Implementing Indigenous and Western knowledge systems in water research and management (part 1): A systematic realist review to inform water policy and governance in Canada

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Implementing Indigenous and Western Knowledge Systems in Water Research and Management (Part 1): A Systematic Realist Review to Inform Water Policy and Governance in Canada

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Implementing Indigenous and Western Knowledge Systems in Water Research and Management (Part 1): A Systematic Realist Review to Inform Water Policy and Governance in Canada

Abstract
Indigenous (First Nations, Inuit, and Métis/Metis) peoples in Canada experience persistent and disproportionate water-related challenges compared to non-Indigenous Canadians. These circumstances are largely attributable to enduring colonial policies and practices. Attempts for redress have been unsuccessful, and Western science and technology have been largely unsuccessful in remedying Canada's water-related challenges. A systematic review of the academic and grey literature on integrative Indigenous and Western approaches to water research and management identified 279 items of which 63 were relevant inclusions; these were then analyzed using a realist review tool. We found an emerging trend of literature in this area, much of which called for the rejection of tokenism and the development of respectful nation-to-nation relationships in water research, management, and policy.

Keywords
Indigenous knowledge systems, water research, water management, water policy, integrative knowledge, systematic realist review, Canada

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Implementing Indigenous and Western Knowledge Systems (Part 1): A Systematic Realist Review to Inform Water Research, Policy, and Governance in Canada

In Canada, the current circumstances of persistent and disproportionate water-related challenges, threats, and burdens experienced by Indigenous (First Nations, Inuit, and Metis/Métis) peoples have not occurred in a vacuum; they have arisen from enduring colonial structures, policies, and practices (Castleden & Skinner, 2014; Galway, 2016; McGregor, 2012; Phare, 2009; White, Murphy, & Spence, 2012).[1] Although their relationships to the water in their traditional territories have been established and preserved for hundreds of generations, current problems (e.g., contaminated drinking water supplies, flooding, ineffective wastewater treatment, agricultural and industrial draws on watersheds) are often a matter of environmental injustice (Mascarenhas, 2007). As a result, Indigenous Peoples in Canada face substantial disparities in water quality, accessibility, and availability when compared to their non-Indigenous counterparts (Adelson, 2005; Basdeo & Bharadwaj, 2013; Hrudey & Hrudey, 2007; White et al., 2012). These disparities emerge from, and contribute to, major challenges for effective water management and research in Indigenous contexts (Canadian Water Network, 2013) and for the country as a whole.

In Canada, the federal government and others (including media, academic researchers, and research funders) acknowledge that inequities exist when it comes to clean drinking water (Health Canada, 2015) and that there are significant impacts from resource development and climate change on water (Ford, 2012; Harper, Edge, Schuster-Wallace, Berke, & McEwen, 2011). But their attempts to address the problems have frequently been unsuccessful (McGregor, 2012; Phare, 2009, 2011; White et al., 2012). First, both government-led investments and academic-driven research have predominantly focused on drinking water, creating a false fragmentation of the transboundary and ubiquitous lifeline that water embodies (Basdeo & Bharadwaj, 2013). Second, attempts to provide access to safe drinking water, wastewater services, and water management have often failed because both government and educational institutions have relied on what is understood to be Western scientific knowledge (McGregor, 2012; White et al., 2012). While Western knowledge is a fluid and evolving knowledge system, its predominant form (as generally employed by government, engineers, and scientists to provide clean drinking water) subscribes to positivist and reductionist notions (Mazzocchi, 2006). What this means in practice is that the focus on "objectivity" has translated to top-down approaches concentrating on infrastructure and technological solutions, rather than the systemic social, economic, and cultural transformation that is needed to protect water, in all of its relationships with people and other species (Ayre & Mackenzie, 2013; Durning, 1992; Jackson & Morrison, 2007; McGregor, 2012).

[1] While our research focus examines the Canadian context, access to safe and secure water resources is a global crisis. Most recent data from the World Health Organization (WHO, 2017) stated that approximately 2.4 billion people lack sufficient sanitation facilities, while nearly 700 million do not have access to potable drinking water. As humanity continues to contaminate and divert the Earth's finite freshwater supply, the disparity between marginialized populations and water "haves" and "have-nots" will continue to be exacerbated across the planet (Barlow, 2009). Though parts of many countries of the Global North are running out of fresh water resources, they are not yet experiencing water shortages due to their wealth and ability to import water from other sources (Barlow, 2009). This is not the case in the poorer nations of the Global South and, as the global population continues to increase beyond 7.5 billion people, water scarcity and the resulting effects will be felt hardest in these developing nations.

In recent years, it has become increasingly apparent that Western knowledge, science, and technology are not addressing water issues and water-related challenges in Indigenous nations and other communities in Canada (Canadian Water Network, 2013; Health Canada, 2015; Mascarenhas, 2007; Sanderson et al., 2015; White et al., 2012). Academic researchers (the vast majority of whom are non-Indigenous) as well as funding agencies are beginning to recognize that local and Indigenous knowledge systems offer the potential for successful and sustainable emergent solutions through context-specific approaches to problem-solving. Nevertheless, despite a recent proliferation of case studies and empirical research on the subject, there has been no systematic review to critically examine what approaches offer the most promising ways to move forward in water research, management, and policy development, nor why or how these approaches hold promise. As such, the purpose of this combined systematic and realist review (SRR) was to examine the extent, range, and nature of peer-reviewed and grey literature that discuss contemporary approaches to integrative Indigenous and Western knowledge systems in water research and management practices in Canada. [2]

Methods

This SRR was conducted as part of a comprehensive integrative knowledge project for the Canadian Water Network (CWN), a Network Centre of Excellence for research encompassing the range of natural sciences and engineering, health sciences, and the social sciences. The overarching goal of our project was to identify and assess the most promising integrative research and management practices, as well as to explore challenges and opportunities for water-related research that uses Indigenous and Western knowledge and science to inform and transform water management practices in integrative ways. Through a model of shared decision making and a balance of power and control (e.g., Castleden, Garvin, & Huu-ay-aht First Nation, 2008), our program of research was informed by input from a National Advisory Committee (NAC), comprised of Western-trained water experts and Indigenous knowledge holders and leaders. To establish an integrative approach to our research design, we held a national Water Gathering in 2014 to seek a broad range of perspectives from additional Indigenous and non-Indigenous water researchers, managers, and integrative knowledge practitioners. They provided feedback and direction that guided and shaped our project in the following instrumental ways: We co-determined the inclusion and exclusion criteria for the SRR; we co-created reflective questions to analyze the results; and we contextualized the results to create recommendations at a second Water Gathering in 2015, reconvening the same group of Indigenous and Western water experts.

Data Collection

A SRR approach benefits from the strengths of both systematic and realist review methods. While a systematic review provides a rigorous, reliable, and replicable methodological approach that examines what was done and by whom in a comprehensive way (Shamseer et al., 2015), a realist review asks about the reasons for what has already been done and its level of success (or failure): Why, how, for whom, and under what circumstances particular processes or practices work (Pawson, Greenhalgh, Harvey, & Walshe, 2005). In combining both review strategies, we systematically identified what had been

[2] Throughout this article, we use the term "integrat*ive* approaches," rather than "integrat*ed* approaches," to refer to the dynamic and ongoing process of knowledge co-production (Bartlett, Marshall, & Marshall, 2012; Bartlett, Marshall, Marshall, & Iwama, 2015).

published in the area of integrative water research and management, and examined why particular approaches, processes, and models have (or have not) worked and the context in which their success or lack thereof occurred. This review strategy is consistently being used within the field of social sciences (Pawson et al., 2005; Petrasek MacDonald, Ford, Cunsolo Willox, & Ross, 2013), and our use of it builds on a growing body of systematic realist reviews.

