS AND KNOWLEDGE OF THE ARCTIC

An international organization focused on the Arctic, Exchange for Local Observations and Knowledge of the Arctic (ELOKA) provides support to Indigenous organizations, communities, and researchers across a number of areas related to data management and use, while supporting communities in their efforts to attain data and information sovereignty in the Arctic. Primarily, ELOKA receives funding through the U.S. National Science Foundation to provide a range of data management support services.

ELOKA operates under the premise that meaningful knowledge exchange can only be achieved by linking physical networks, or technology, and human networks: community members, researchers, decision-makers, trainees, and others. ELOKA partners with Indigenous community members and representative organizations and networks all across the Arctic, from Canada and the U.S. to Greenland and Russia. ELOKA convenes workshops and events to facilitate exchange around themes related to data sovereignty, data management, and community-based observing.

In Canada, ELOKA provides data management support to community-based monitoring initiatives with the explicit goal of upholding Indigenous ownership and authority over Indigenous knowledge and data, for example, by following OCAP® principles across Canada and adhering to community-based research guidelines established in partnership with specific communities and research bodies such as the Natural Sciences and Engineering Research Council (NSERC), Social Sciences and Humanities Research Council (SSHRC), and Canadian Institutes of Health Research (CIHR) (Johnson et al., 2015).

For more information see the ELOKA website: https://eloka-arctic.org
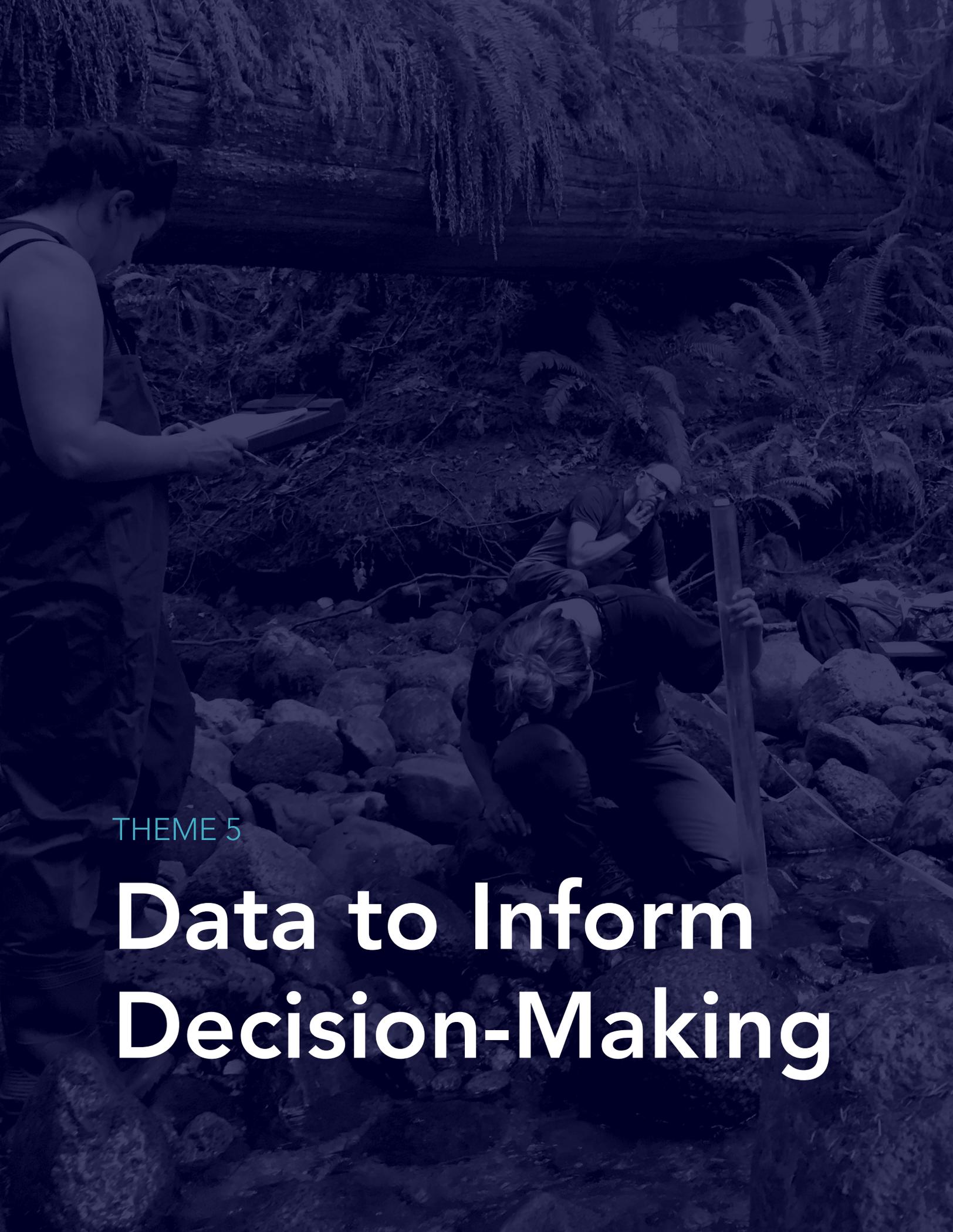
THEME 5

Data to Inform
Decision-Making

Overview

Community-based water monitoring is generating valuable information and engagement around freshwater issues from the ground up. But how can these efforts be mobilized to drive action on protecting and restoring the health of freshwater resources and ecosystems? Addressing this question requires an understanding of the end uses (and users) of CBWM data, and the types and format of information that are best suited to serve those uses and users.

Challenges

The following are common challenges encountered when applying CBWM data in decision-making:

- Confusion about the types of data needed by decision-makers and how the data are used makes it difficult for CBWM groups to ensure that their programs are relevant and reaching the right audiences. Many complex decision-making processes make it difficult to understand if, how and when CBWM data can plug in.

- Limited support and capacity for data analysis, interpretation, visualization and communication of CBWM data are limiting the translation of raw data into useable information and knowledge.

- There are perceived administrative and legal barriers to use of CBWM-generated data in government decision-making and a lack of overarching policies on integration of CBWM into decision-making.

- There is confusion around how to meaningfully and respectfully include IK in policy and other decision-making processes.

Opportunities

CBWM is already contributing critical data towards a shared knowledge base and better understanding of environmental change. It has the potential to serve a wide range of purposes, from the design and implementation of public awareness campaigns and tracking long-term trends in water quality, to specific decision-making processes such as policy development, planning, regulatory compliance, and stewardship programs. CBWM data also has potential for use at multiple, nested scales ranging from particular places, neighbourhoods and communities to watersheds, provinces and territories, Indigenous territories and across the country.

When the desired end use of the data is clear, appropriate protocols for data collection, management, interpretation, and communication can be chosen accordingly. Ethically open data supports data reuse, for example to answer different research questions or for different scales of analyses, while democratization of research and science can be further supported through methods and tools that support communication of information in formats that are accessible, culturally appropriate, and contextually useful (Kanu et al., 2016).

For CBWM initiatives led by or involving Indigenous peoples, sharing of information and knowledge should also respect and be guided by cultural protocols and other standards developed by Indigenous governments and organizations, such as the First Nations Principles of OCAP® (Johnson et al., 2015).

PUTTING KNOWLEDGE INTO ACTION

Research shows that community-led monitoring can increase the speed of decision-making at the local level. This is because community members are best placed to observe environmental change in real-time, are more motivated to guide management actions that affect them directly (Danielsen et al., 2014; Conrad and Hilchey, 2010), and are well-placed to assess the success of management actions taken to address problems or threats. Successful examples of knowledge mobilization through CBWM, such as the Canadian Shellfish Sanitation Program and the Northwest Territories-wide CBM Program case studies noted below, illustrate how programs that are designed specifically to incorporate CBWM can be effective in facilitating exchange of data and information, and make it easy for monitoring groups to see their observations applied to real-world issues.

The Canadian Aquatic Biomonitoring Network (CABIN) provides an example of putting CBWM data into action at the national level. Maintained by ECCC, the CABIN is a "network of networks" consisting of government organizations at all levels, Indigenous communities, academia, industry, and other NGOs. CABIN data is housed in a centralized ECCC database that is designed to enable data sharing. It is anchored by a nationally consistent training program, implemented and maintained in partnership with the Canadian River Institute, that provides the knowledge and skills required to conduct a biomonitoring program to consistent national standards. The "network of networks" approach amplifies the collection of information and allows for cost-effective, powerful data sharing to inform resource management decision making and support the assessment of cumulative effects.

FUTURE DIRECTIONS

There is also emerging work pointing to the potential of CBWM as a tool for asserting Indigenous sovereignty, jurisdiction, and authority in decision-making processes (Kotaska, 2013; Wilson et al., 2018). The Mikisew Cree development of an Aboriginal Extreme Flow concept for the Athabasca River is one example: "Data has been used to validate the concept of the Aboriginal Extreme Flow… and to constructively challenge aspects of Alberta's Surface Water Quantity Management Framework, most notably the assumptions in their Aboriginal Navigation Index or ANI" (Mikisew Cree First Nation, 2016, p. 6).

Despite these successful case studies, a recent study suggests that Canada lags behind other countries when it comes to incorporating CBWM data into monitoring, legal, and regulatory frameworks governing water quality and quantity (University of Victoria Environmental Law Centre, 2018). Other jurisdictions, such as the United States and the European Union, have begun institutionalizing processes to facilitate the consideration of CBWM, and all types of citizen science, in decision-making processes. A number of federal laws and programs in the U.S. have intentionally built in opportunities for public participation in decision-making through monitoring and data sharing arrangements[4]. There is a significant opportunity for Canada's federal government to draw on both successful domestic examples and global experience to strengthen policy frameworks and develop the supports needed to better connect CBWM data and programs to decision making.

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[4] This was set in motion by a 2015 memorandum issued by the President's Office of Science and Technology Policy to the federal government, instructing various agencies to promote the use of citizen science data in government science and policy (Office of Science Technology and Policy, 2015).

Draft Recommendations

The federal government can help mobilize knowledge for action with the following actions.

1. Coordinate federal support to strengthen CBWM through a cross-departmental strategy:

- Champion a focus on CBWM at Canadian Council of Ministers of the Environment (CCME)
- Develop a cross-departmental strategy to support and leverage CBWM in Canada

2. Better integrate CBWM data in decision-making at various levels (policy, planning and management).

- Identify appropriate opportunities to write provisions for use of CBWM data into existing decision-making processes related to water management and policy (e.g. under the Fisheries Act, proposed Impact Assessment Act, Canadian Navigable Waters Act).
- Support regional/drainage basin scale CBWM data comparison, integration and analysis
- Provide clarity around acceptable thresholds for data quality (tied to specific intended uses).
- Support development of tools and approaches to help contextualize raw CBWM data.
- Track the ways in which government departments use CBWM data in decision-making and publicly report on these data uses (E.g., through use of DOIs).

3. Promote knowledge-sharing best practices in government-funded research and science.

- Promote development of tri-agency partnerships with CBWM initiatives and incentivize the use of citizen science data in water research through grant applications.
- Encourage academics to be involved in other forms of communication beyond peer-reviewed publications. Encourage recognition of the value of non-traditional outputs.
- Adopt the principles of transparency, openness and mindfulness regarding data stewardship and its reuse.
- Ensure that information and knowledge products derived from CBWM data for policy are first reported back to the community in a timely fashion.
- Work with the tri-agencies to reduce "embargo periods" in federally funded research involving CBWM partnerships and data.
- Respect Indigenous policies, standards and protocols relating to the use of Indigenous knowledge and data collected by and in Indigenous communities.

