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Fisheries knowledge exchange and mobilization through a network of policy and practice actors

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ABSTRACT

Conservation researchers have been shown to be motivated by the application of their work to address real world problems. However, a significant number of recent studies in the sociology of science and related fields such as knowledge exchange and knowledge mobilization have shown that direct influence of conservation science on policy and practice is rare. To improve conservation science uptake, we need a better understanding of how knowledge mediation and interpretation by potential knowledge users actually happens. This article examines qualitative data from a set of 65 interviews with government staff and other stakeholders and rights holders involved with rainbow trout (*Oncorhynchus mykiss*) management in British Columbia, Canada. The focus of the investigation is on the ways that scientific knowledge moves through this network of actors. We approach knowledge exchange and mobilization as a social and political process. Our analysis makes use of the concept of knowledge mediation spaces as the specific settings in which actors deliberate and make sense of multiple forms of knowledge and competing social interests. Four knowledge mediation spaces were identified in the case study: sharing expertise and best practices, consultation on policy direction, program delivery, and research partnerships. Sharing of knowledge among actors in this network was found to be influenced by the movement of individuals from one organization to another throughout their careers. We also found that there is frequent interaction among actors for problem solving and seeking expert advice and that scientific methods strongly inform the actions of fisheries actors; yet science does not always play a role in policy formation. We recommend researchers place more emphasis on engaging stakeholders and Indigenous rights holders more directly in order to inform their research agendas and to facilitate more direct pathways for knowledge exchange, and by extension impacts on management and conservation.

1. Introduction

Conservation science, as an applied discipline, is oriented towards active protection and restoration of biodiversity and ecosystems (Kariva and Marvier, 2012). Research has shown that conservation scientists are motivated by seeing their research used in practical ways (Singh et al., 2014). However, direct impacts of university-based research on policy and practice are rare, and indirect impacts are not always evident, occur circuitously, and/or are significantly time-delayed (Adams and Sandbrook, 2013; Rose, 2015). In conceptualizing the challenge of encouraging (and observing) impact, we begin with Phipps et al.'s (2016) conceptualization of research impact as any instance in which an organization or community takes up new information to use it as a basis

for a decision to maintain, adjust, or substantially change a given policy or practice. Conceptualizing impact in this way puts the emphasis on real-world decisions by end users, rather than by tracking readership or citation of articles as is often done (Phipps et al., 2016). Several recent papers have similarly argued that while traditional metrics of research impact that focus on dissemination are important, higher level impacts come from social, environmental, and economic outcomes that are not well captured using those measures (Singh et al., 2019; Cooke et al., 2020; Louder et al., 2021).

Our approach to knowledge generation and exchange is rooted in the sociology of science, similar to that of Fazey et al. (2014). In that seminal article, Fazey and colleagues argued that knowledge is constructed and that its interpretation is influenced by an individual's prior knowledge,

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personal and professional experience, and group and organizational culture. This means that factors such as social norms, values, and power influence how knowledge is received and applied, often in the form of narratives distilled from data or findings (Buschke et al., 2019; Stern et al., 2021). Narratives that are favoured by influential and trusted actors ultimately shape policy and practice directions (Nurse-Bray et al., 2014; Armitage et al., 2015; Berdej et al., 2015; Rose, 2015; Rose and Parsons, 2015; Clark et al., 2016).

Studies of knowledge exchange and knowledge mobilization have shown that social and professional relationships are critical for facilitating the movement of knowledge within and across organizations (e.g., Crona and Parker, 2011; Kulig and Westlund, 2015; Nguyen et al., 2020). Interpersonal relationships move knowledge via advice-seeking, and add important dimensions of personalization and trust (Young et al., 2016a). Relationships help decision-makers access the information and knowledge that they need (Gale and Cadman, 2014; Kulig and Westlund, 2015), where knowledge is pulled and pushed between the domain of science and the domain of action (e.g. conservation and management) in an iterative process (Roux et al., 2006). When making decisions or plans, conservation actors have been shown to draw on personal experience, discussion with colleagues and experts, guidelines from governments and NGOs, and other informal sources (Pullin et al., 2004; Cook et al., 2012; Gale and Cadman, 2014; Rose, 2015; Rose and Parsons, 2015; Fabian et al., 2019; Kadykalo et al., 2021a).