We conducted a search of peer-reviewed and grey literature, published in English for the time period beginning January 1979 to October 2014; a replicate search was conducted based on direction from our NAC in order to compile any new material published from October 2014 to the end of August 2015 (end-date of the project). The search was conducted across three electronic aggregator databases (Scopus, Web of Science, and Google Scholar), using keywords established by the authors and refined through consultation with a reference librarian (see Table 1 for search strings).

Citations returned from Scopus and Web of Science were screened for relevance using a two-stage process by two independent reviewers from our team: first, titles and abstracts were screened for relevance, followed by a full text screen. Articles returned from Google Scholar were reviewed and collected for inclusion until the entire results page was deemed irrelevant to the scope of the project (as per Furgal, Garvin, & Jardine, 2010). The grey literature was searched using one electronic database (Library and Archives Canada) and two agency websites (Canadian Public Policy Collection; Government of Canada Publications). In addition, an online search engine (Google) was used to perform a scan of the grey literature,[3] where the first 50 records were examined to retrieve any missing literature (see Furgal et al., 2010). A final search occurred by visiting organization and agency websites whose published reports emerged in the first round of grey-literature retrieval with the hope of finding similar reports.

Articles were screened to ensure that they were water-focused within a Canadian context and reported empirically on integrative knowledge processes of research and/or management. Where disagreement occurred between team members conducting this screening, meetings were held until all were in agreement. Relevancy to the project was determined using a ratings scale of 0 to 3 (see Table 2 for inclusion criteria and scaled rating). Four reflective questions (Box 1) guided the decision to exclude or include. In cases where relevance could not be determined, or if two or more reviewers did not initially agree on inclusion or exclusion, the research team conducted a full text review. The full text review applied the same inclusion and exclusion criteria.

[3] Defined for the purposes of our research as original material published online or in print outside of peer-reviewed academic journals. This includes, for example, government and non-governmental organizations (NGOs), among others.

Table 1. Literature search keyword strings used to search the article databases and generate our list of included records

Google Scholar, Scopus, and Web of Science	Google
(1) = First Nation OR Metis OR Inuit OR Aboriginal OR Indigenous AND Water	Aboriginal OR Indigenous AND Water AND Canada AND report AND Governance
(1) AND Collaboration	Aboriginal OR Indigenous AND Water AND Canada AND report AND management
(1) AND Co-management	
(1) AND Governance	Aboriginal OR Indigenous AND Water AND Canada AND Knowledge
(1) AND Indigenous Knowledge	Integrative traditional knowledge AND water management
(1) AND Source Water Protection	
(1) AND Water Access	Indigenous traditional knowledge AND water management AND community report
(1) AND Water Quality	
(1) AND Water Security	

Table 2. Inclusion and Exclusion Criteria Scaled Rating Used to Determine Article Eligibility for Inclusion in Our Review

0	Water is not the central component to the research; no empirical data are discussed; integrative knowledge or knowledge integration is not referred to; not a Canadian context
1	Water is somewhat central; some empirical data are discussed; integrative knowledge processes and practices are implied/can be inferred; not a Canadian context, but it is arguing for generalizability
2	Water is either central or a wholistic perspective has been used and water is discussed at length; empirical data are discussed; integrative knowledge processes/practices are referred to; Canadian context is discussed
3	Water is central (whether a wholistic perspective is used or not); empirical data are discussed; integrative knowledge processes/practices are described fully; Canadian context is discussed

Box 1. Inclusion and Exclusion Criteria Reflective Questions

a. Is the article reporting on empirical data?

b. Does the article describe integrative knowledge processes of research or management with respect to water?

c. Is water the focus of the article, or is a wholistic perspective taken within which water is included?

d. Is it describing a Canadian context?

Data Analysis

To facilitate analyses and synthesis of relevant articles, a "Reporting Tool" was created through discussions with the project's NAC and attendees to the first Water Gathering. The SRR Reporting Tool was comprised of 33 questions (see Table 3) that were framed around the following broader research considerations:

- What integrative knowledge approaches have worked in the past;
- How were benefits perceived and actualized from a research, management, and/or community point of view;
- What were the findings, implications, and conclusions of previous studies that have sought to implement Indigenous knowledge and methodologies with Western knowledge and methodologies; and
- How were Indigenous perspectives and methodologies (including those that were consistent with Indigenous paradigms of relationality [Wilson, 2008]) implemented during the research process in ways that were culturally appropriate, and that ultimately helped to promote effective water policy, governance, and/or decision-making (if at all)?

For our analysis, the literature was divided into groups (First Nations, Inuit, Métis/Metis, and multi-site contexts) and analysed by three research team members. For each piece of literature, they responded to all 33 questions as fully and accurately as possible, given the available information. These responses were then compiled and coded; responses were graphically illustrated where possible, though some questions elicited detailed responses that required analysis after close reading.

Table 3. Systematic Realist Review Reporting Tool

Variable	Definition/Description
	DESCRIPTIVE
1. Year Published	Year in which the article was published.
2. Journal Title	Title of journal in which article was published.
3. Title of article/ research project	Full title of the article/research project.
4. Type of Article	Classification of article type • Full length • PhD dissertation • Master's thesis • Report • Conference paper • Workshop summary • Water stewardship strategy • Discussion paper • Other considerations: editorials, reviews, commentaries
5. Classification of Article	Classification of article: • Theoretical • Empirical with data • Mixed • Water stewardship strategy • Workshop summary • Report • Reflection paper • Other (please specify)
6. First Author Affiliation	Information about the first author, the institution/organization that the author was associated with when they produced the article. First author affiliation can usually be located within the article (below abstract or at the end of the article). In cases where an association is not provided, Google search engine will be used to identify the primary affiliation at the time of the publication. • Researcher • Government • Non-governmental organization (NGO) • Civil society • Other (please specify)
Researcher	Individual is associated with an educational institution (university or college). Also includes individuals working for private and/or for profit company conducting research for the purpose of fulfilling company goals and objectives.
Government	Individual working for or in association with a municipal, provincial, federal, or international government body.
NGO	Individual working for or in association with a non-profit organization on the work in question.
Civil Society	Public servants (e.g. health care professionals, legal practitioners, public safety personally) or any others whose primary profession is to serve the public, but who is not a government employee.

Table 3. Systematic Realist Review Reporting Tool (continued)

Variable	Definition/Description
7. Does the first author self-identify (in the text of the article) as Indigenous, Inuit, First Nations, or Métis/Metis?	Does the first author self-identify (in the text of the article) as Indigenous, Inuit, First Nations or Métis/Metis? • Yes (Give details) • No
8. First Author Background	Department that the first author is affiliated with at the time of publication. This will usually be identified within the article; if not provided, Google will be used to identify the primary affiliation at the time of publication. • Health • Science • Social Science • Engineering • Geography • Interdisciplinary • Other (please specify)
9. Contact information	Corresponding author listed and email address.
10. Corresponding Author Affiliation (if first author is different from corresponding author)	Information about the institution/organization that the corresponding author was associated with when they produced the article. Corresponding author affiliation can usually be located within the article (below abstract or at the end of the article). In cases where an association is not provided, Google search engine will be used to identify the primary affiliation at the time of the publication. • Researcher • Government • NGO • Civil society • Other (please specify)
11. Corresponding Author Background (if first author is different from corresponding author)	Department that the corresponding author is affiliated with at the time of publication. This will usually be identified within the article; if not provided, Google will be used to identify the primary affiliation at the time of publication. • Health • Science • Social Science • Engineering • Geography • Interdisciplinary • Other (please specify)
12. Funding agency	Funding agency (or agencies) acknowledged.
CONTEXT	
13. Geographic Focus	Geographic location in which the research was based. • Detailed State, Province, Territory, Region • Mixed/Multiple • Other
14. Project Lead (if stated)	Person identified as the project lead.