Case Studies

WWF-CANADA'S WATERSHED REPORTS

Through its Watershed Reports, WWF-Canada set out to create the first national picture of the health of and threats to Canada's freshwater. While WWF-Canada doesn't engage in monitoring, the Watershed Reports use data from as many monitoring organizations as possible. Watershed Reports take data and complex analysis to transform them to create a product that is easily transmissible and understood.

To create the Reports, WWF-Canada first consulted with leading freshwater scientists to develop an assessment framework. That framework was then used to produce reports on the health and threats to Canadian rivers. An interactive website was designed to publish the results, engage Canadians and raise awareness about the watersheds they live in.

This platform and project can give a voice to smaller monitoring groups and make them a part of national freshwater discussions. Often, groups operating on a smaller scale have nowhere to share their data, meaning it doesn't get used as much as it could. Watershed Reports gives them that option. Since its creation, Watershed Reports has been used by many individuals and organizations to advocate for infrastructure, water management and policy changes. Many organizations use the results as leverage to support their own work, or even use it to establish priorities.

For more information see the website for WWF-Canada's Watershed Reports:
http://watershedreports.wwf.ca/#canada/by/threat-overall/profile

SWIM DRINK FISH

A national initiative, Swim Drink Fish is a stewardship organization focused on blending science, law, education, and storytelling with technology, and works towards swimmable, drinkable, fishable water for everyone.

Swim Drink Fish's initiatives have different way of sharing knowledge, using digital communications technology to promote public access to information wherever and whenever people need it. Swim Drink Fish uses made-in-house apps and web platforms to communicate that information to the public.

Swim Drink Fish has demonstrated that there is demand for data sharing standards, especially in a field where monitoring practices are relatively well-established and consistent. The biggest challenge continues to be the clash between today's "open by default" mentality and the traditionally closed mentality of government and institutional data-holders. Whenever Swim Drink

Fish has struggled to deliver current water quality information to the public, it has been largely due to attitudes towards data sharing, rather than because of technical or financial barriers.

For more information see the Swim Drink Fish website: http://www.swimdrinkfish.ca/

CANADIAN SHELLFISH SANITATION PROGRAM

The Canadian Shellfish Sanitation Program (CSSP) is a federal food safety program jointly administered by the Canadian Food Inspection Agency (CFIA), DFO and ECCC. The goal of the CSSP is to protect Canadians from the health risks associated with the consumption of contaminated bivalve molluscan shellfish such as mussels, oysters and clams. Under the CSSP, ECCC's Shellfish Water Classification Program (SWCP) conducts surveys of bivalve molluscan shellfish growing areas for the purposes of classifying areas for harvesting of species.

The CSSP has several active partnerships with Indigenous communities in B.C. to collect marine water quality samples as an alternative service delivery option for the program, including with the Tsleil-Waututh Nation (TWN) in Indian Arm. On October 25, 2016, the TWN completed their first FSC harvest in 34 years with the collection of 17.9 kg of softshell clams!

For more information see the Canadian Shellfish Sanitation Program website: http://www.inspection.gc.ca/food/fish-and-seafood/shellfish-sanitation/eng/1299826806807/1299826912745

NORTHWEST TERRITORIES CUMULATIVE IMPACTS MONITORING PROGRAM

Based in the Northwest Territories, the Cumulative Impacts Monitoring Program (CIMP) supports better resource management decision-making and the wise use of resources by furthering the understanding of cumulative impacts and environmental trends. Monitoring cumulative impacts is a constitutional obligation of the Sahtu, Gwich'in and Tłı̨chǫ comprehensive land claim agreements and a statutory requirement of Part 6 of the Mackenzie Valley Resource Management Act.

The program uses a partnership approach to achieve its objectives. Partners include Aboriginal governments, universities, industry, and federal and territorial government departments. A steering committee of First Nations, Inuvialuit, Métis, federal and territorial government representatives guide the program.

All NWT CIMP project results are available on the NWT Discovery Portal. Also, beginning in 2016, all data from currently funded NWT CIMP water quality projects is available on the Mackenzie DataStream.

For more information see the description of the Cumulative Impacts Monitoring Program on the GNWT website: http://www.enr.gov.nt.ca/en/services/cumulative-impact-monitoring-program-nwt-cimp/about-us

GROUPE D'ÉDUCATION ET D'ÉCOSURVEILLANCE DE L'EAU (EDUCATION AND WATER MONITORING ACTION GROUP)

Based in Québec, Prince-Edward Island and French communities in New Brunswick and Manitoba, la Groupe d'éducation et d'écosurveillance de l'eau (G3E) (Education and water monitoring action group) works towards the protection of aquatic ecosystems through the development of citizen science initiatives as well as educational and scientific tools useful for aquatic ecological monitoring. Having received initial support from ECCC's Biosphere and from a variety of different partners, G3E now ensures its finances through a variety of funds, from government to private.

Since 2000, over 50 000 young people and 50-plus organizations have participated in the projects, and more than 275 bodies of water have been studied and adopted. Annually, close to 3000 young people participate, over 50 bodies of water are monitored, and 35 organizations either participate or help with co-ordination. Having a team of regional co-ordinators has multiplied the impacts of the programs and increased G3E's reach. Outcomes of G3E's programs could not have been achieved without collaborating with a diverse group of external partners. Critical knowledge sharing and transfer is due in large part to this regional co-ordinating team as well as the openness of G3E and its partners to share their experiences and tools, allowing a greater number of citizens to participate in monitoring their waters

For more information see the G3E website: http://www.g3e-ewag.ca/home.html

THEME 6

Sustainable Funding

Overview

Community-based Water Monitoring (CBWM) is, by nature, a continuous process that yields many of its greatest benefits if performed consistently over long periods of time. Thus, sustained funding is key to achieving the full benefits of CBWM for communities and governments alike.

Indeed, some of Canada's most successful CBWM programs are not necessarily the ones with the most funds in a given year, but those with sustained funds year over year. This enables groups to build the capacity to not only be effective in their monitoring efforts but yield significant financial and non-financial benefits. For instance, through the Atlantic Coastal Action Program (ACAP), Environment Canada provided core funding to each of the ACAP groups (see the case study at the end of Theme 1: Capacity Building) ,who were then able to leverage these funds well beyond their original value to achieve greater social, economic and environmental outcomes. The financial benefits of ACAP are well documented.

Had Environment Canada conducted the same work using a traditional approach, with government offices and employees rather than a community-led approach, it would have had to spend 12 times as much money to derive similar benefits. ACAP's economic impact (GDP) was, in total, about 22 million dollars in direct and spin-off economic activity from 1997 to 2001, which far exceeds Environment Canada's six million-dollar investment (McNeil et al., 2006 pg. 373).

Beyond yielding a high economic return on investments, depending on the level of community ownership and participation, CBWM can generate a range of benefits by building on many different community values, as seen in Figure #.

Coastal Guardian Watchmen programs generate 10 to 1 annual return on investments

The Coastal Guardian Watchmen programs illustrate how much value can be derived from investments in community-led monitoring initiatives. The Coastal Guardian Watchmen programs operate under management agreements that respect the title and rights of First Nations in ancestral traditional territories and undertake the following activities consistent with CBWM:
- Gather data on the ecological health and community wellbeing;
- Compile and share data to inform decision-making, and
- Work with Coastal First Nations, provincial and federal governments to ensure coordinated and robust monitoring and enforcement of environmental management plans.

A costs and benefits analysis that examined both monetary (e.g., wages) and harder to measure non-monetary community values (e.g., cultural wellbeing, community capacity, governance authority, and taking care of territory, among others) found that Guardian Watchmen Programs generate a 10 to 1 annual return on investment (ROI) within the coastal First Nations that operate them. In other words, for every dollar invested, the Nation benefits 10 times that amount. For some programs, the First Nation can benefit from an annual ROI as high as 20 to 1. These contributions also extend beyond the First Nations that lead the programs, benefiting other coastal communities, government agencies, and the broader Canadian public. (EcoPlan International, 2016)

Challenges

CBWM groups frequently encounter the following challenges:

- **Short-term funding:** For CBWM programs that rely on governments to sustain their activities, the need for long-term core funding is often at odds with federal policy and budgetary timelines. Funding agencies both within and outside of governments rarely provide multi-year funding for monitoring, and when they do, the support will typically not extend beyond three years.

- **Project-based funding:** It is widely acknowledged that "without long-term, holistic, and sustainable financing for CBM, initiatives are constrained to the project level" (Bellfield et al., 2015, p. 153). Funding shortages, created by short-term or project-based funding models, have also been linked to poor data quality and fragmentation issues (Bliss et al., 2001; Conrad and Daoust, 2008). Unstable funding results in inconsistent monitoring activities and reduces the credibility and utility of CBWM data.

- **Eligible costs:** Tight restrictions on eligible costs on the part of different funders poses a significant challenge to CBWM groups tasked with covering all phases of a monitoring program from data collection and management to analysis, interpretation and reporting. Desire for tangible outcomes (as reported in metrics and before / after) detracts from funding for less easy to quantify outcomes such as social connection and knowledge sharing through water.

Opportunities

SHIFTING FUNDING MODELS
The financial and non-financial benefits of CBWM programs justify a shift towards multi-year or core funding models (Bonney et al., 2014; Conrad and Daoust, 2007; EcoPlan International, 2016). We echo Conrad and Hilchey's findings, noting that "if relevant government agencies have the foresight to acknowledge the multiple benefits of CBM programs and want to link

their efforts to enhanced environmental management, they can make funding for CBM a priority" (2010, p. 282).

Some provincial and territorial governments are already championing inventive funding models that provide reliable, long-term resources for community-led monitoring and water stewardship initiatives. For instance, the Northwest Territories Community-Based Monitoring Program represents an example where the GNWT provided long-term funding to support CBWM. A plan and associated funding for CBWM is embedded in the NWT Water Strategy, indicating a formal recognition of its value in achieving shared water objectives. For more information about the NWT-Wide Community-Based Water Monitoring Program, see their website (https://www.nwtwaterstewardship.ca/node/105).

Efforts to shift from project-based to core funding models are also being tested by some federal government departments. Though the impacts have not yet been measured, CIRNAC has recently invested $31.4 million over five years for the Indigenous Community-Based Climate Monitoring Program, signaling a shift away from project-based funding models. ECCC also recently awarded Swim Drink Fish $1.8 million for CBWM in the Great Lakes, which includes establishment of monitoring hubs in three Indigenous communities (see case study in Theme 5: Mobilizing Knowledge for Action).

Adaptive and resourceful CBWM programs can thrive during periods of fiscal austerity and political change by leveraging the funds that are available, particularly when they are well-networked and have at least one permanent staff person. That said, as argued in a recent assessment of the Canada-wide CBWM landscape, "considering that CBM is often indirectly supporting the mandates of multiple levels of government responsible for water-related issues, governments should play a role in alleviating the financial, technical and logistical burdens associated with CBM" (Carlson and Cohen, 2018, p. 175).

Draft Recommendations

The federal government can help mobilize knowledge for action with the following actions.

1. Develop multi-year, core funding options.

- Develop multi-year, core funding for CBWM programs rather than project-based funding wherever possible.