There is also an extensive literature on barriers to the use of scientific evidence for conservation in practice and policy. Barriers include actors not having access to peer reviewed literature, limited organizational capacity for accessing and interpreting the science, institutional inertia,

mismatches in priorities or decision-making processes, lack of trust in the research or researchers, and the influence of advocacy groups with an interest in maintaining the status quo (see Rose et al., 2018; Nguyen et al., 2019; Walsh et al., 2019). Underlying these barriers, adoption of scientific knowledge can often be hindered by a reluctance to take the political risk to change policy or management approaches, rather than a lack of knowledge among conservation staff (Shafer et al., 2015; Artelle et al., 2018; Nguyen et al., 2018).

We investigate scientific knowledge mobilization and exchange in relation to rainbow trout (*Oncorhynchus mykiss*) management in British Columbia (BC), Canada (Kadykalo et al., 2020, 2021b). We use qualitative data from interviews to analyse how actors involved in the management of rainbow trout, as potential knowledge users, come into contact and become familiar with scientific research. Rainbow trout are important for recreational and subsistence fisheries, but impacts from climate change are putting greater pressure on wild populations. As cold-water salmonids, rainbow trout are impacted by hydrological changes such as increased water temperatures in summer, decreased water oxygen content, and increasing frequency of drought (Wenger et al., 2011; Jones et al., 2012; Whitney et al., 2016). These changes in habitat quality and quantity arising from climate change will have direct and indirect effects on fish health, condition, and survival (Whitney et al., 2016) with associated knock-on effects on fish populations and communities (Lynch et al., 2016).