Table 3. Systematic Realist Review Reporting Tool (continued)

Variable	Definition/Description
15. Who does the project involve?	List the names of identified partners involved in the development, implementation and/or evaluation of the project. • Community • Government (municipal, provincial/territorial, federal) • Other organizations or institutions • Other stakeholders
16. Was an Indigenous community/organization partner identified? Was the Indigenous community identified as a "partner" or was the language used suggestive of other relationships (e.g., participants in a study)? That is, was a community-based participatory research (CBPR) or conventional approach used?	Was an Indigenous community/organization partner identified • Yes • No If YES – Who is identified as the community/organization partner?
17. Is water the main focus?	Is water the main focus? • Yes • No What form of water is being referred to? • Drinking water • Storm water • Wastewater • Sea ice • Lakes, rivers, streams • Sea or ocean • Watershed/ water basin • Water governance • Other (please specify)
18. How is water incorporated into the study?	Describe how water has been incorporated into the study. What aspect(s) of water research or management are addressed in the study? • Public health • Resource management • Environmental/ecosystem health • Infrastructure (e.g., water treatment, sewage, storage) • Cultural and/or gendered significance/relationship • Governance • Transportation • Sport/recreation • Water safety • Other

Table 3. Systematic Realist Review Reporting Tool (continued)

Variable	Definition/Description
19. What was the research purpose?	List the research question(s) and/or research objectives listed by the authors.
20. Does the article acknowledge treaty and Aboriginal rights that recognize the right to clean water? If so, in what way?	Does the article acknowledge treaty and Aboriginal rights that recognize the right to clean water? • Yes • No If yes, describe what role Treaty and Aboriginal rights played.
	MECHANISMS
21. What methodology /methodologies were used?	List the research methodology/methodologies used by the researchers: • Ethnography • Phenomenology • Grounded Theory • CBPR • Case study • Experimental • Empirical • Mixed methods (identify all methodologies used) • Other(s) (please specify)
22. What research methods were used?	Methods used for data collection (list all that apply). • Interviews (structured, semi-structured, unstructured) • Focus group • Survey • Participant observation • Document review • Monitoring • Photovoice • Digital media, including participatory video or digital storytelling • Sharing circle • Oral history • Ceremony • Other(s) (please specify)
23. Did the authors distinguish between Indigenous and Western methodologies and/or methods?	Did the authors distinguish between Indigenous and Western methodologies and/or methods? • Yes • No
24. How were Indigenous methodologies/methods defined?	Definition of Indigenous methodology/methods by authors (if provided). Please note if no definition was provided.
25. How was Indigenous knowledge defined?	Definition of Indigenous knowledge by authors (if provided). Please note if no definition was provided.

Table 3. Systematic Realist Review Reporting Tool (continued)

Variable	Definition/Description
26. Was the integration of Indigenous and Western science/methods stated explicitly?	Was the integration of Indigenous and Western science/methods stated explicitly? • Yes • No
27. Were integrated/integrative processes identified and if so, how?	Describe how the authors talked about integrative processes.
28. How were integration/integrative processes defined?	Definition of integration/integrative processes by authors (if provided). Please note if no definition was provided.
29. What description of the research relationship or community-based research approach was provided?	How is the research relationship described? What, if any, steps were taken to engage Indigenous community/organization partner involvement through all or some of the research process? • Design • Oversight • Data collection • Data analysis • Knowledge sharing (academic, policy, community/organization, other) • Not sure/not specified • Other (please specify)
30. Limitations acknowledged?	What, if any, limitations were acknowledged?
	OUTCOMES
31. Are any of the findings specifically directed at integrated water management? If yes, what are they?	List the key findings and conclusions from the study that are specifically related to integrated water management.
32. How was Indigenous knowledge implemented?	Look to the outcomes of the project or conclusions of the paper to help determine whether they reflect partial, full, or no implementation of Indigenous knowledge. Report what the authors describe as evidence for having implemented Indigenous knowledge.
33. What benefits to the community and beyond were discussed?	What were the benefits described (perceived or actualized)? • Policy • Governance • Health • Theoretical • Environmental • Band council • Cultural • Economic • Social • Not sure/not specified • Other (please specify)

Findings

After the title and abstract search, 226 articles were retrieved from Scopus, Google Scholar, and Web of Science. After screening the titles and abstracts for relevance, 29 articles were included, 37 excluded, and 36 moved to a full text review. The full text review resulted in an additional 11 peer-reviewed articles included (leading to a total of 40 included; 64 excluded). With respect to the grey literature, a total of 13 theses and dissertations and 40 reports were retrieved; two reports had to be excluded due to inaccessibility. After review, 12 reports and 11 theses and dissertations were also included in the SRR (see Figure 1). In sum, 279 documents were reviewed, and 63 documents were included in our SRR.

We have grouped the results of our findings into six broad thematic categories that emerged from the literature:

a. Descriptive data;

b. Context, that is, under what context water was considered or discussed;

c. Research purpose;

d. Mechanisms, that is, what methodologies were employed and/or discussed within the literature;

e. Integrative knowledge approaches employed and discussed;

f. Cited outcomes.

Descriptive Data of Authors and Articles

Although our literature search spanned 35 years, all of the retrieved literature was published in or following the year 2000. The majority of included peer-reviewed and grey literature (71%)[4] was published after 2009, with a surge in publication during 2013 (Figure 2). The majority of literature reviewed were peer-reviewed articles (n = 40 articles, 63%), with most of these articles (n = 35, 88%) describing primary research. Approximately one quarter (n = 15, 24%) of all first authors identified as First Nations, Inuit, or Métis/Metis within the text of the article (Figure 3). Within the sample, 38 articles (61%) identified non-Indigenous researchers working in partnership with Indigenous communities, and 14 of the included works (22%) discussed working with Indigenous organizations or creating knowledge exchange opportunities bringing Indigenous and non-Indigenous peoples together. The majority of the first authors were from the social sciences (n = 38, 60%), with little representation from the fields of health (n = 7, 11%), natural sciences (n = 4, 6%), or engineering (n = 3, 5%; Figure 4).

Context and Scope of Included Articles

The geographic focus of the literature was predominantly Ontario (n = 13; 21%), British Columbia (n = 11, 17%), Nunavut (n = 8, 13%), and the Northwest Territories (n = 7, 11%). All projects, however, did involve communities from all across Canada.

[4] Percentages have been rounded to the nearest whole number.