2. Fund new and existing Indigenous Guardian Programs to improve Indigenous-Crown relationships and advance reconciliation through Indigenous-led programs

- Continue to provide long-term funding through initiatives like the Indigenous Community-Based Climate Monitoring Program, the Indigenous Guardians Program and the Aboriginal Aquatics Resources and Ocean Monitoring Program.

3. Streamline and simplify federal funding processes.

- Address tight turnaround times for funds granted and required spending that don't reflect the reality of monitoring timeframes.
- Adapt prescriptive funding models: recognize that the competitive funding landscape creates unequal opportunities and that some CBWM programs require additional resources and support (e.g., more rural or isolated sites requiring additional mileage allowances)
- Take a less restrictive approach to eligible expenses

4. Embed CBWM spending within federal water monitoring budgets

- Explore co-management approaches that embed long-term funding for CBWM within federal water management frameworks to combine efforts, achieve common goals, and avoid duplication.

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Appendix

Selected federal programs and funds relating to CBWM

A number of federal and provincial departments currently or have previously supported CBWM initiatives through funding programs, training, or the provision in-kind resources. Examples include but are not limited to the following:

ENVIRONMENT AND CLIMATE CHANGE CANADA

Community Aquatic Biomonitoring Network (CABIN)
Great Lakes Sustainability Fund
Lake Winnipeg Basin Stewardship Fund
Atlantic Ecosystems Initiative
Indigenous Guardians Fund
Gulf of Maine Initiative
St. Lawrence Action Plan
EcoAction Community Funding
Environmental Damages Fund
Great Lakes Protection Initiative

CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

Northern Contaminants Program
Indigenous Community-Based Climate Adaptation Monitoring Program

DEPARTMENT OF FISHERIES AND OCEANS

Aboriginal Aquatic Resource and Oceans Management Program (AAROM)
Community Aquatic Monitoring Program (CAMP) (cross-appointed with ECCC)
DFO Partnership Fund
Coastal Restoration Fund

RESEARCH GRANTING COUNCILS

Natural Sciences and Engineering Research Council
Social Sciences and Humanities Research Council
Canadian Institutes of Health Research
Canada First Research Excellence Fund - E.g., Global Water Futures Program

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Final Recommendations

Elevating Community-Based Water Monitoring
in Canada

About This Document

These recommendations are the outcome of a national roundtable discussion aimed at identifying actionable steps the federal government can take to show leadership and support in advancing community-based monitoring of freshwater ecosystems in Canada. The roundtable was convened in November, 2018 by Living Lakes Canada, WWF-Canada and The Gordon Foundation. All three organizations engage with CBWM in different ways and are committed to advancing collaborative and evidence-based water stewardship across Canada.

The convening team thanks the roundtable participants for their willingness to share their work, knowledge and expertise with the Government of Canada. We would also like to thank Environment and Climate Change Canada (ECCC) and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) for providing financial and in-kind support for this initiative and most importantly for their openness and willingness to work collaboratively towards achieving shared water stewardship objectives.

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Overview

In November of 2018, The Gordon Foundation, Living Lakes Canada and WWF-Canada convened a collaborative dialogue around federal government engagement and support for community-based water monitoring (CBWM) in Canada. The key objective was to identify actionable steps the federal government can take to show leadership and support in advancing community-based monitoring of freshwater ecosystems in Canada.

More than 50 leading Indigenous and non-Indigenous CBWM practitioners, water scientists, policy and data experts took part in panels and workshops designed to illuminate the breadth and diversity of initiatives across the country, along with common challenges and opportunities.

Through focused discussions, participants developed tangible recommendations on how the federal government can strategically engage with and support CBWM efforts across Canada. Recommendations are divided into the following key thematic areas of focus:

1.   Capacity building
2.   Effective monitoring
3.   Data management
4.   Regional and national collaboration
5.   Data to inform decision-making

Water governance in Canada is complex and cross-jurisdictional. While this fragmented landscape poses challenges, community groups offer an untapped capacity. The federal government can overcome fragmentation by working alongside CBWM initiatives to ensure communities and governments have the data necessary to manage and maintain healthy freshwater resources[1].

To support reconciliation with Indigenous peoples, any implementation of the recommendations outlined below must uphold the standards of UNDRIP and the federal government's Principles Respecting the Government of Canada's Relationship with Indigenous People[2].

The following recommendations for the Government of Canada were developed collaboratively with diverse experts, including individuals with practical experience carrying out both Indigenous and non-Indigenous CBWM programs, combined with insights drawn from roundtable participants.

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[1] While federal supports for CBWM are the focus of these recommendations, many Indigenous Nations, municipalities, provinces and territories provide significant supports for CBWM through leadership, collaboration, and resourcing.

[2] These principles mark a move to align federal policy with the provisions of UNDRIP, such as affirming self-determination and free, informed and prior consent. The Declaration can be read on the U.N. website, accessible at www.un.org/development/desa/indigenouspeoples/ declaration-on-the-rights-of-indigenous-peoples.html.The federal government's principles can be found on the Department of Justice Canada's website, accessible at www.justice.gc.ca/eng/csj-sjc/principles-principes.html.

Capacity Building

The following actions can be taken by the federal government to build capacity for CBWM.

1.1 Invest in cross-sectoral partnership development.

- Take stock of the nature and effectiveness of engagements in CBWM by federal departments and agencies, including levels of engagement, scope of financial and human resource investments, and objectives of the programs. Determine levels of investment of human and financial resources, identify common goals and objectives across programs, and assess key strengths and weaknesses in engagements.

- Develop partnerships with CBWM organizations and other sectors to conduct monitoring.

- Partner with Indigenous "bridging organizations" to leverage existing capacities. Bridging organizations refer to groups and organizations that create connections across sectors and at different levels of governance to build trust, share resources and knowledge, and facilitate co-ordinated action towards achieving common goals and mandates.

- Increase the level and duration of funding for Indigenous-led CBWM programs such as Indigenous Guardians.

1.2 In Indigenous monitoring contexts, give highest priority to Indigenous protocols and policies in establishing CBWM programs and undertaking collaborative data collection.

- Ensure that investment begins with acknowledging Indigenous self-determination and accounts for the broader political, economic, and jurisdictional challenges and inequities resulting from ongoing legacies of colonialism.

- Encourage non-Indigenous partners within federal departments to build their capacity to work with Indigenous peoples by improving individual and organizational understanding of Indigenous systems of knowledge, law, and governance, for example, through training.

- Focus capacity-building efforts on investments that are directed by community needs and ensure that these are honoured in knowledge-sharing and program governance agreements.

1.3 Invest in youth programming to strengthen and grow CBWM by improving access to required tools and training.

- Work with Indigenous and non-Indigenous CBWM practitioners to implement training in field practices and specific protocols. Examples of such approaches include:

- Canadian Aquatic Biomonitoring Network (CABIN)

- Environment Technology programs

- Academic accreditations for work done in the field, specifically for Indigenous Guardians

- Train the trainer programs

- Safety training (First Aid, CPR, swift water rescue, etc.), especially for those working in remote locations

- Indigenous Guardians programs and internships

- Provide more opportunities for Indigenous and non-Indigenous CBWM practitioners to obtain training in data management, analysis and interpretation.

1.4 Support expenses of monitoring by providing access to lab space, in-kind support, or both, for lab analyses, as use of commercial labs can be cost-prohibitive.

Effective Monitoring

The federal government can take the following actions to encourage effective monitoring:

2.1 Participate in the co-design of water monitoring plans.

• Honour the importance of Indigenous knowledge and local perspectives in the creation of water monitoring plans that are driven by community questions and needs.

• In co-designing, identify through existing provincial and federal monitoring agreements and CBWM programing opportunities where existing research infrastructure (e.g., HYDAT stations network) or long-term datasets can be leveraged to determine data monitoring gaps and needs.

• Support development of a CBWM program design toolkit and checklist in collaboration with experienced CBWM practitioners, both Indigenous and non-Indigenous.

• Provide leadership on best practices and standards for monitoring protocols, to ensure spatial, temporal, and methodological consistency and comparability amongst communities of practice, where desired and appropriate.

• Provide support for and participate in sampling and lab comparison studies to evaluate data comparability.

• Follow principles of Open Government, ensuring protocols are openly shared and accessible.

Regional and National Collaboration

The federal government can take the following actions to promote regional and national collaboration:

3.1 Facilitate coordination and collaboration among a growing range of actors.

- Support non-governmental organizations, platforms, and networks that are well-positioned to facilitate regional collaboration (e.g., Indigenous Leadership Initiative / Indigenous Guardians, Swim Drink Fish, Our Living Waters).

- Seek opportunities to co-design and manage water monitoring through mechanisms that promote cross-sectoral collaboration (e.g., watershed- and basin-based entities such as non-governmental organizations, water boards and councils).

- Follow best practices for program governance and community engagement when working within networks and with partnerships (e.g., Northern Contaminants Program).

  - Clearly articulate best practices in publicly accessible forums such as government websites.

  - Strengthen efforts to increase the role of Indigenous monitoring networks in federal water monitoring programming, as outlined in federal mandates.

3.2 Create formal, integrated regional liaison positions within existing entities or offices of federal departments and entities.

Regional liaison positions could accomplish the following goals:

- Create and maintain relationships both across federal departments and with external CBWM organizations, including provincial, territorial and Indigenous governments, NGOs, and academia

- Share knowledge on protocols, funding and training opportunities to maximize the impact of CBWM organizations in the areas where they work.

- Help CBWM groups make their data and information relevant to policy by ensuring it is available during policy and decision-making discussions.

- Act as a hub or institutional knowledge-keeper within federal government as part of a broader nation-wide CBWM network.

- Host a biennial gathering of CBWM organizations, where the focus would be on collaboration, idea exchanges and future planning, and where youth would be involved in all discussions. For example, the United States Environmental Protection Agency and other federal agencies sponsor gatherings for the North American National Water Quality Monitoring Council and Volunteer Monitoring Network.

- Promote CBWM across federal departments, for example, by integrating CBWM into individual departmental mandates, priorities and programs. Such positions could also examine funding sources from relevant departments to see how they can be adjusted to support CBWM.

- Broadly, actively and consistently engage in CBWM through the following activities:

- Attending local and regional non-governmental CBWM gatherings and water management meetings to enhance federal awareness of the scope of CBWM work across watersheds and to stay abreast of opportunities to collaborate;

- Investing staff time and resources (capacity, financial support, other infrastructure) in projects that are designed to bring local actors together to address practical issues of common concern.

Data Management

The federal government can help improve CBWM data management by taking the following actions:

4.1 Provide support to scale up existing data management efforts both within and outside government to leverage capacities and avoid duplicating efforts.

- Take stock of where and how CBWM data is currently housed and shared and make this information publicly available in a clearing house or catalogue.

- Where appropriate, leverage existing technology and support independent data sharing platforms[3] so that they can serve the needs of CBWM groups over the long term.

- Provide incentives for CBWM groups funded through federal programs to use existing platforms where possible rather than building new systems from scratch, and facilitate knowledge and resource sharing to this end.

4.2 Build CBWM data management capacity.

- Tie CBWM funding to data management-related activities; that is, require that fundees provide a data management plan and evidence of how and where data is being managed and shared

- When reviewing existing or proposed data management plans, ensure that there is adequate support and access to locally-relevant tools and training for managing data effectively.

- Encourage the use of existing data management best practices wherever practical and appropriate. Work with communities to ensure a good match between the practices put in place and the objectives of the monitoring program.

- Design data systems to reflect social and organizational components such as policy, data access models, legal and ethical dimensions and other facets related to the human context.