2. Knowledge-action framework

This research makes use of the knowledge-action framework

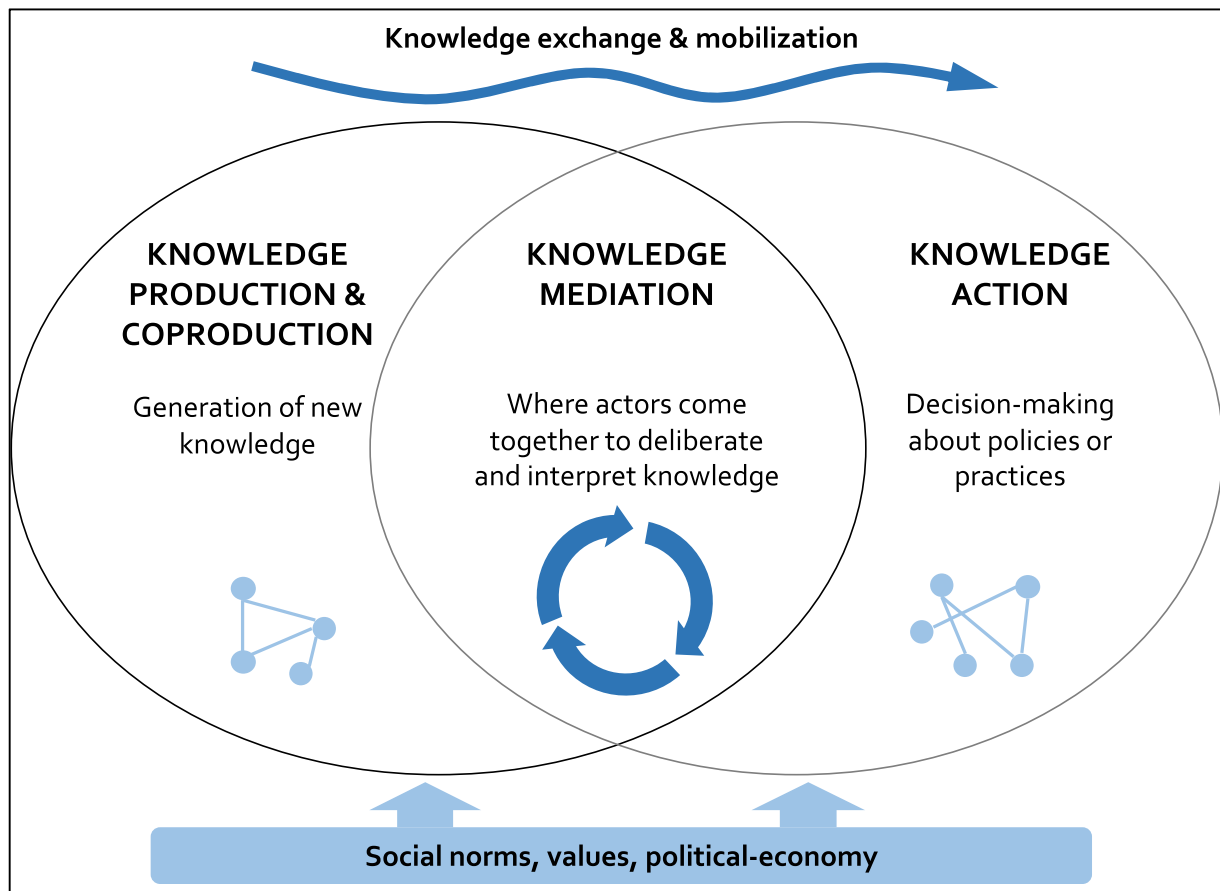


Fig. 1. New emphases in the framework include knowledge mediation as a non-linear process, and recognition that social norms, values, and political-economy affect all dimensions. Knowledge mediation spaces are conceptualized as specific contexts within the knowledge mediation dimension in which people deliberate and make sense of knowledge.

Knowledge-action framework adapted from Nguyen et al. (2017).

developed by Nguyen et al. (2017). The framework is intended to assist description and analysis of the movement of knowledge from generation to application. Fig. 1 offers an updated framework that places additional emphasis on (1) the influence of social norms, values, and political-economy (i.e., the political and economic interests of key groups), (2) knowledge exchange and mobilization as non-linear processes, and (3) social interactions and relationships that can shape the movement of knowledge towards action. The framework – both original and in modified form here – has three dimensions. These dimensions, including new areas of emphasis, are explained in this section.

The first dimension is knowledge production or co-production. Within the conservation field there has been increasing recognition of the breadth of sources of knowledge, including Indigenous knowledge, participatory science (e.g., citizen science or community-based science), and scientific research in academia and government. Knowledge co-production, where researchers and partners mutually define goals and carry out steps of the research process, has gained prominence (Wyborn, 2015). Co-production helps to shorten the distance between knowledge production and practical application of knowledge and often increases the knowledge impacts, though it can be difficult and costly (Sutherland et al., 2017; Oliver et al., 2019).

The second dimension is knowledge mediation. As we explain below, this article focuses on this dimension. Knowledge mediation is represented in the framework as a dynamic and non-linear process. Knowledge does not flow directly from knowledge to action – it passes through networks of actors, is evaluated according to actors' interests, values, and beliefs, and can be reinterpreted and potentially misunderstood or blocked throughout (Reed et al., 2014; Nguyen et al., 2017). Boundary organizations – often understood as organizations that work across science-policy interfaces – can also play a role in making sense of knowledge for different groups of actors (Star, 2010; Gustafsson Lidskog, 2018). As can knowledge brokers or evidence bridgers, intermediary individuals or organizations that work across science-practice boundaries (Cvitanovic et al., 2015a; Farwig et al., 2017; Kadykalo et al., 2021a). The social relationships among actors are particularly important as individuals are embedded within structures of power as well as networks of political and social influence that affect how they accept or reject certain forms of knowledge (Purdy, 2012; Weiss et al., 2012; Young et al., 2016b). Interactions among fisheries actors are key for understanding the mediation and flow of knowledge (Leonard et al., 2011; Alexander et al., 2016). Hence, one divergence from Nguyen et al.'s (2017) original model in our conception of the knowledge mediation dimension is that it is considered as an overlapping space, rather than a separate space, from the other two dimensions. None of the processes within the knowledge mediation dimension ensure that any aspects of knowledge will move from knowledge production to action.

The third dimension is knowledge-based action. The premise of the knowledge-action framework is that information and knowledge can make its way from actors who are involved in the production of knowledge to actors who are willing and able to apply that knowledge in ways that benefit people and the natural world. Those actors in the conservation field include staff in natural resource related government agencies, Indigenous rights holders, conservation organizations, industry, farmers and other private landowners, educators, resource users, and other researchers. As explained at the outset of this article, we conceptualize research impact to include influence on decision-making about practices or policies (Phipps et al., 2016; Cooke et al., 2020). The decision can be to leave the practice or policy alone, even if perfectly informed by new knowledge. Examples of impactful outcomes may include changes in consumer or resource user behaviour, joint agreements and programs to control invasive species, or creation of public education platforms (Nguyen et al., 2017).