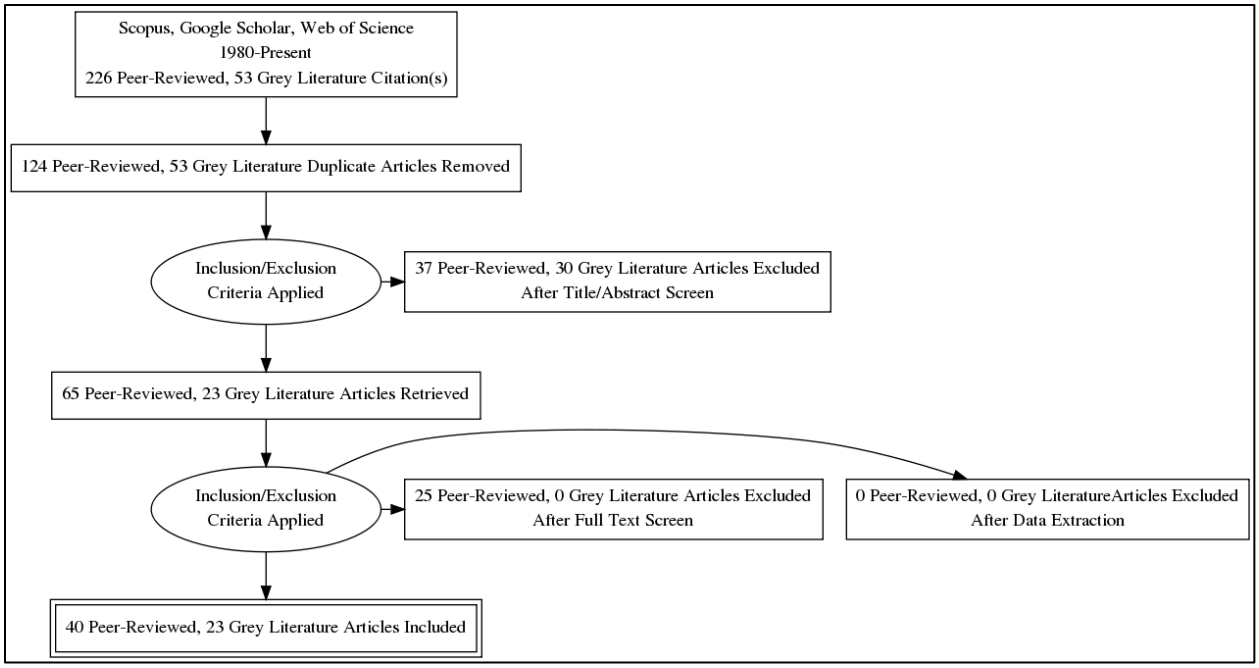

Figure 1. **Process of SRR literature inclusion and exclusion.**

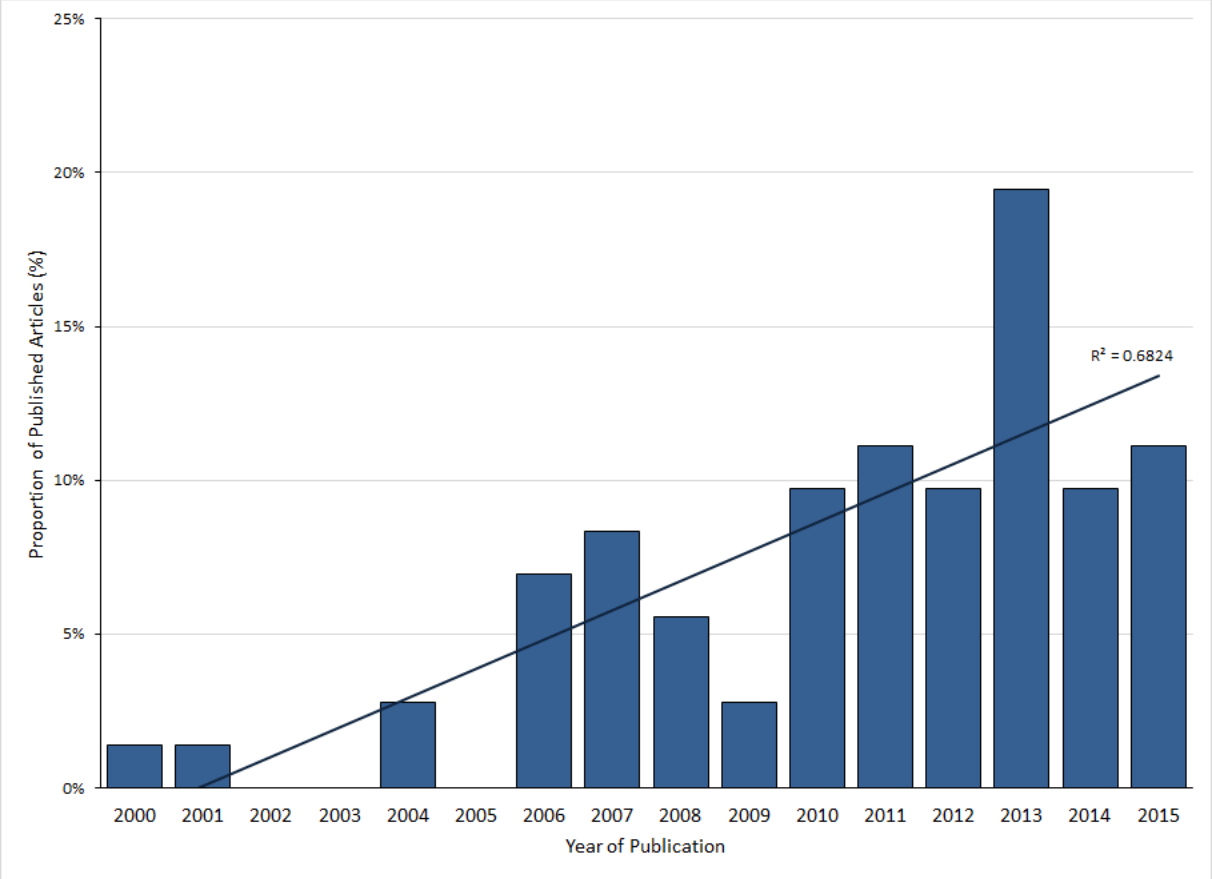

Figure 2. Year of publication of included records.