- Invest in "data rescue" by supporting initiatives to digitize and manage historical CBWM data.

4.3 Respect and implement principles of data sovereignty within Indigenous water monitoring contexts.

- In conducting research with First Nations, adhere to OCAP® principles (Ownership, Control, Access and Possession), which provide useful standards, including how to approach data management[4].

- In conducting research with Inuit, uphold their specific principles and guidelines for access, ownership and control over water data and information.

4.4 Provide leadership on best practices and standards for managing data to promote interoperability.

- Lead by example and promote use of FAIR data principles in design of data management systems (data is Findable, Accessible, Interoperable and Reusable).

- Champion and communicate existing and well-established data standards and help establish them where needed[5].

- Ensure that these resources are publicly available in plain language; for example, develop an online catalogue for data management standards, templates, and use case examples for data management methodologies that have worked well. Similar existing resources like the Portage Network hosted by the Canadian Association of Research Libraries could guide this process.

- Encourage and participate in adoption of a standard metadata schema, through a process of engagement with data providers and data users, to agree on common standards for data sharing.

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[3] For example, DataStream, the Canadian Watershed Information Network (CanWIN) and Swim Guide.

[4] OCAP® is a registered trademark of the First Nations Information Governance Centre (FNIGC).

[5] Including the US EPA WQX standard for water quality, the Swim Drink Fish Open Standard for Recreational Water, or the Open Geospatial Consortium Standards (i.e. Sensor Observation Service and WaterML).

Data to Inform Decision-Making

The federal government can help use data to inform decision-making with the following actions:

5.1 Co-ordinate federal support for CBWM across departments.

- Champion CBWM at the Canadian Council of Ministers of the Environment (CCME) by providing standards and other resources for CBWM groups and organizations.

- Develop a cross-departmental strategy to leverage CBWM in Canada. Ensure that this becomes part of the work plan for the federal liaison position recommended in Section 3.

5.2 Establish processes for integrating CBWM data into federal databases and decision-making at various levels (policy, planning and management).

- Include provisions for use of CBWM data in existing regulatory, legislative and policy processes with an impact on water, for example, under the Fisheries Act, proposed Impact Assessment Act, and Canadian Navigable Waters Act.

- Ensure CBWM data used in regulatory, legislative and policy processes not only includes empirical data, but can also include traditional and Indigenous knowledge and testimony.

- Work with communities and monitoring groups to develop tools and approaches that help provide context for raw CBWM data.

- Ensure CBWM groups understand when, where and how their data can be used in a policy context.

- Ensure governance systems include CBWM groups in decision-making processes.

- Track and report the ways in which government departments use CBWM data in decision-making to normalize the practice.

5.3 Promote knowledge-sharing best practices in government-funded research and science.

- Enable Tri-Agency partnerships[6] with CBWM initiatives, and provide incentives for the use of CBWM data in water research through grant applications.

- Work with the Tri-Agency administration to reduce "embargo periods" of data in federally-funded research involving CBWM partnerships or data.

5.4 Provide case studies of data analyses and interpretations to demonstrate how successful CBWM programs can inform decision-making.

- Recognize the value of non-traditional outputs beyond peer-reviewed publications among federal scientists and academic institutions working with communities. Examples range from non-academic reports to websites and other creative media.

- Before public dissemination, ensure that information and knowledge products derived from CBWM data are provided to the community that collected the data, and in a timely fashion.

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[6] The Tri-Agency Financial Administration includes the Natural Sciences and Engineering Research Council of Canada (NSERC), Canadian Institutes of Health Research (CIHR) and Social Sciences and Humanities Research Council of Canada (SSHRC)

Acknowledgments

The organizing team thanks the roundtable participants for their willingness to share their work, knowledge and expertise with the Government of Canada. We are especially grateful to the many advisors, authors, and key reviewers whose insight and contributions made this work possible. Our advisory group provided strategic direction and guidance from the project's initiation through to the publication of these final recommendations.

CAPACITY BUILDING

Bruce Maclean, Mikisew Cree First Nation Community-Based Monitoring Program

Gila Somers, Government of the Northwest Territories NWT-Wide Community-Based Monitoring Program

Jana Kotaska, Coastal Stewardship Network, Coastal First Nations – Great Bear Initiative

Joanne Nelson, Decolonizing Water Project, Program on Water Governance, University of British Columbia

Nicole Wilson, Program on Water Governance, University of British Columbia

EFFECTIVE MONITORING

Alexis Kanu, Lake Winnipeg Foundation

Kelly Munkittrick, Cold Regions and Water Initiatives, Wilfrid Laurier University

REGIONAL AND NATIONAL COLLABORATION

Alice Cohen, Acadia University

Edda Mutter, Yukon River Inter-Tribal Watershed Council

Emma Wattie, Atlantic Water Network

DATA MANAGEMENT

Carolyn DuBois, The Gordon Foundation

Claire Herbert, Canadian Watershed Information Network

Gabrielle Parent-Doliner, Swim Drink Fish

Peter Pulsifer, Exchange for Local Observations and Knowledge of the Arctic

DATA TO INFORM DECISION-MAKING

Lindsay Telfer, Canadian Freshwater Alliance and Our Living Waters

Meredith Brown and Larissa Holman, Ottawa Riverkeeper

Susan Leech, The Firelight Group

KEY REVIEWERS

Aislin Livingstone, The Gordon Foundation

Carolyn DuBois, The Gordon Foundation

Catherine Paquette, WWF-Canada

Elizabeth Hendriks, WWF-Canada

Katarina Hartwig, Living Lakes Canada

Larry Hildebrand, World Maritime University

Lindsay Day, The Gordon Foundation

Tony Maas, Forum for Leadership on Water

The convening team would like to thank
the following for their support

Featured Case Studies

Elevating Community-Based Water Monitoring in Canada

APRIL 2019

Living Lakes CANADA

WWF

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About This Document

This document features a rich diversity of community-based water monitoring initiatives across Canada. These case studies are intended to serve as a companion document for the final recommendations of Elevating Community-Based Water Monitoring in Canada, a collaborative initiative aimed to foster federal government engagement and support for community-based water monitoring (CBWM) in Canada.

These case studies were prepared by The Gordon Foundation, Living Lakes Canada and WWF-Canada. All three organizations engage with CBWM in different ways and are committed to advancing collaborative and evidence-based water stewardship across Canada.

The convening team thanks the many advisors and authors whose insight and contributions made this work possible.
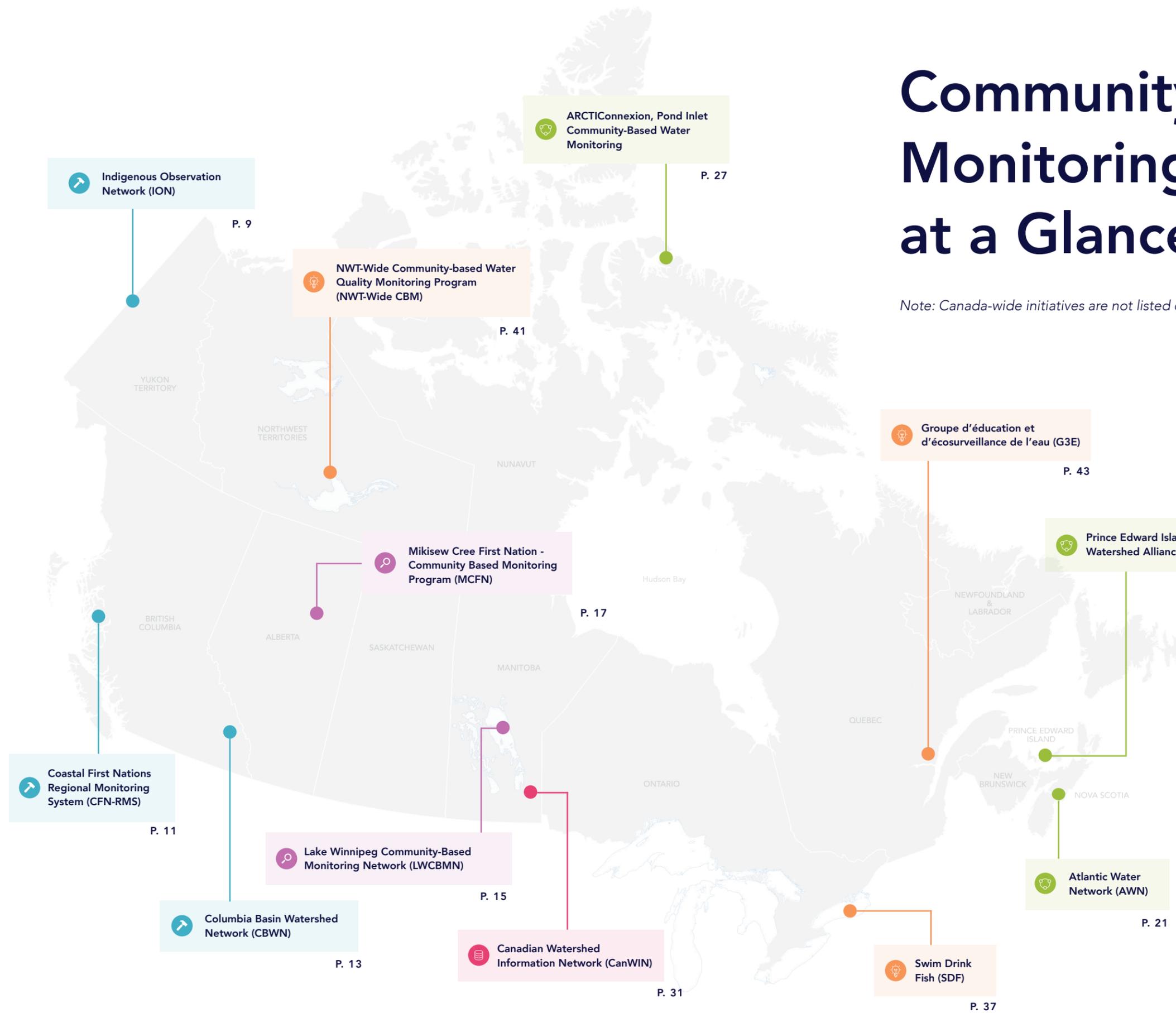
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Community-Based Water Monitoring in Canada at a Glance

Note: Canada-wide initiatives are not listed on the map.

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Case Study Themes

- Capacity Building
- Effective Monitoring
- Regional & National Collaboration
- Data Management
- Data to Inform Decision-Making

Canada-Wide Initiatives

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Atlantic Coastal Action Program (ACAP)

New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador

Objectives

ACAP was a federal government initiative operated by Environment Canada. Its purpose was to help Atlantic Canadians restore and sustain local watersheds and adjacent coastal areas. Environment Canada and 15 ACAP groups (also known as the "ACAP family") worked together to develop environmental management plans, raise awareness, and advance scientific research to inform restoration efforts for freshwater systems, estuaries and Atlantic harbours.

Model

ACAP served as an umbrella entity for member community-based organizations, each of which operated independently with a Board of Directors and full-time staff. It was designed to provide a "new framework of governance which allowed the public to have more meaningful involvement in decision-making. It would involve all sectors (governments, industry, communities) working together towards a common vision of sustainability"[1].

Funding

From 1991 to 2009, ACAP provided long-term core funding to ACAP groups. These initial investments allowed groups to leverage further funding from additional sources including philanthropic organizations, academic grants, and other levels of government. In 2009, through the Atlantic Ecosystem Initiative, the model shifted from core funding to project-based funding. This has had a significant negative impact on the capacity of individual organizations to continue their monitoring activities, particularly smaller, less resourced groups.