As described with the original framework by Nguyen et al. (2017), there are also feedback loops and learning that take place across the knowledge-action framework. These feedback loops help connect all three dimensions as knowledge is continually re-evaluated and

re-interpreted. The feedbacks are meant to re-enforce recognition of non-linearity and multi-directional movement of knowledge across the knowledge-action framework.

This article further develops the knowledge-action framework through investigation of processes and mechanisms within the knowledge mediation dimension. We aim to consider and understand where and how knowledge exchange and mediation occurs. As we have situated our understanding of knowledge as socially constructed, we emphasize that scholarship on knowledge mediation also needs to take into consideration how natural resources are perceived and managed. For instance, Whyte (2018) demonstrated how settler colonialism is a foundation for injustices against Indigenous peoples and for ecological domination. Acknowledging the foundational linkages between settler colonialism and scientific approaches to resource management is critical for understanding how knowledge is perceived by different actor groups. Indigenous scholars have emphasized the importance of making space for multiple forms of knowledge, and also the need for research leadership from marginalized groups (Latulippe and Klenk, 2020; Reid et al., 2020). Similarly, Odekunle (2020) reflected on discrimination within science, including the lack of diversity and inclusion in scientific fields. These literatures help to contextualize evaluation of whose knowledge is heard and whose knowledge counts when it comes to making informed fisheries conservation decisions. We note that while our analysis within this article does not directly use this type of lens, we do situate the discussion within these broader discourses.

To inform this investigation, we draw from Toomey et al. (2017) and the idea that knowledge exchange does not occur at a singular time or in a singular place, but in a series of interactive 'action spaces'. We also build from consideration that actors mediate knowledge based on the normative tasks and problems that they are faced with (Lebel et al., 2006; Armitage et al., 2012; Cvitanovic et al., 2015b). To avoid confusion with terminology, in this article we will refer to these spaces as *knowledge mediation spaces* to emphasize that we are focused on the settings in which actors interact and deliberate interests and values related to fisheries management. In the case of rainbow trout scientific knowledge, what does qualitative evidence tell us about the movement of knowledge within mediation spaces? In particular, we analyse (1) how actors interact within rainbow trout management knowledge mediation spaces and (2) how knowledge exchange and mobilization are taking place within those spaces.

3. Methods

The research presented in this article is part of a larger project entitled "*Sustaining Freshwater Recreational Fisheries in a Changing Environment*" that uses genomics tools to support the rainbow trout recreational fishery in British Columbia (BC). The project has both natural science and social science research goals. Its overall aim is to identify governance recommendations for sustainable rainbow trout populations and its recreational fishery (see also Grummer et al., 2019; Taylor et al., 2019; Kadykalo et al., 2020; Kadykalo et al., 2021b).

A qualitative approach based on open-ended interview questions was used to gather opinions and perspectives of actors connected to rainbow trout science and management. The interview questions were designed to encourage open-ended discussion about rainbow trout assessments, roles of organizations and individuals, knowledge channels, and views on knowledge and science (Axinn and Pearce, 2006; Young et al., 2018). We developed the initial population frame for the interviews based on a review of authors of 'grey' (government) literature on fish policy and regulations and searching the BC Government Directory (<https://dir.gov.bc.ca/>) for government employees who work in fisheries management using the keywords "fish" or "fisheries". The population frame was then further developed in consultation with two senior managers in the provincial government and a senior scientist with the Freshwater Fisheries Society of BC to ensure that key government employees, stakeholders, and rightsholders were identified. The population frame was

then supplemented by snowball sampling from voluntary referrals by respondents. A total of N = 161 individuals or organizations were contacted to request an interview.