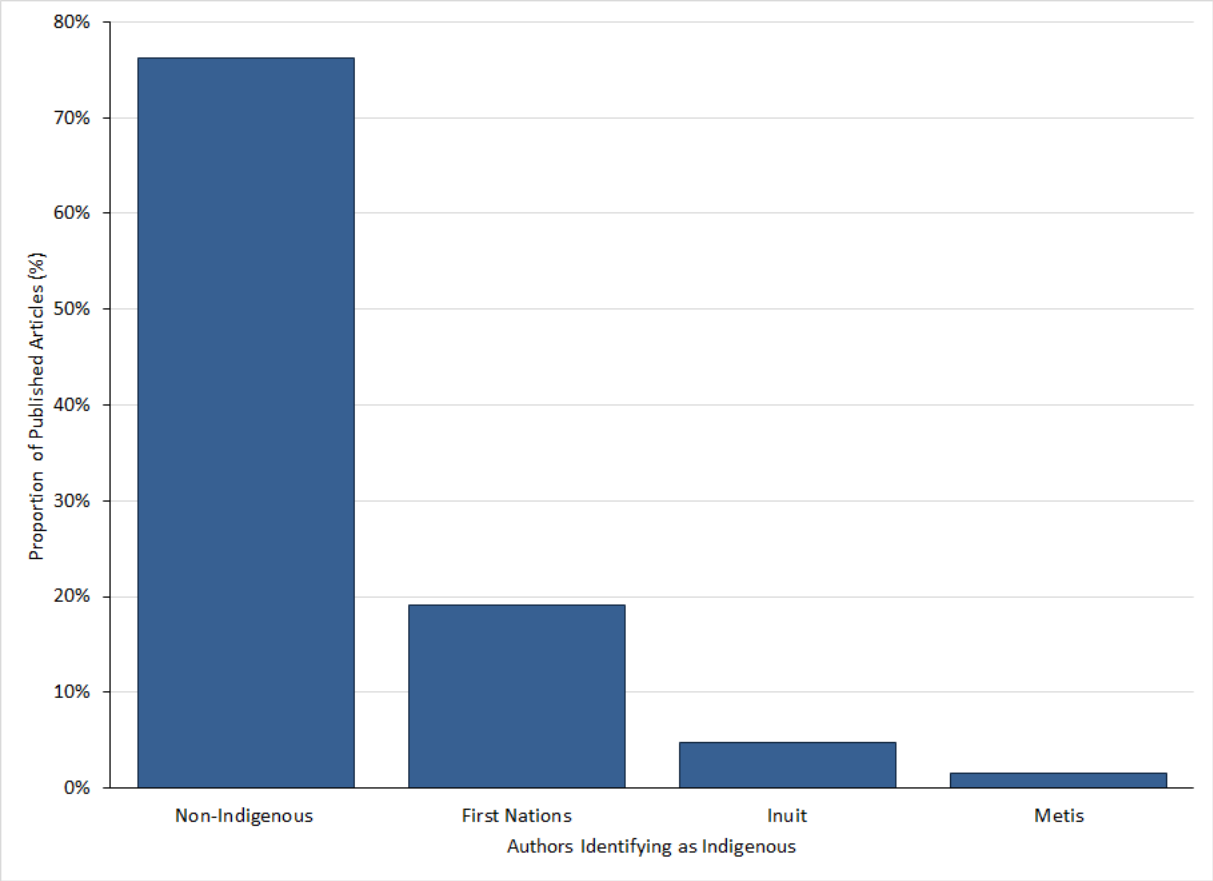

Figure 3. **Proportion of Indigenous authorship on included records.**

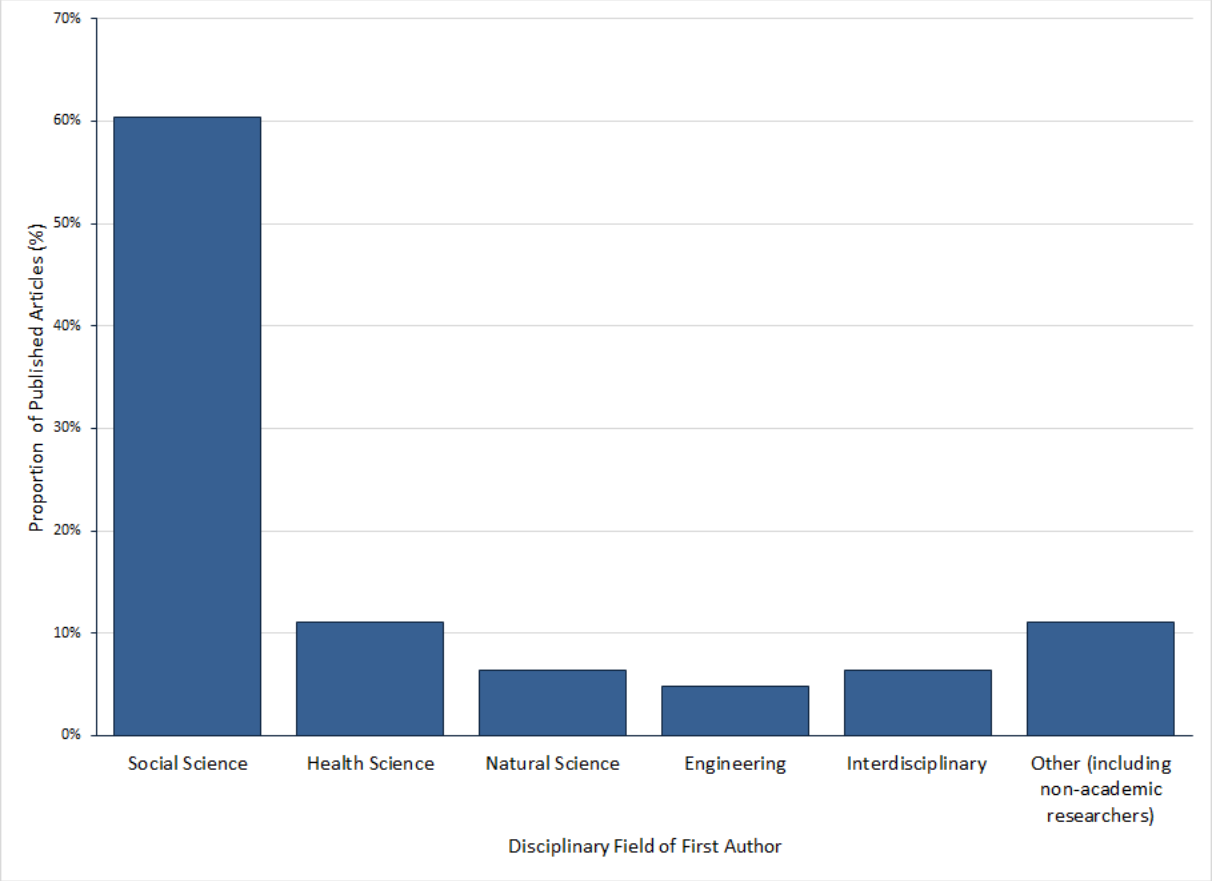

Figure 4. **Proportion of included records by discipline.**

Aligning with our inclusion criteria, 89% of the examined literature had water as its main focus. Our review confirmed that the research to date has predominantly focused on water in the context of drinking water (26%); those that did not, instead used water as an example of how Indigenous knowledge, ideas, and practices are applied to water and used in other environmental contexts (see Jones, Rigg, & Lee, 2010; King, 2004; Peace & Myers, 2012; Riedlinger & Berkes, 2001).

The literature revealed a recent rise (n = 14, 12%, published after 2009) in the number of articles written about water governance. While this might suggest an expansion in the conversation about Indigenous governance in Canada, it is notable that the authors of half of the records focusing on water governance (8 of 14) are associated with a single research group, the Water Policy and Governance Group (i.e., Baird et al., 2013; Cave, 2012; Dupont et al., 2014; Finn, 2010; Plummer, de Grosbois, Armitage, & de Loë, 2013; von der Porten & de Loë, 2010, 2013a, 2013b, 2014). For the most part, authors in general did not give more than a cursory acknowledgement of Aboriginal and treaty rights (n = 25, 40% discussed or acknowledged), if at all (n=32, 51% no acknowledgement). Researchers focusing on communities in British Columbia (western Canada) referred to the relative absence of written treaties in that province, in comparison to other provinces and territories in Canada (see Jones et al., 2010; King, 2004; Sam, 2013; von der Porten 2013; von der Porten & de Loë, 2014). Discussion of Aboriginal rights in the northern territories of Canada focused on land claims in research, rather than water rights (Berkes, Berkes, & Fast, 2007; Woo et al., 2007). Only one article stated that Aboriginal rights to natural

resources were ceded in written agreements that would give them a level of access and control over these resources (Grimwood & Doubleday, 2013), while others highlight that the federal government still does not actively support the terms of these agreements (Szach, 2013; von der Porten, 2013).

What the Research States as its Purpose and Objectives

We examined the stated research purposes and the objectives of the author(s), in order to gather a more indepth and nuanced view of current foci in water research and management. The goals of the research included in the SRR fell into five broad thematic categories:

a. Integrative approaches to research and knowledge co-production;

b. Indigenous relationships to waters and lands;

c. Institutional arrangements and capacity;

d. Water governance; and

e. Drinking water and human health.

Integrative approaches to research and knowledge co-production. When authors explicitly stated that their intention was to use Indigenous knowledge and Western science alongside each other, they were referring to:

a. Producing new knowledge,

b. Describing a process about how this was done, and/or

c. Theorizing how this can be done.

The language used in these articles reflected the intention to use Indigenous and Western science in complementary ways, including discussions about cooperative or collaborative management (co-management; for examples, see Armitage, Berkes, Dale, Kocho-Schellenberg, & Patton, 2011; Gearheard et al., 2006; Plummer et al., 2013; Riedlinger & Berkes 2001; Wolfe et al., 2007). Only Gearheard and colleagues (2006) explicitly stated researcher reflexivity in their objectives, though Wolfe and colleagues (2007) incorporated a consideration of the challenges "linked to the integration of Western science and traditional knowledge approaches" (p. 76) within their objectives, implying reflective practice.