Who's involved

Governments, community-based organizations, industry, and the general public.

Core capacity building activities

Environment Canada funding enabled each organization to maintain staff, allowed for the development of Comprehensive Environmental Management Plans, and meant each group's office could continue to operate.

Highlights

Leveraging resources: Studies of ACAP's costs and benefits between 1997 and 2001 revealed that the government's investment resulted in significant economic, social and ecological gains. Had the government itself undertaken the same degree of monitoring performed by the ACAP groups, it would have cost Environment Canada twelve times the amount of money. ACAP clearly demonstrates how core government funding can have substantial impacts and be leveraged beyond the initial investment[2].

For more information, see McNeil, Rousseau, and Hildebrand (2006).

[1] McNeil et al., p. 369
[2] Wattie, 2016

Indigenous Observation Network (ION)

Yukon River Basin, Transboundary

Objectives

ION is the largest international, Indigenous-led monitoring initiative combining Indigenous Knowledge and western science to research, sustain and protect the Yukon River Basin (YRB). The network studies and monitors climate sensitive parameters to address landscape and water quality changes along the Yukon River and its tributaries. Through this research, ION provides long-term datasets and critical information that have implications for watershed planning at community, watershed, and global scales.

Model

ION is based on a partnership model between Alaska Native Tribes and First Nations, the Yukon River Inter-Tribal Watershed Council (YRITWC), and the United States Geological Survey (USGS). YRITWC is an Indigenous non-profit organization, consisting of 74 First Nations and Alaska Native Tribes.

Funding

The YRITWC, USGS and Indigenous governments work together to submit short-term proposals (one to three years) to U.S. and Canadian funding agencies and private foundations, while Indigenous governments have provided in-kind contributions. Individual Alaska Native Tribes and First Nations provide staff time and equipment (for example use of boats) for water quality sampling. In Alaska, the water quality samplers are funded by the U.S. EPA IGAP (Indian General Assistance Program), while in Yukon and B.C., Canada, First Nations do not receive any specific sources of funding to participate in the program.

Who's involved

Over 300 community members have been trained to conduct sampling and analysis of water quality data. The YRITWC provides support for monitoring through sample collection, processing and shipment within communities and to the USGS. The USGS provides data analysis and interpretation support. The YRITWC and USGS work to make the data publicly available through raw data files and engaging outreach materials.

Core capacity building activities

- Water quality data collection for more than 30 different biogeochemical parameters over 50 sites from Atlin, B.C., to Kotlik, Alaska

- Combined with USGS, ION has water data spanning more than 30 years for some sites

- 1500+ samples have been collected to date, covering the entire 2,300-mile reach of the Yukon River

- The Active Layer Network monitors 17 sites throughout the YRB to study the impact of permafrost on water quality

- Data management and visualization is provided through USGS Sciencebase, Circumpolar Active Layer Monitoring (CALM) program, and FieldScope online platforms[3]

Highlights

ION datasets are directly linked with decision-making processes such as the Yukon River Watershed Plan and are focused on prioritizing Indigenous water rights and governance. Indigenous leadership in CBM within the YRB has been essential to meeting community needs. As a" bridging organization," YRITWC plays a key role in facilitating cross-sector collaboration. Strong collaborative relationships ensure that technical and financial capacities are fairly distributed. Peer-reviewed publications based on ION data are a testament to quality of the data collected.

For more information, see the Yukon River Inter-Tribal Watershed Council website: **www.yritwc.org/science**

[3] Schuster, 2011; Herman-Mercer, 2016; Herman-Mercer et al., 2018; Toohey et al., 2018

Coastal First Nations Regional Monitoring System (RMS)

Coastal First Nation territories in the North and Central Coast of British Columbia and Haida Gwaii

Objectives

The RMS facilitates coordinated monitoring by Coastal Guardian Watchmen in First Nations to strengthen relationships with resource users, build an enforcement presence in the region and establish a solid baseline of data for decision-making. Specifically, the RMS seeks to: develop a standardized approach to monitoring priority issues at the regional scale; provide tools for communities to collect, store, and retrieve data; compile and compare coast-wide data; and empower communities to use the information in planning and decision-making. The water monitoring component of the RMS consists of stream surveys to collect water quality data, conduct salmon habitat assessments, and survey returning salmon to improve knowledge in priority watersheds. Protocols for monitoring oceanographic conditions will soon be added to the RMS.

Model

The RMS was developed with the Coastal First Nations' Stewardship Offices and is administered by the Coastal Stewardship Network (CSN), a program of the Coastal First Nations – Great Bear Initiative. The Coastal Stewardship Network (formerly the Coastal Guardian Watchmen Network) supports the stewardship staff of the alliance of First Nations, providing regional and technical support to individual First Nations and coordinating the RMS.

Funding

CSN is funded through philanthropic grants and government-to-government agreements. Individual First Nations fund Coastal Guardian Watchmen programs from own-source revenue, Coast Funds, carbon credits, grants, agreements with federal and provincial governments, and/or fee-for-service. Coast Funds was created in 2007 to help support a sustainable economy in the Great Bear Rainforest and Haida Gwaii.

Who's involved

Current members include the Stewardship Offices of First Nations Communities on the North and Central Coast of British Columbia, Haida Gwaii, and North Vancouver Island (Haida, Heiltsuk, Gitga'at, Kitasoo/Xai'xias, Metlakatla, Nuxalk, Wuikinuxv, and Nanwakolas Nations).

Capacity building activities

The RMS supports monitoring by providing:

- a standardized approach to monitoring priority issues at the regional scale
- tools for communities to collect, store, and retrieve their data (including the custom-designed CoastTracker app, which is used on tablets to collect data)
- coast-wide data to compile and compare for use by communities
- support for data management, use, and information-sharing
- a two-year Guardian Watchmen training program delivered by CSN alongside Vancouver Island University.

Highlights

Stable funding: First Nations successfully leverage funding from different sources to fulfill Nation-identified needs for long-term research and monitoring.

Ongoing training: Skills are kept current and orientation to new developments in the CoastTracker is provided.

Adaptive design: With support from the CSN, member Nations of the RMS evaluate the system to ensure it meets the changing needs of First Nations; keeps pace with advances in technology; continues to inform First Nations' land and marine planning; and promotes collaboration between Guardian Watchmen and non-Indigenous monitoring groups[4].

For more information, see the Coastal First Nations website https://coastalfirstnations.ca/our-environment/programs/regional-monitoring-system/

[4] Kotaska, 2013

Columbia Basin Watershed Network (CBWN)

Columbia River Basin, British Columbia

Objectives

Water stewardship groups in the basin have identified water monitoring as a priority. CBWN aims to promote discussion and participation in water-monitoring activities across the basin. CBWN is also collaborating on a regional water monitoring framework and open access Data Hub initiative with Living Lakes Canada, which will help member groups share data. CBWN is committed to working with groups and government agencies to ensure that this data is meaningful, is used to support decisions and is used to help communities understand watersheds and the impacts that development and climate change have on them.

Model

CBWN is led by a Board of Directors at the regional level. Member organizations coordinate and conduct water quality and quantity monitoring in their respective jurisdictions. Member organizations also engage in a variety of stewardship, research and educational activities. The CBWN supports these activities through training, advice, linking people with appropriate skills/knowledge to groups, and grant-writing assistance.

Funding

CBWN was primarily funded by a grant from the Columbia Basin Trust. CBWN also relies on grants from the Loblaw's Water Fund and Lush Cosmetics and benefits from significant in-kind contributions from member groups and individuals.

Who's involved

Members include representatives from across and beyond the Canadian portion of the Columbia River Basin, including: regional First Nations councils; local non-profit watershed stewardship groups; municipal, provincial and federal agencies; regional colleges and provincial universities; and residents of the Columbia Basin not affiliated with any member group. The CBWN science advisory committee provides advice for ongoing development of a basin-wide monitoring framework and Data Hub dialogue facilitated by

Living Lakes Canada, and provides advice to individual groups on appropriate monitoring design, protocols and equipment.

Initially, the Columbia Basin Water Quality Monitoring Project (CBWQ) was a CBWN project coordinated by Mainstreams Environmental Society. When the CBWQ became a separate entity it remained closely linked to the CBWN and the data collected will be made available on a Columbia Basin open access data hub when completed.

Core capacity building activities

CBWN organizes workshops for member groups that cover technical field-based skills, communication skills, mapping skills, fundraising skills and greater understanding of water governance. CBWN provides training and equipment to regional non-profit groups, and fundraises for local water monitoring projects. Increasing the capacity of the individual groups encourages greater independence and effectiveness of their stewardship activities and builds water-literate and climate-resilient communities.

Highlights

CBWN plays a key role in supporting and coordinating water monitoring and information sharing among water stewards in the Columbia River watershed. In addition to coordinating the Basin's monitoring network, CBWN is spearheading an open access data hub initiative to house regionally collected data which should provide significant near-term support to individual groups in their watershed-specific work. CBWN has served as a core distribution hub for Columbia Basin-wide water information and has a number of avenues of communication through which to distribute knowledge and resources.

For more information, see the Columbia Basin Watershed Network website: **http://cbwn.ca**

Lake Winnipeg Community-Based Monitoring Network (LWCBMN)

Lake Winnipeg Watershed

Objectives

The LWCBMN, coordinated by the Lake Winnipeg Foundation (LWF), was launched in fall 2015 to increase the spatial and temporal resolution of phosphorus monitoring. Across the Lake Winnipeg watershed, this network mobilizes citizens to generate useful and credible water quality data to identify phosphorus hotspots—areas that contribute a disproportionately high phosphorus load to local waterways. LWCBMN volunteers follow scientifically-vetted sampling protocols to ensure the credibility of data. Protocols are compatible with provincial and federal water-quality monitoring initiatives, which means LWCBMN data can be easily integrated into decision-making processes, and can guide evidence-based policies and practices.

Model

LWCBMN is guided by the expertise of LWF's Science Advisory Council (SAC), composed of nationally recognized freshwater scientists from across the country. Recognizing the potential of citizen science to improve phosphorus monitoring, LWF's SAC has developed and refined robust data collection and analysis protocols. Regional watershed districts and conservation partners throughout Manitoba provide on-the-ground expertise and support for sampling activities, as well as connections to local volunteers.

Funding

Annual funding is received from multiple private and public foundations. Recently, the network received a four-year federal funding commitment from ECCC. All funding to-date is project-based.

Who's involved

LWF's CBM coordinator works alongside citizen volunteers, watershed district staff and government partners to coordinate sampling activities and lab analyses. LWF's science advisors review all interpreted data and network reports.

Core monitoring activities

Water samples collected by citizen science volunteers and watershed district staff are analyzed for phosphorus concentration by LWF staff and science advisors. LWF staff generate annual regional reports, and map phosphorus hotspots to inform policy development. Regular field audits ensure protocols are followed, proper training is conducted and appropriate equipment is being used. LWCBMN is participating in an inter-agency lab comparison study with ECCC, DFO and Manitoba Sustainable Development to ensure that all phosphorus data collected is compatible. LWF just partnered with The Gordon Foundation to launch Lake Winnipeg DataStream, to share CBWM data as part of the national DataStream network.