Interviews were conducted in person and over the phone between April and November 2018 (interview guides are provided in Appendix A). A total of 65 interviews were conducted (response rate of 40%) with participants from natural resource management branches of Indigenous governments (n = 4), parliamentary governments (n = 33), as well as representatives from nongovernmental stakeholder groups (n = 28) who have been involved in the management of recreational and subsistence rainbow trout fisheries (Table 1). An additional 96 individuals were contacted but did not participate because they a) did not respond to our requests or b) declined to participate due to little interest or no expertise in rainbow trout. Among the respondents, 56 were male and 9 were female. We acknowledge that this gender gap is problematic and, unfortunately, we were not able to correct for it as we were reliant on voluntary participation. The entire province of BC was covered by representative respondents including each of the 9 different resource management regions in BC. This study was conducted in accordance with the University of Ottawa Research Ethics Board (File Number: 02–18–08). All participants gave informed consent to participate in the study. Although some interviewees granted permission to use their names, all quotes shared in this article are attributed anonymously in order to protect everyone’s identities.

Interview transcripts were coded and analysed using NVivo 12 software (QSR International Pts Ltd., 2018). The coding process involved two steps; each step was carried out by one member of the author team, with a different author carrying out each step. In the first step author ANK categorized the responses according to the original interview questions in order to isolate relevant content. The relevant codes for this analysis were: 1. contact with (provincial) government, 2. networks and knowledge channels, 3. organization and role, and 4. partnerships and alliances. In the second step author MA conducted inductive coding, for which the coded responses were re-read for emergent themes (Braun and Clarke, 2006; Thomas, 2006). Of interest was the identification of ways that actors interact and deliberate within knowledge mediation spaces. These emergent themes were analysed with respect to processes of knowledge mobilization and exchange.

Table 1

Affiliations of the 65 participants grouped as members from natural resource management branches of Indigenous governments, and parliamentary governments, as well as stakeholders.

Indigenous governments	N	Parliamentary governments	N	Stakeholders	N
Biologists	2	Biologists	17	Academia	6
Fisheries Managers	2	Directors	3	BC Hydro	2
		Fish & Wildlife Section Heads	6	Environmental non-governmental organization	5
		Human Dimensions Specialist	1	Freshwater Fisheries Society of BC	6
		Policy Analysts	2	Private environmental consultants	6
		Conservation Science Section	3	Retired provincial government employees	3
		Federal Department of Fisheries and Oceans Science Branch	1		
Total (N = 65)	(4)		(33)		(28)

4. Results and analysis

Interview coding revealed four knowledge mediation spaces in which we were able to analyse processes of knowledge mobilization and exchange (Table 2). The inductive coding process initially yielded seven categories. Some of these categories were removed due to insufficient data and others were combined due to internal similarities, thus refining the categories into the four knowledge mediation spaces. As this was an inductive, case-specific process we do not suggest that they will be universally applicable.

The number of occurrences of codes is a useful approach for providing an overview of coding results, but occurrences alone cannot be seen as a reflection of the weight of importance given to each theme by the interviewees. Together, the number of interviews with a code and the number of occurrences of a code demonstrate that topics were raised by many individuals, rather than being raised repeatedly by a smaller number of individuals. Processes within each of the knowledge mediation spaces are analysed in the following subsections.

4.1. Sharing expertise and best practices

Sharing of expertise and best practices as a knowledge mediation space refers to the ways that actors intentionally communicate about their experiences or knowledge. This knowledge mediation space is often problem or ‘needs’ driven, where actors seek out information or advice related to specific challenges.

Sharing of expertise and best practices was discussed by interviewees in the context of knowledge channels as well as assessments of rainbow trout. Analysis of the interviews revealed that the process of sharing scientific knowledge on rainbow trout (including genomics research outcomes) is multi-directional. There is a pull from certain government employees seeking academic or other expert advice. There are also academics who seek government specialists’ advice, particularly because government biologists are often regionally-based and have local, in-situ knowledge. “What I found is that [government] biologists are fabulous to deal with because they have local expertise. They are passionate, they want to do something, and they’re a really good source of knowledge for us” (Academia, male, interview reference #13).

We found an inclination among government staff to work within departments or agencies before seeking out external advice. “We work really well between our regions and also between our departments. We have our ecosystems department here which is our habitat department. We do everything fish related, they would do everything more habitat related. So we do work closely with them” (Provincial natural resources ministry, male, interview reference #18). Advice seeking across regions often occurs when other regions do similar work, and staff may look for information about how they carry out their work and challenges that they have faced. Prominent and experienced staff are also sought out to inquire about what research and monitoring techniques may have been attempted in the past (e.g., for sampling designs).