Indigenous relationships to waters and land. This literature documented Indigenous relationships to water and/or lands, oral histories, and traditional knowledge. Interestingly, these articles also tended to be published more recently; two-thirds of articles in this category were published after 2010 (Anderson, Chow, & Haworth-Brockman, 2011; Baird et al., 2013; Caine, 2013; Fresque-Baxter, 2013; Grimwood & Doubleday, 2013; Longboat, 2012; McGregor, 2012; Peace & Myers, 2012; Restoule et al., 2013; Sam, 2013; Szach, 2013). Three articles specifically explored the perspectives of women and their relationship with land and water (Anderson, 2008; McGregor, 2011; Szach, 2013) and one focused on youth (Fresque-Baxter, 2013).

Institutional arrangements and capacity. The articles in this category sought to identify institutional arrangements for water management and flesh out the roles and purposes included therein. They also attempted to determine the institutional impacts on particular management processes and whether they constrain or facilitate the water-related management goals and outcomes. These inquiries were undertaken in order to facilitate navigating the complex institutional arrangements and responsibilities vis-à-vis water in Canada (for examples, see Armitage et al., 2011; Cave, 2012; Chilima, Gunn, Nobel, & Patrick, 2013; Gajadhar, 2013; Graham, Edgar, & Mitchell, 2009; Health Canada, 2015; Joe-Strack, 2012; King, 2004; Lebel & Reed, 2010; Lemoine, 2012; Longboat, 2012; Rizvi, Adamowski, & Patrick, 2013; Sam, 2013; Willms & Shier Environmental Lawyers, LLP, 2006).

Water governance. Articles that discussed water governance critically evaluated current governance regimes and governing bodies in order to determine methods that work and to identify the opportunity for alternative models. Alternative models were predicated on Indigenous governance models and sought to overturn the colonial relationship between Settlers[5] and Indigenous Peoples as it is experienced within research and beyond (see Baird et al., 2013; Cave, 2012; Gajadhar, 2013; Jones et al., 2010; Lemoine, 2012; Norman, 2012; von der Porten, 2013; von der Porten & de Loë, 2010, 2013a, 2013b).

Drinking water and human health. The research purposes for articles in this category linked water management strategies to the relationships between drinking water quality and physical health in an effort to improve both water and human health. These articles generally retained a focus on water quality (see Harper et al., 2011; Martin et al., 2007) and did not include discussions of emotional, mental, cultural, or spiritual health connections to water, though there were exceptions to this rule (e.g., Goldhar, Bell, & Wolf, 2013; Patrick, 2011).

Mechanisms for Conducting Research

The most commonly used methodology was a case study[6] approach (28%) followed by empirical approaches (17%) and literature reviews (12%). A community-based participatory approach was noted in eight (13%) of the included articles. Interviews ($n = 40$, 27%) and document or literature reviews ($n = 31$, 21%) were the most commonly used methods, followed by focus groups ($n = 15$, 10%) and participant observation ($n = 13$, 9%). Storytelling (see Berkes et al., 2007; Caine, 2013), place-based learning (Caine, 2013; Grimwood & Doubleday, 2013), oral history (Berkes et al., 2007; Riedlinger &

[5] In the context of this article, a Settler is any non-Indigenous person in Canada, whether through ancestral or contemporary immigration over the past 500 years.

[6] We use the language provided by authors describing their own studies; with respect to 'case studies', we recognize that many may actually be referring to empirical approaches.

Berkes, 2001; Sam, 2013), and sharing circles (Szach, 2013) were also identified. The majority of articles (87%) did not define or distinguish between Indigenous and Western methods and/or methodologies.[7]

Indigenous knowledge was referenced more frequently, with approximately one-quarter of articles including a definition of Indigenous knowledge, and an additional one-fifth acknowledging its existence without offering a definition. In most cases, Indigenous knowledge was not explicitly or "neatly" defined, reflecting its intangible nature and echoing historical challenges with respect to the definition of Indigenous knowledge (Matsui, 2013). In several articles, definitions were based on the community research partners' input (e.g., Grimwood & Doubleday, 2013; Woo et al., 2007). However, references to respect, local understandings of place, spirituality, language, and fluidity over time were consistently included in definition discussions.

Integrative Knowledge Approaches

The SRR revealed that 35% of articles explicitly stated that they were employing Indigenous and Western ways of knowing in integrative ways. Written discussions about integrative processes considered the research relationship; the importance of knowledge exchange opportunities and how these function as integrative processes in and of themselves; knowledge co-production, including how integrative processes can be used to form policy that respects, values, and is a proponent of multiple ways of knowing; as well as how Indigenous and Western knowledge used together benefit each other as well as improve the success of the goal or problem to which they are being applied. Similarly, recognizing that integrative approaches might include any number of methods, Huntington, Gearheard, Mahoney, and Salomon (2011) noted that, most importantly, respect and interpersonal relationships must be present. While McGregor (2008), in her review of the 2000 State of the Lakes Ecosystem Conference, described how Indigenous representatives saw the approach taken there to be an "add-on approach," where Indigenous knowledge was to be incorporated or integrated into an existing Western scientific framework.[8]

The barriers to integrative approaches were acknowledged as limitations in some papers, which included language and translation challenges (e.g., Berkes et al., 2007; Lemoine, 2012; Nichols, Berkes, Jolly, Snow, and the Community of Sachs Harbour, 2004; Perron, 2011) but also considered the lack of Indigenous voices in decision-making processes about water (e.g., White et al., 2012) and the unequal weight given to Western knowledge in comparison to Indigenous knowledge (e.g., Geertsema, 2009). Similarly, the challenges of "fitting" Indigenous knowledge into Western structures was noted as problematic, in that it reflected the divisions between wholistic and siloed worldviews (Berkes et al.,

[7] Cree scholar Shawn Wilson (2008) posits that relational accountability (researchers as actors and interpreters in and of our relationships with each other and the cosmos) is the key to determining whether or not research methods fall within an Indigenous research paradigm. Wilson (2008) goes on to state, "traditional Indigenous research emphasizes learning by watching and doing" (p. 40), though participatory research methods are not necessarily required as long as the borrowed methods are consistent with an Indigenous research paradigm. Cree and Saultaux scholar Margaret Kovach (2009) also argues that ensuring value for the community is integral to Indigenous methods and Indigenous research paradigms as a whole.

[8] This was a common problem described by members of our project's NAC and Water Gathering participants, and which is inherently disrespectful and devaluing of other ways of knowing.

2007). Perhaps most importantly, McGregor (2008) argued that Indigenous knowledge loses its meaning when applied outside of its original context within a Western scientific setting.

Research Outcomes and Author Recommendations

The reported outcomes of the research papers included in the SRR fell into three general categories:

a. Findings specifically directed at integrative water management;

b. Implementation of Indigenous knowledge in (Western) research or management processes; and

c. Benefits to the community and beyond.

Findings specifically directed at integrative water management. Papers that offered findings about integrative water management identified the need for place-based approaches to contemporary water research and management through the inclusion of local Indigenous knowledge systems and community partners, as this approach—several authors argued—leads to more meaningful and mutually beneficial research and management outcomes in comparison to non-integrative research. Authors argued that the implementation of Indigenous and Western knowledge systems can improve water and human health outcomes for all those involved (Baird et al., 2013; Berkes et al., 2007; Daley, Castleden, Jamieson, Furgal, & Ell, 2014; Goldhar et al., 2013; Harper et al., 2011; Huntington et al., 2011; Lawrence & Pillsworth, 2011; von der Porten & de Loë, 2010). Several authors reported findings specific to co-management processes, while others alluded to possible improvements within existing institutions and their arrangements. Grimwood and Doubleday (2013) underscored the importance of recognizing diverse perspectives, rights, and responsibilities. Time, trust, effective communication, and "sensitivity" to Canada's colonial history were also acknowledged as necessary (Armitage et al., 2011; Wolfe et al., 2007).