Highlights

Because volunteers are dispersed across Manitoba and sample sites are chosen near where they live, LWCBMN can quickly mobilize volunteers to collect samples when it matters most (for instance during high-water events). Data collection and analysis protocols and equipment are scientifically rigorous, generate relevant data, are simple, and reduce the chance of human error. LWCBMN makes use of existing monitoring infrastructure through the Water Survey of Canada National Hydrometric Network. LWCBMN data is currently used to inform decision-making by watershed district managers, and has been acknowledged as increasing provincial capacity to target phosphorus load reductions and improve water quality across Manitoba.

For more information, see the Lake Winnipeg Community-Based Monitoring Network website: **www.lakewinnipegfoundation.org/lake-winnipeg-community-based-monitoring-network**

Mikisew Cree First Nation - Community Based Monitoring Program (MCFN-CBM)

Peace Athabasca Delta (PAD), northeastern Alberta. The PAD is defined as the delta region that mostly overlaps with the Mikisew Cree's traditional territories and Wood Buffalo National Park. This includes areas of study from Peace Point at the northwestern limit, the Slave River as the northernmost point, Sandy Point at the upper northeastern point, Birch River as the southwestern point, Baseline 27 as the southern point and Richardson or Jackfish Lake as the southeastern limit.

Objectives

Through its CBM program, MCFN seeks to sustain healthy traditional lands that support MCFN members for the next seven generations. The program's mission is to protect MCFN Treaty and Aboriginal Rights through active monitoring of the environment using traditional knowledge and science in a respectful balance. Since 2008, the MCFN CBM program has been using scientific methods and local Indigenous and traditional knowledge and wisdom passed down by Elders to watch, listen, understand and report on activities that may cause harm to their traditional lands and resources in the PAD.

Model

To ensure the success of the program, MCFN CBM works with a variety of partners. For example, they have a strong informal partnership with Parks Canada to coordinate research into wild foods. A customized data collection and management app has also been developed through a partnership.

Funding

The MCFN CBM program has an established office on the Doghead Reserve in Fort Chipewyan and maintains one full time staff member and two part time staff. Funding is provided by the First Nation with additional support provided by the provincial and federal governments.

Who's involved

The MCFN CBM program employs professionally trained Environmental Guardians who are members of MCFN. The program relies routinely on input from community Elders.

Core monitoring activities

MCFN CBM programs measure water depth and navigation, water quality, ice thickness and snow depth. CBM staff collaborate with other Indigenous, federal, provincial, territorial and university researchers in examining fish and wildlife contaminants. MCFN CBM Guardians also respond to emergencies such as the October 2013 Obed spill.

The results of their studies are used to inform community members about the state of the traditional territory, to assist the leadership in establishment of Indigenous policies and to inform consultation processes surrounding the impacts of resource development.

Highlights

The program relies on both scientific and Indigenous Knowledge monitoring methods so members can better understand environmental changes at local and regional scales.

For more information see the Mikisew Cree First Nation-Community Based Monitoring Program website: mikisewgir.com/cbm/

Canadian Aquatic Biomonitoring Network (CABIN)

National

Objectives

To measure changes in biological communities in order to assess freshwater ecosystems.

Model

CABIN is a program developed by Environment and Climate Change Canada (ECCC) that coordinates monitoring and analysis efforts across the country. CABIN is responsible for creating a standardized monitoring protocol that all participants must follow. Approved methods and tools are developed based on rigorous science and evolve with current research. To be able to fully participate in CABIN, individuals and organizations must have undergone a training program that includes a data collection field practicum delivered by ECCC and various third parties and online modules on data entry, reporting and analysis through the Canadian Rivers Institute. This standardization ensures that the data produced is of the highest quality, and can be confidently used by any participant.

Funding

CABIN is supported by the federal government through its online database as well as reporting and analysis tools. Each organization participating in CABIN is responsible for its own funding for training, monitoring and analysis.

Who's involved

Participants in the CABIN program include federal, provincial and territorial government scientists, academia, industry, CBWM groups, environmental organizations, and First Nation communities. Provided participants have completed the training and adhere to the strict monitoring, data management and analysis protocols, anyone can join.

Core monitoring activities

CABIN has created, and continually updates, their own standardized monitoring protocol. This includes how to properly perform a kick-sample, which environmental conditions surrounding the sample site to note, water quality parameters to measure and how to classify the geomorphology of the area. A procedure is currently being developed for use of environmental DNA (eDNA) within the CABIN protocol for benthic analysis. CABIN uses site-specific data to create reference condition models for given watersheds and areas. Analysis tools depend on the development of regional models by ECCC that use the Reference Condition Approach.

Living Lakes Canada is exploring how the CABIN protocol can include Indigenous Knowledge by adding traditional stream names and other water-related vocabulary in participants' respective Indigenous languages.

Highlights

CABIN relies on standardized data collection techniques and training in data entry, reporting and analysis tools for participants, with QA/QC built into the data collection techniques. The program is currently used for wadeable streams. Protocols for large rivers and wetlands are in development.

For more information, see the ECCC CABIN resource website:
www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network.html

Atlantic Water Network (AWN)

Inland waters, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador

Objectives

The mission of AWN (formerly CBEMN, the Community-Based Environmental Monitoring Network) is to build capacity among stewardship and watershed organizations by providing access to water monitoring and conservation resources such as standardized training via WET-Pro water monitoring kits, a secure and open access data hub (Atlantic DataStream) and the free use of an environmental monitoring equipment bank.

Model

AWN operates as an umbrella organization for not-for-profit community-based monitoring organizations in Atlantic Canada. The network is governed by an advisory committee composed of academics, government representatives, CBM organizational representatives and concerned citizens. AWN's core operations are run by two full-time staff, though this number fluctuates depending on funding availability.

Funding

For over a decade, AWN has been housed in the Geography and Environmental Studies department of St. Mary's University in Halifax, Nova Scotia. AWN activities received core funding from a five-year SSHRC grant for the CURA H20 project (2011-2016) which built capacity and provided resources for water monitoring in Atlantic Canada. Upon completion of this initiative, which was focused primarily on developing a standardized approach to water quality monitoring, AWN was successful in obtaining three-year core funding from ECCC's Atlantic Ecosystems Initiative and has since broadened its mandate. The network relies heavily on supplemental funding from provincial governments, philanthropic sources and plenty of in-kind support.

Who's involved

Approximately 30 not-for-profit water stewardship organizations make up the network. AWN supports regional academic research and has fostered relationships with provincial and federal governments.

Core collaboration activities

AWN facilitates collaborative water monitoring and environmental stewardship in Atlantic Canada by providing training, equipment loans (online WET-Pro training and complementary toolkits), data management resources (including data sharing on Atlantic DataStream) and support in the development of watershed-specific monitoring plans. WET-Pro training describes watershed processes, outlines quality assurance and quality control measures and describes what parameters a program should include based on local concerns.

Highlights

By sharing resources, AWN has contributed to the development of a standardized approach to water quality monitoring across Atlantic Canada through its online database, WET-Pro training and toolkit.

Alignment among monitoring protocols and data management strategies was ensured through collaboration with ECCC and Nova Scotia Environment in the development of AWN content. Collaboration with academic researchers has helped measure and communicate the credibility of CBWM data to other audiences[5].

For more information see the Atlantic Water Network website **atlwaternetwork.ca**

[5] Shelton, 2013

Prince Edward Island Watershed Alliance (PEIWA)

Inland waters, Prince Edward Island (PEI)

Objectives

PEIWA is a non-profit co-operative association of 24 community-based, not-for-profit watershed management groups on PEI. PEIWA supports the development of new and existing Watershed Groups in meeting their objectives to improve and protect the environmental quality of their waters. PEIWA aims to facilitate collaboration and communication among groups by providing opportunities to convene for training, collective input in public policy and raising awareness of local watershed issues.

Model

As an umbrella organization the Alliance serves as the main voice for all of the groups which together account for water stewardship activities covering approximately 95 percent of PEI. PEIWA prioritizes principles of collaboration and resource-sharing but respects the autonomy of individual member groups to achieve their own locally specific research, conservation and management goals.

Funding

The provincial government of PEI provides multi-year, core funding to members of the Alliance through a Watershed Management Fund that is divided among the groups via a specific funding formula that focuses on watershed size, community involvement and performance indicators such as leveraging capacity. Organizations have leveraged provincial funds by approximately 5:1 by fundraising through other sources including federal environmental funding streams (such as the Eco-Action program), with some minimal funding provided by philanthropic foundations and the private sector.

Who's involved

Watershed groups are typically composed of a volunteer Board of Directors, a paid coordinator, field crew supervisor, seasonal employees, and volunteer stewards and monitors.

Core Collaboration activities

- Water quality monitoring for key parameters of local and regional interest including temperature, nitrates (including reduction trials), dissolved oxygen, pH, and suspended sediments

- Estuarine monitoring including estuary watch to locate and record anoxic events

- Fish population monitoring

- Stream restoration

- Participation in the CABIN program

- Watershed groups also monitor coastal erosion, tree distribution, species at risk, and soils.

Highlights

Leveraging capacity: while core funding provided through the WMF is enough to cover operational costs, some groups have higher capacity to leverage these funds and expand programming. Partnering on projects and funding applications has led to fairer resource distribution.

Strong partnerships: partnerships established with local farmers, woodlot owners, and community organizations has helped minimize the impacts of local industries on freshwater health. Often this involves educating industries about provincial incentive programs (e.g., ALUS, NAPA), etc.).

Policy results: PEIWA members have been instrumental in contributing to the development of the province's *Watershed Strategy* and recently drafted *Water Act* (2017).

For more information see the Prince Edward Island Watershed Alliance website: **www.peiwatershedalliance.org**

Ecological Monitoring and Assessment Network (EMAN)

Canada-wide

Objectives

The Ecological Monitoring and Assessment Network (EMAN) was established as a national network of organizations involved in ecological monitoring in Canada to better detect, describe, and report on ecosystem changes. EMAN promoted the integration of long-term, multidisciplinary ecosystem research projects and their results across Canada. EMAN helped to standardize protocols and contributed to making data accessible between the network partners and communicating the information to decision-makers.

Model

Environment Canada established EMAN in 1994 and funded the EMAN Coordinating Office (EMAN CO) to coordinate ecological monitoring and research to meet national, regional and local needs for environmental information on ecosystem function and change.

Funding

EMAN was funded by Environment Canada from 1994 to 2010 and its operating budget supported network activities. In the end, relying solely on a single source of funding, particularly government funding, proved risky with budget cuts. A model with more distributed authority in terms of governance and funding would have increased the resiliency of the network.

Who's involved

EMAN was a cooperative partnership of government and non-governmental organizations, academic institutions, Indigenous organizations and community groups. EMAN partners worked collaboratively to improve the effectiveness of ecosystem monitoring and to demonstrate its relevance by better informing decision-making and influencing behaviours.

Core collaboration activities

EMAN connected different stakeholders through a shared goal of ecosystem monitoring to detect changes over time through standardized protocols. Monitoring protocols allowed for standardization in study design, sampling procedures, sample and data analysis, and reporting methods, ensuring information was useful for issues analysis and ecological understanding at the local, national and international scale. Standardized monitoring protocols included those for marine, freshwater and terrestrial ecosystems. EMAN co-produced ecological assessments and reports, organized annual science meetings across Canada for network partners and training opportunities in standardized protocols, and provided other tools and resources (such as the EMAN data repository). Despite these successes, greater impact and influence over decision-making could be better achieved if the network also engaged decision- and policy-makers.

Highlights

Many conservation professionals and citizen scientists continue to monitor using EMAN protocols. EMAN demonstrated the importance of collaborative, multi-stakeholder monitoring, and made the case for citizen science as a way to effectively monitor ecosystem change across Canada. EMAN also demonstrated the importance of secured funding and a leadership role through a coordinating office to strengthen the network.

For more information, see the archived ECCC website for EMAN: **www.ec.gc.ca/faunescience-wildlifescience/default. asp?n=E19163B6-1**

ARCTIConnexion, Pond Inlet Community-Based Water Monitoring

Pond Inlet, Nunavut and adjacent watersheds

From climate change to water quality and wealth: Inuit researchers advancing monitoring capacity for Arctic water systems in Nunavut

Objectives

ARCTIConnexion's objectives have been to implement a novel research framework based on community leadership, cultural relevance, and youth skills development for advancing scientifically rigorous water research capacity in Nunavut.

Model

A non-profit organization, ARCTIConnexion promotes a vision for research that is driven by and for Indigenous communities, and for Indigenous youth to train other youth in collaboration with academic scientists and community researchers. The program is mentor-based: university researchers mentor Inuit researchers, helping guide the development of studies from initial questions to publication.

Funding

Funding has been project-based to date. Community and university researchers apply for joint research funding to support community-based research projects. Initial Pond Inlet funding was provided by Health Canada's Climate Change and Health Adaptation Program. Federal financial support has also been provided by INAC through the Nunavut General Monitoring Program, and SSHRC Insight Development Grant.

Who's involved

Staff and university researchers, program initiator Tim Anaviapik Soucie and community members including Inuit youth.

Core collaboration activities

Local watershed monitoring is carried out using field- and satellite-based data that integrates climate (weather), landscape parameters (vegetation, soils, permafrost), hydrological conditions (stream flow, water level) and water quality measures (DO, pH, conductivity, bacterial, benthic invertebrates). Participatory mapping and traditional knowledge is used to guide the research locations and questions.

To-date, key successes include: developing research and leadership skills in Inuit youth; reframing the position of Inuit Knowledge and Scientific knowledge in Arctic research settings; project expansion to the communities of Arviat, Baker Lake (2018), and Taloyoak, Nunavut (2019); community laboratory infrastructure for water quality assessment in Pond Inlet and Baker Lake and increased understanding of the connections between landscape, climate and water.

Highlights

Research by Inuit, for Inuit: Community-led research with scientific mentorship builds true research capacity in a decolonizing and empowering spirit of Truth and Reconciliation. A mentorship approach to the research transforms a conventional Arctic science approach into a more sustainable, meaningful and impactful relationship.

For more information, see the ARCTIConnexion website: **arcticonnexion.ca/project/pond-inlet/**

DataStream

Mackenzie River Basin, Atlantic Canada, Lake Winnipeg Watershed

Objectives

DataStream provides the infrastructure to support open sharing of water quality data across multiple programs and jurisdictions. DataStream's mission is to promote knowledge sharing and advance evidence-based, collaborative decision-making so our waters remain healthy for generations to come.

Model

DataStream is led by The Gordon Foundation at the national level and is carried out in collaboration with regional monitoring networks. The Gordon Foundation coordinates input from regional partners, data contributors, subject matter experts and advisors. Expert product managers and engineers at Tesera Systems Inc. develop the software and implement feedback in accordance with agile best practices.

DataStream's approach has an embedded economy of scale, meaning that with each new iteration and improvement to the system, every monitoring organization, contributor and user benefits.

Funding

The Gordon Foundation works with regional partners to secure funds needed to build new local hubs and ensure sufficient HR resources are available to inform context-specific development, launch and rollout of regional DataStream hubs. The Gordon Foundation funds its programs through a combination of its own endowment and funds raised externally. Regional partners contribute either in-kind or financial resources to support DataStream infrastructure improvements (no minimum contribution required).

Who's involved

Regional partners include DataStream's founding partner, the Government of the Northwest Territories (GNWT), in the Mackenzie River Basin; the Atlantic Water Network (AWN) in Atlantic Canada; and the Lake Winnipeg Foundation in the Lake Winnipeg watershed. Contributors, known as data stewards, include watershed groups, Indigenous Guardian programs, governments and researchers.

Core data management activities

Independent home for data: Provides a long-term home for data collected across sectors with a focus on community monitoring initiatives.

User-friendly access: Allows users to easily access, search, visualize and download datasets.

Data model: Ensures data is available in consistent, predictable, useful and internationally recognized formats [EPA-developed exchange of water quality data (WQX) standards].

Quality control: Automated validation ensures consistent quality and ready-to-use data.

DataStream is already being applied in a real-world setting by: 1) CBWM organizations and Indigenous governments (24 communities contribute data to Mackenzie DataStream, 41 CBWM groups currently share data on Atlantic DataStream), GNWT uses DataStream as part of its NWT Water Stewardship Strategy; 2) academic research funded by the GNWT Cumulative Impacts Monitoring Program, which requires submission on DataStream; 3) ECCC and provincial governments are collaborating with DataStream to bring regional, long-term monitoring data online.

Highlights

Strong partnership model: All activities are carried out in partnership with leading organizations across the country that are well-placed to effect change at the right levels.

Ethically open access: DataStream is free and open for anyone to use. Since its inception, DataStream has gradually been implementing processes in line with FAIR data principles (data is Findable, Accessible, Interoperable and Reusable).

For more information see the Gordon Foundation website:
http://gordonfoundation.ca/initiatives/datastream/

Canadian Watershed Information Network (CanWIN)

Hudson Bay Watershed

Objectives

The Canadian Watershed Information Network (CanWIN) is a web-based collaborative platform hosted at the University of Manitoba (UM) within the Centre for Earth Observation Science (CEOS). Its mandate is to support research, education, management, policy and evidence-based decision-making about nutrient- and climate-related issues in the Nelson River and Hudson Bay watersheds. CanWIN's mission is to provide a web-based collaborative platform that integrates disparate watershed-related data from a site-specific (local) level with data at provincial, national and global scales; to communicate key research findings in plain language; to provide open access to research data and reports in non-proprietary formats and to use ethical data sharing methods to address unique key stakeholder needs and privacy concerns (for example Inuit and First Nations) while finding ways to share and integrate Indigenous Knowledge and science.

Model

CanWIN (formerly the Lake Winnipeg Basin Information Network) was created by Environment Canada as part of the Lake Winnipeg Basin Initiative under Canada's Action Plan on Clean Water and was transferred in 2012 to the UM. CanWIN works with a variety of stakeholders, including researchers and non-governmental agencies to build standardized and interoperable tools to increase accessibility and ease of data sharing across the watershed. We provide an open by default platform which allows upload of any data type and visualization of certain types (e.g. csv, pdf).

Funding

Initiative funding is provided through the UM and the Lake Winnipeg Basin Program funded by ECCC. Additional funders include Manitoba Hydro and the Lake Winnipeg Foundation. Maintenance, development and upgrade of core systems is provided by the UM computer services. Services include systems administration (hardware and software maintenance and upgrades, database management, data security, backup services) and permanent housing of documents within the UM libraries. Total in-kind support provided by the UM is approximately $150,000 per year.

Who's involved

Collaborators include freshwater and arctic researchers, federal and provincial agencies, and non-profit organizations. CanWIN is also a member of the Canadian Consortium for Arctic Data Interoperability (CCADI), a consortium of five universities, two Inuit organizations, and a variety of government and non-governmental agencies.

Core data management activities

CanWIN currently hosts many different types of data, from community-based monitoring to historical and active research programs. CanWIN provides support to users on managing the complete data lifecycle, from project conception to data sharing and archiving.

Highlights

By working with multiple data managers, users and subject matter experts, CanWIN is working towards national and international standards for a common vocabulary and metadata standard, which increases the interoperability and therefore usability of the data. This harmonizing of disparate data and language enables users to ask new research questions by giving them the ability to analyze complex, multi-themed watershed issues across broad spatial and temporal extents.

For more information see the University of Manitoba website:
http://lwbi.cc.umanitoba.ca

Exchange for Local Observations and Knowledge of the Arctic (ELOKA)

Arctic, International

Objectives

ELOKA's goal is to facilitate the collection, preservation, exchange, and use of local observations and Indigenous Knowledge of the Arctic to meet local and regional decision-making needs. ELOKA provides support to Indigenous organizations, communities, and researchers across a number of areas related to data management and use. ELOKA's work is intended to support communities in attaining data and information sovereignty in the Arctic (in other words, communities decide how their data are protected or shared).

Model

The ELOKA leadership team works closely with Indigenous organizations, local communities, the research and funders to establish an effective, flexible working model that evolves as the broader context changes. ELOKA is hosted by the National Snow and Ice Data Center (NSIDC), which provides stable data repository services and technical expertise.

Funding

ELOKA receives funding through the National Science Foundation to provide a range of data management support services. A set of separate, complementary grants that use the ELOKA infrastructure and expertise have been established, including contracts with individual partners.

Who's involved

ELOKA operates under the premise that meaningful knowledge exchange can only be achieved by linking physical networks (technology) and human networks (community members, researchers, decision-makers, trainees, others). ELOKA partners with Indigenous community members and representative organizations and networks all across the Arctic, from Canada and the U.S. to Greenland and Russia.

Core data management activities

ELOKA builds partnerships with Arctic Indigenous communities and researchers to create digital tools to support the curation and sharing of Indigenous Knowledge and local observations following best practices. Key activities include: data preservation and archiving; facilitation of data discovery and distribution; dynamic data presentation that maintains relevant context around the information; digital mapping and community-contributed mapping and GIS; assistance in developing data management plans, data collection protocols, documentation, and organization; developing connections between Indigenous Knowledge and conventional science approaches to Arctic observing; convening workshops to facilitate exchange around themes related to data sovereignty, data management, and community-based observing, and matchmaking between scientists and Arctic communities based on research needs, interests, and questions.

Highlights

Management of community-contributed data has both technical and social dimensions: There is no single approach that will address data management needs and concerns for all communities.

Data management technologies and infrastructures should be context-appropriate: Because of the limited Internet bandwidth in many parts of the Arctic, ELOKA has made efforts to minimize the bandwidth speed required to use applications by developing optimized technologies.

Projects should recognize and support data sovereignty: ELOKA provides data management support to CBM initiatives with the explicit goal of upholding Indigenous ownership and authority over Indigenous Knowledge and data[5].

For more information see the ELOKA website: **eloka-arctic.org**

[6] Pulsifer and McNeave, 2014

WWF-Canada's Watershed Reports

Canada-wide, basin and sub-watershed scale

Objectives

WWF-Canada set out to create the first national picture of the health of and threats to Canada's freshwater. A key part of the creation of Watershed Reports was considering how this information could be used, and how best to make that happen.

Model

WWF-Canada is a national non-governmental organization with a mandate to reverse the decline of wildlife.

Funding

Funding is provided by various foundations, corporate partnerships and grants.

Who's involved

WWF-Canada staff are responsible for gathering data collected by outside organizations and partners. These partners include government departments (federal, provincial and territorial), other environmental non-governmental organizations (ENGOs), watershed groups, conservation authorities and community-based monitoring groups. WWF staff run the analysis and attribute overall scores to watersheds and sub-watersheds. These results are then published on the Watershed Reports interactive website.

Core activities

While WWF-Canada doesn't engage in monitoring, the Watershed Reports use data from as many monitoring organizations as possible. Watershed Reports take data and through analysis transform them to create a product that is easily transmissible and understood. To create Watershed Reports, WWF-Canada first consulted with leading freshwater scientists to develop an assessment framework. That framework was then used to produce reports on the health and threats to Canadian rivers. An interactive website was designed to publish the results, engage Canadians and raise awareness about the watersheds they live in.