An emphasis on redefining Indigenous Peoples' roles in collaborative water management also emerged from our analysis. Many authors acknowledged that implementing Indigenous knowledge in water research and management strategies would serve to benefit all Canadians and emphasized the importance of respecting Indigenous Knowledge and treating it as equal to Western Knowledge (Chiefs of Ontario, 2007; Lavalley, 2006; Szach 2013). While some argued effectively for a nation-to-nation governance model (see, for example, von der Porten & de Loë, 2014), there was little to no discussion of how this could be operationalized. That said, two publications highlighted that dependency relationships on governments must dissolve by either pooling common resources through nation-to-nation collaboration (von der Porten, & de Loë, 2010) or evolving self-government (White et al., 2012). Findings from co-management experiences were also offered as recommendations to improve the work of integrative approaches to water management and research (see Box 2).

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Box 2. Recommendations from Co-Management Literature

a. Improved communications between First Nations and government officials (Finn, 2010) and, specifically, prioritization of face-to-face communication (Wolfe et al., 2007);

b. Culturally sensitive operator certification (Graham et al., 2009, Smith, Guest, Svrcek, & Farahbakhsh, 2006);

c. Application of traditional conflict resolution techniques (Graham et al., 2009);

d. New and enforceable water laws that involve First Nations in their creation (Finn, 2010);

e. Knowledge holders from the communities should define the process in which it is applied into policy (Finn, 2010; von der Porten & de Loë, 2010);

f. Increased data sharing and collaboration between First Nations leaders, industry, academia, and jurisdictions (Joe-Strack, 2012; von der Porten & de Loë, 2010).

Implementation of Indigenous and Western knowledge systems. In the papers we reviewed, integrative implementation in research and management processes generally took the form of a collaborative team of Indigenous and Settler peoples, but these teams did not necessarily reflect equal responsibility or participation throughout the project; rather, it was often that Indigenous Peoples would participate at specific points in the process. There were cases where the authors discussed the implementation of Indigenous knowledge systems in management, such as the Aboriginal Steering Committee that emerged from *Northern Voices, Northern Waters* (Miltenberger, 2011), the Great Bear Lake Management Plan discussed in Caine (2013), and the Whitefish Lake Plan (Natcher, 2000). In their paper, Peace and Myers (2012) noted that their knowledge mobilization products included film and photovoice products that were published online, community-based ice monitoring, surveillance, and communication networks, and information products on land, water, and ice safety. These types of outputs are outside the box of conventional academic publications that tend to narrate findings and conclusions to academic audiences, and speak to the importance of long-term partnerships that can support such integrative knowledge implementation.

Benefits to the community and beyond. Benefits that authors identified for taking an integrative approach were listed as enhanced understanding about a particular phenomenon, such as water governance (Cave, 2012; Finn, 2010; von der Porten, 2013). More often, however, these benefits were identified as new knowledge that translated (or could be translated) into cultural, and/or environmental (water), and/or human health benefits. While much of the SRR literature included identification of the potential to influence policy through their research or project outcomes (Anderson, 2011; Armitage et al., 2011; Gearheard et al., 2006; Harper et al., 2011), it was often difficult to discern whether the research translated into direct benefits for the community partner.

Discussion

Our SRR findings pull together, in one place, the gamut of scholarship on water research and management that has sought to implement Indigenous and Western knowledge systems in Canada over the past 35 years (1979 - 2014). Our findings first provided some descriptive data about this body of work before moving into an analysis of breadth and depth of approaches. Here, we identified five broad themes: integrative approaches to research and knowledge co-production; Indigenous relationships to waters and lands; institutional arrangements and capacity; water governance; and drinking water and human health. Using our SRR tool, we then explored the methods that have been used to do this type of work, the extent to which such implementation is described or discussed in the literature, and the outcomes or recommendations arising from undertaking this integrative approaches. These findings are discussed below.

The descriptive data about the literature recorded through the SRR reveals an increasing awareness of the value and necessity of collaborative, integrative, community-based and participatory approaches in research and water management, as evidenced by the recent upsurge of relevant publications. The bulk of included literature was published after 2009, which flows soon after the United Nations announced its Declaration on the Rights of Indigenous Peoples (2007)—a global call for recognition of Indigenous rights to, among other things, environmental decision-making and self-determination. Additionally, in 2010 the Panel on Research Ethics in Canada outlined new guidelines for research involving Indigenous Peoples, which encouraged implementation of Indigenous knowledge in Indigenous-focused research.

The descriptive and contextual insights into these publications also characterizes *who* is undertaking these approaches to water management and research—and *what* gaps or opportunities for future work might exist. Perhaps not surprisingly, only a minority of first authors identified as Indigenous (although more could self-identify and not include this designation within the text of their article), as the reality of water governance and research landscapes in Canada is still very much dominated by the Settler population; thus, it is their voices that are still dominating the water narrative. While our data are specific to the water context, this finding reflects the fact that despite increasing numbers of Indigenous researchers, Settlers still dominate the research landscape, even when it comes to issues concerning Indigenous Peoples (Ball & Janyst, 2008), thus pointing out the need to address the gap in Indigenous-led scholarship in the academy by supporting capacity development and mentorship (see, for example, the work of Canadian Institute of Health Research in that area: Richmond, Martin, Dean, Castleden, & Marsden, 2013).

The dearth of first authors and funding emerging from the science and engineering disciplines is also worth noting. This could be because there are relatively few researchers from the natural sciences or engineering undertaking integrative, collaborative, or community-based participatory research approaches in their work relating to water. This trend has also been noted elsewhere (see Feldman, 2004; also cited in Kershaw, Castleden, & Laroque, 2014) and was echoed by participants at our Water Gatherings, a group that included natural scientists and engineers who felt as though they were anomalies in their fields. Yet the strengths of integrative knowledge approaches are equally applicable in their contexts; using integrative approaches can help ensure that results better address the needs of the community, strengthen relationships, build capacity, and ultimately improve water quality or management processes (Lavalley, 2006; McGregor, 2012; Phare, 2011; Walkem, 2007). We also

recognize that description about the inclusion of integrative methods and findings may not have been deemed important by some authors, peer reviewers, and/or editors in these (and other) fields of study, potentially leaving some of the "story" on the editing room floor.

Thus, while acknowledging the value of Indigenous knowledge systems and approaches to research is increasing in the water-related literature, we "aren't there yet" in terms of creating space for Indigenous-led or co-led research in collaborative inquiry or for applying integrative research approaches across all disciplines; in fact, we are no where near "there." Given the legacy of failure and harm resulting from decades of neglecting and de-legitimizing Indigenous ways of knowing in settings both within and beyond the academic research environment (Koster, Baccar, & Lemelin, 2012), bringing Indigenous and Western knowledge together makes (urgent) sense, particularly in response to Canada's newly released Truth and Reconciliation Commission of Canada's (2015) Calls to Action. At the same time, we agree with Bartlett and colleagues (2012, 2015), who noted that trying to implement Indigenous and Western approaches in wholistic and equitable ways in any given research project is often easier said than done, and the message from Castleden, Sloan Morgan, and Lamb (2012), who noted that many researchers who take integrative approaches need to "spend the first year drinking tea" (p. 160).

The SRR revealed several gaps with existing integrative knowledge approaches. The most commonly employed research methods were described as "Western," with few research or management approaches including explicit mention of Indigenous methods or methodologies. Most articles considered water only in the context of drinking water; importantly, gendered and generational relationships to water, as well as emotional and/or spiritual connections to water, were almost always ignored, contributing to an erasure of complex, multilayered, and wholistic understandings of water. An exclusive focus on endpoint solutions, such as drinking water treatment and sanitation does little to incorporate Indigenous methodologies such as relationality (Wilson, 2008), by minimizing or blanket erasure of any spiritual and relational components of water, rather than considering it as an aspect of a legitimate ontology. This is problematic as the creation and implementation of new knowledge cannot occur within an exclusively Western research paradigm; attempts to do so will result in the extractive nature of science that has occurred for decades in academe: removing context that matters (Koster et al., 2012).