This platform and project can give a voice to smaller monitoring groups and make them a part of national freshwater discussions. Often, groups operating on a smaller scale have nowhere to share their data, meaning it doesn't get used as much as it could. Watershed Reports gives them that option.

WWF-Canada communicates every aspect of the Water Reports process which includes providing information about the analysis (methods, scripts) as well as results. Through this exercise, WWF-Canada has also shared many of its key learnings and suggestions for monitoring and analysis in Canada.

For more information see the website for WWF-Canada's Watershed Reports: **watershedreports.wwf.ca/#canada/by/ threat-overall/profile**

Highlights

Since its creation, Watershed Reports has been used by many individuals and organizations to advocate for infrastructure, water management and policy changes. Many organizations use the results as leverage to support their own work, or even use it to establish priorities. Key takeaways include:

1. **Identify the audience:** knowing the intended audience has played a large part in determining how to effectively communicate the reports.

2. **Ground truth:** while this project was national in scale, WWF-Canada continually connected with local organizations and data providers to ensure consistency between results and reality.

Swim Drink Fish (SDF)

National, with initiatives at different scales. Swim Guide is an international program.

Objectives

Swimmable, drinkable, fishable water for everyone.

Model

SDF is a stewardship organization focused on blending science, law, education, and storytelling with technology. SDF has eight initiatives, each of which has a specific mission contributing to the goal of building a national movement of active, informed, and engaged individuals.

Funding

SDF Galas provide unrestricted funds that allow the organization to respond to community needs. Flagship initiatives have a major foundation or government funder.

Who's involved

Core staff carry out operations for SDF's various initiatives and volunteers make the vision come to life. SDF's community-based recreational water quality monitoring program in Toronto counts between 100 and 200 volunteers a year, and is managed by a single coordinator.

Core activities

SDF uses digital communications technology to promote public access to information wherever and whenever people need it. Programs typically translate scientific or policy information into simple data points that are accessible to the general public. Once translated, SDF uses made-in-house apps and web platforms to communicate that information to the public.

All of SDF's platforms are free to use for other non-profit affiliates. The following are three examples:

1. **Swim Guide:** Website and app to help easily find close swimming beaches, and protect public health with current information on water quality. Available in English, French and Spanish, Swim Guide shares data for 8,000 beaches in ten countries, and counts nearly three million users. Swim Guide also runs wim Drink Fish operates community monitoring programs in Toronto, Vancouver, Niagara, and Zhiibaahaasing First Nation.

2. **Great Lakes Guide:** Digital content and data that connects people to the Great Lakes and highlights the region's ecological, cultural, and economic significance

3. **Great Lakes Communities Monitoring Initiative:** Establishing six volunteer-led recreational water quality monitoring hubs on the Great Lakes to bring affordable water quality monitoring to underserved communities.

Key lessons - there is demand for data sharing standards, especially in a field where monitoring practices are relatively well-established and consistent. The biggest challenge continues to be the clash between today's "open by default" mentality and the traditionally closed mentality of government and institutional data-holders. Whenever Swim Drink Fish has struggled to deliver current water quality information to the public, it has been largely due to attitudes towards data sharing, rather than because of technical or financial barriers.

Highlights

Data collection: Wherever Swim Drink Fish is active, data collection has increased.

Data openness: Part of Swim Drink Fish's work involves actively promoting the release of data, including machine readable data, to the general public.

Data exchange: One of Swim Drink Fish's main data initiatives is the development of data-exchange standards that allow beach managers to share beach water quality information automatically across jurisdictions.

For more information see the Swim Drink Fish website: **www.swimdrinkfish.ca**

Canadian Shellfish Sanitation Program (CSSP)

Canada-wide

Objectives

The goal of the program is to protect Canadians from the health risks associated with the consumption of contaminated bivalve molluscan shellfish (for example, mussels, oysters and clams). Under the CSSP, ECCC's Shellfish Water Classification Program (SWCP) conducts surveys of bivalve molluscan shellfish growing areas for the purposes of classifying areas for harvesting of species such as clams, oysters, mussels and scallops.

Governance

The CSSP is a federal food safety program jointly administered by the Canadian Food Inspection Agency (CFIA), DFO and ECCC. The program is governed by a memorandum of understanding. Legal authority for the Canadian Shellfish Sanitation Program is provided by the Fisheries Act, the *Management of Contaminated Fisheries Regulations*, the *Fish Inspection Act* and the *Fish Inspection Regulations.*

Funding

Under the agreement, ECCC pays for the analysis of marine water quality samples for the purpose of reclassification of the harvesting areas.

Who's involved

CFIA, DFO and ECCC. In 2005, Tsleil-Waututh Nation (TWN), a Central Coast Salish community, requested that the CSSP be expanded into their traditional territory to classify potential shellfish harvesting areas. Intended uses for shellfish are wide-ranging and may include: wild harvest, aquaculture, Food, Social and Ceremonial (FSC) and recreation, among others.

Core activities

These areas were previously impacted by sewage discharges from wastewater treatment plants, and at that time were classified as closed. Following wastewater impact assessments conducted by ECCC, a survey of the potential harvesting area was completed under a collaborative agreement, whereby ECCC staff trained TWN members to collect water quality samples for delivery to ECCC's microbiology laboratory in North Vancouver. Key components of the current Agreement for Community Based Monitoring in Indian Arm for the reclassification of existing prohibited areas within Burrard Inlet include:

- No money is included in the agreement. All efforts are provided through in-kind support.

- ECCC provides sampler training, sampling equipment, laboratory analyses and project coordination.

- All work financed using program funds.

- TWN provides dedicated trained personnel, sampling vessel, related CCG-approved safety equipment and vehicle for sample cooler delivery. All work provided using band funds.

Highlights

On October 25, 2016, the TWN completed their first FSC harvest in 34 years with the collection of 17.9 kg of soft shell clams. This agreement demonstrates the power of partnerships and how a willingness to experiment with alternative service delivery models can effectively connect community-based monitoring to decision-making in a way that truly matters to local communities.

For more information see the Canadian Shellfish Sanitation Program website: **www.inspection. gc.ca/food/fish-and-seafood/shellfish-sanitation/ eng/1299826806807/1299826912745**

NWT-Wide Community-based Water Quality Monitoring Program

Northwest Territories

Objectives

The Northwest Territories (NWT)-Wide Community-Based Water Quality Monitoring Program (NWT-Wide CBM) was developed to support communities in the development and implementation of aquatic community-based monitoring and research programs. These were designed to address concerns about changes to water quality over time including the impacts from stressors from upstream development and climate change, among others. Growth of CBM in the territory will increase awareness of water issues, improve traditional knowledge collection and application as well as increase community involvement in and ownership of research and monitoring program design.

Model

The Department of Environment and Natural Resources (ENR) is the lead agency coordinating implementation of the NWT Water Stewardship Strategy. The NWT-Wide CBM program was developed collaboratively by ENR alongside Indigenous, federal and municipal governments, non-governmental organizations, communities and others. Part of ENR's responsibility is to provide capacity supports to communities across the NWT as they become more involved in water stewardship activities, including through monitoring and research.

Funding

The NWT-wide CBM program is funded through the ENR.

Who's involved

ENR works with 21 communities across the territory to monitor water quality at over 40 sites on 24 NWT rivers and lakes.

Core activities

ENR plays a coordinating role in delivery of the overall program. This includes providing CBM partners throughout the territory with information about monitoring design, access to hands-on training, funding through equipment and monitoring resources, and support for data collection, analysis and management. Communities are involved through every step of the program from sampling site selection to data collection and program evaluation. The following are examples of past and ongoing NWT-Wide CBM projects: 2013 monitoring; Slave River and Delta Partnership; Community-based Cumulative Effects Monitoring Framework; Cumulative Effects Monitoring Pilot Project; Drinking Water.

Beginning in 2016, all data from currently funded NWT-Wide CBM water quality monitoring initiatives is available on Mackenzie DataStream.

Highlights

Decision-making: the NWT-Wide CBM Program is shaped by community questions about their watersheds, this ensures that information collected by local monitors is relevant for local decision-making. "Though CBM is geared to local-level concerns, identifying linkages with other levels of decision-making increases the usefulness of CBM data… With respect to transboundary waterways, CBM information will support implementation of bilateral water management plans with upstream jurisdictions"[5] .

Participation: a high degree of community participation in the program from inception through to delivery and evaluation fosters community buy-in for ongoing activities and trust in the data generated.

Data accessibility: CBM results are are shared with communities before being distributed elsewhere in both raw and analyzed and interpreted formats ensuring that it is both meaningful and understandable.

For more information see the description of the NWT-wide CBM Program on the GNWT website: **https://www.enr.gov.nt.ca/en/ services/water-management/community-based-monitoring**

[7] Somers as cited in Kanu et al., 2016, p.16

Groupe d'éducation et d'écosurveillance de l'eau (G3E)

Québec, Prince-Edward Island, French communities in New-Brunswick and Manitoba

Objectives

Since 1989, G3E has worked towards the protection of aquatic ecosystems. They have developed citizen science initiatives as well as educational and scientific tools useful for aquatic ecological monitoring. G3E invites communities to use them to keep an eye on the health of their home waters and to make informed decisions about conservation, restoration or awareness activities.

Model

G3E operates many programs under four broader umbrellas: citizen science; nature and education; training and education toolkits; and broader public activities. Under the citizen science umbrella are three main programs, each with its own goals, target audience and methods: 1) J'adopte un cours d'eau (Adopt a River) 2) Survol Benthos (Benthic overview), and 3) Des cours d'eau branchés (Live-stream Your River App).

Funding

Having received initial support from ECCC's Biosphere and from a variety of different partners, G3E now finances its activities through both government and private funding.

Who's involved

Each program targets different sectors of society, from education and school groups, other ENGOs and watershed groups, labs, government departments (such as SEPAQ) and the public. The different programs offer the training necessary for participants. Scientific and educational tools as well as protocols are adapted for the audience.

Core activities

Adopt a River is an educational program with a citizen science approach. It encourages youth to take action to protect their rivers. Participants assess freshwater health through physicochemical and bacteriological tests, by monitoring benthic macroinvertebrates and recording fish observations. These activities are followed by environmental awareness raising and restoration efforts. The Survol Benthos program monitors the health of small streams using benthic macroinvertebrates as indicators. An online interactive map allows for anyone to quickly understand the health of sites using indices. The Live-stream Your River App is available through iTunes and includes a step-by-step protocol to quickly identify the health of a water body. Des rivières surveillées: s'adapter pour l'avenir is a permanent CBWM project aiming to document the impact of climate change on riverine ecosystems.

Highlights

Having a team of regional coordinators has allowed the program to reach a greater area and audience and to collaborate with a diverse group of external partners. Knowledge sharing and transfer is achieved in large part by the regional coordinating team and the openness of G3E and its partners in sharing tools and experience. Since 2000, 50,000+ youth and 50+ organizations have participated in G3E projects, and more than 275 bodies of water have been studied and adopted. The province uses the benthic data collected, which has doubled the territory covered by benthic monitoring. Regional coordinators, watershed groups, provincial parks and certain NGOs also integrate the data into their own assessments, guiding protection and conservation actions.

For more information see the G3E website: **www.g3e-ewag.ca/ home.html**

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