Research principles such as those described in Bartlett and colleagues (2012) and community-based participatory research (e.g., Castleden et al., 2012) that seek to develop research projects through an entirely collaborative process can prove effective in generating meaningful engagement and knowledge implementation. However, these approaches are still on the margins in the Canadian research community, and so, not surprisingly, were not cited as frequently used. This raises concerns (also reflected within some of the reviewed literature) that Indigenous knowledge is incorporated into an existing Western scientific framework as an afterthought, or through an "extract and add-on" approach.

Similarly, some papers raised the issue of the absence of Indigenous knowledge and voice when moving research to decision making and action. Western knowledge is frequently privileged over Indigenous knowledge, particularly in decision-making contexts (Geertsema, 2009; White et al., 2012). Outside the realm of water-focused integrative approaches, Nadasdy (2003) interrogates the political milieu in which co-management operates in the context of wildlife management, where decision-making power is vested in Western institutions, systems, and structures. Nadasdy argued that truly "equal" valuation and representation is impossible without a restructuring of the institutions, practices, and underlying

assumptions of wildlife management itself, because the political power to act on knowledge remains with Western institutions. In the context of water governance and nation-to-nation relationships, the conspicuous absence of discussion on Indigenous and treaty rights throughout the reviewed literature points towards opportunities for stronger consideration and meaningful and nuanced inclusion.

Despite the challenges we have identified within the literature, this SRR has also provided insight into the central lessons learned amongst researchers and practitioners who undertake integrative approaches to their water work. For example, they have noted that Indigenous knowledge is embedded within the context, language, and places it is produced, and thus, context-specific integrative approaches to contemporary water research and management is central to encouraging better research and management outcomes, and associated improvements in water and human health (Woodward, Jackson, Finn, & McTaggart, 2012). As well, there is a consistent message that integrative approaches must be in line with each individual community's standards, desires, and directives (e.g., Perron, 2011). Other overarching themes and lessons that emerged from the texts include the development of respectful relationships to carry out projects, from initial design to knowledge sharing and decision making; this was repeated throughout many papers, underscoring the importance of face-to-face relationship building and the trust it facilitates (e.g., Huntington et al., 2011). It is essential that the processes of integrative knowledge production reflect the values of equity, reciprocity, and shared responsibility (e.g., Armitage et al., 2011; Cave, 2012; Gearheard et al., 2006; Longboat, 2012). Particularly in the context of Canada's ongoing colonial relationship with Indigenous Peoples, there is an emphasis on redefining Indigenous Peoples' roles in collaborative water management, either through nation-to-nation models of water governance or co-governance; a project which requires not only the transformation of the ways we produce knowledge, but also changes to the ways knowledge informs decision-making processes, and to those decision-making processes themselves.

Limitations

The SRR was intended to capture the breadth and depth of integrative water research and management in Canada. With any study, comes limitations. Here we recognize that the SRR only captured what has been published in English, which is a key limitation to a Canadian-focused review as the country has two official languages, English and French, and French was excluded.[9] Additionally, our knowledge of the authors' experiences is constrained by what can be conveyed through written work, as well as what has been able to be published. One important lesson learned through the course of this research, including the Water Gatherings, is that there is a wealth of knowledge, experience, and even written documentation that is absent from the published literature and, therefore, inaccessible through our database searches. We have sought to overcome this limitation by reaching out to the first authors (typically academics) of exemplars in this field (identified through the SRR) to conduct semi-structured qualitative interviews with them and their community partners (Castleden et al., 2017 as Part 2 of this research in this journal).

[9] For an international comparison, please see Stefanelli et al. (2017a, 2017b).

Recommendations

This research examined literature within the Canadian context, and through this examination, we have provided recommendations derived from the authors of included literature, as well as our own insights from reflecting on our past research practices in this area. Additionally, though these recommendations emerged from the Canadian context, they have research and policy implications that can be translated to broader international contexts.

a. Increased support for Indigenous people to encourage success in the realm of academia. As peer-reviewed, published literature from reputable journals guides the discourse, the encouragement of strong Indigenous voices through financial and educational support is integral to integrative research in water resource management and beyond.

b. Encourage collaboration between Indigenous and Western knowledge holders at the outset of a research project proposal. Designing a project with guidance from Indigenous community leaders and members runs counter to the current funding structures in academia whereby grant submissions require detailed descriptions of research proposals, therefore an increase in grant development funding can further support this type of approach to research, where it can become community-driven not just investigator-driven.

c. Collaboration between the natural sciences, engineering, social sciences, and health sciences on research teams presents an opportunity for integrative research to occur if Indigenous knowledge systems across these disciplinary divides are also equitably engaged.

d. As the global population, and subsequently the stresses on finite freshwater resources, continues to increase, researchers are encouraged to take a more wholistic perspective of water quality – beyond encouragement solely for investments in infrastructure. Pollution, diversion, and water ethics did not appear often in this research, despite their tremendous importance.

e. Indigenous Peoples have developed complex systems of place-based knowledge. The place-based nature of this knowledge, however, does not necessarily translate between contexts or lend itself to the development of "cookie-cutter" policies that can be used in various contexts. Instead, we recommend spending time with communities and engaging in meaningful discussions to develop community-specific objectives for addressing water challenges.

Conclusion

This article contributes to filling a substantial knowledge gap regarding the state of integrative Indigenous and Western knowledge approaches to water research and management in Canada, which, to date, has been largely understood through case studies and general review articles. Importantly, this work accompanies a burgeoning field of literature on integrative approaches, and substantiates findings from community-based participatory research, and other integrative approaches to research and management that have application beyond the Canadian context examined in this work. Ultimately, the

insights from this research support Indigenous nations and organizations, and their allies who are building partnerships, striving for reconciliation, and healing by working together for a shared future.

The importance of establishing an advisory committee comprised of Indigenous and Settler water experts to guide this research cannot be overstated. This committee allowed for Indigenous and Western knowledge holders to contribute to the design, analysis, and dissemination of the research. Due to the international nature of the ongoing water crises, and the generations of place-based knowledge held by Indigenous populations across the globe, the establishment of an Indigenous–Settler advisory committee is a strategy that is applicable for integrative water research in international contexts for governments, academia, and beyond.

Throughout this article, we have used the term "integrat*ive* approaches," rather than "integrate*d* approaches," to refer to the ongoing process of knowledge co-production. This language was an intentional decision, arising from input gathered through discussions with our NAC, Water Gathering participants, and within the literature. The term "integrated" suggested that an endpoint exists, and has maybe even been reached, where two dichotomous knowledge systems have come together in stasis. In contrast, the term "integrative" is meant to imply that the co-learning journey is neverending, and to reflect the fluid nature of knowledge and knowledge exchange (Bartlett et al., 2012, 2015). This, we maintain is a key take-home message from our research.

In light of the Truth and Reconciliation Commission of Canada's (2015) Final Report and Calls to Action, the current federal government's claim to wanting a nation-to-nation relationship with Indigenous Peoples in this country, and the United Nations (2007) Declaration on the Rights of Indigenous Peoples (which Canada only recently agreed to support, without qualification), water is a catalyst for changing our relationship to the land and with each other. Political will from institutional environments (i.e., funding agencies and universities) is needed to support the transformational learning and research processes that value Indigenous ways of knowing as equal to (and in some cases, preferred over) Western systems of knowledge and practice. In the context of disproportionate burdens associated with water-related challenges and risks experienced by Indigenous nations, and in light of the strengths and benefits of integrative research and management approaches, we cannot continue with the status quo of exclusion or tokenism if we are to change the way we relate to and engage with water.

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