When government staff seek external advice, it can take the form of

Table 2

Coding results of themes as mediation spaces.

Knowledge mediation space	Number of interviews with code	Number of occurrences of code
Sharing expertise and best practices	44	65
Consultation on policy direction	32	41
Program delivery	20	30
Research partnerships	16	17

Number of interviews with code is the total number of interviewees who discussed this topic. Number of occurrences code is the total number of times a topic was discussed and coded. Code occurrence is a rough proxy of relative importance of each topic (total interviewees = 65).

formalized advisory teams or informal personal communications with topic experts. Formation of advisory teams can be dependent on time sensitivity and whether a species is high profile. Advisory teams can be drawn from professional groups or interest groups that represent collective interests beyond the individual level. In terms of personal communications, we found that as individuals move through their careers, they carry relationships forward and remain in contact with friends and former classmates and colleagues. Interviewees emphasized the importance of these relationships and networks in terms of knowing who to turn to for specific expertise.

There are also times when government staff do not know who to reach out to regarding a specific topic or issue. Some interviewees mentioned that they regularly consult the table of contents of fisheries journals to stay up to date on research trends, other interviewees turn to peer reviewed literature in order to seek answers for specific issues or topics. Article authorship is one means of identifying potentially relevant experts to seek out.

Certain academics are also sought out for their scientific expertise. While government departments often have ample internal knowledge of fisheries management topics (including quantitative analyses), the number of internal specialists is more limited.

“We can go to universities for advice if we’re not sure how to do an assessment. We can call them. How do we do this analysis, how do we structure a project. Lots of contacts at universities who like to just provide advice because they’re happy to talk about practical work.” – Provincial natural resources ministry, male, interview reference #10.

“If there are methods that are not something we routinely use like there is some eDNA work that we’re hoping to start out, we consult with local academics or academics from across North America. We have had meetings with folks in the States that have been working on bull trout eDNA questions and salmonid eDNA questions, so we consult with those.” – Provincial natural resources ministry, male, interview reference #16.

Government staff also explained that they work with both faculty and graduate students. Topics of discussion can include the feasibility of a project or ideas for how to improve projects that are ongoing. Faculty can also draw on government staff, NGOs, consultants, or Indigenous peoples for practical examples and case work to support their teaching.

4.2. Research partnerships

This knowledge mediation space refers to formal and informal partnerships that are formed between organizations and individuals. The emphasis here is on two-way relationships over an extended time period, as opposed to one-time or short-term interactions.

Research relationships were discussed with respect to networks and the ways that organizations form relationships to address specific questions and problems. The group of actors involved in research partnerships form a multi-faceted, complex network. Interviewees discussed several types of formal and informal partnerships involving government biologists and policy staff, academics, Indigenous rights holders, private organizations (e.g., BC Hydro, a province-owned electric utility), and consultants. Structured social network analyses have shown that these types of networks can directly influence conservation actions (e.g. Fischer et al., 2014; Barnes et al., 2016).

On the less formal side, government scientists explained how they reach out to counterparts in other regions (i.e., other provinces within Canada or other countries), often on a monthly basis. Topics that they discuss may include how to support each other with challenges stemming from research needs. Those challenges may be related to budget limitations or sharing experiences with implementation of fishing regulations. At other times, government scientists seek out the advice of more experienced colleagues. For instance, one biologist discussed how they may share ideas for sampling design and confirm if it is an appropriate protocol and if it will collect the data they require. Formal relationships can also form between government scientists and consultants when they need to outsource support.

“I think it’s a symbiotic thing for the government biologists and I. It seems these days their ability to get in the field is getting harder and harder. You know there’s more and more red tape and basically, I’m less encumbered by that. A day in the field is a day in a field for me. So, it’s good for them and it’s definitely good for me. It means that I can work as a small consultant without all the infrastructure needed at time to do whole large studies on my own. Government capital, boats, gear, those kinds of things are available in those partnerships.” – Private environmental consultant, male, interview reference #17.

There was also discussion in interviews about the relationships between government biologists and academia. Interviewees spoke favourably about the nature of these relationships, *“It’s very collaborative and very supportive. It’s a productive one I would say”* (Academia, male, interview reference #12). Partnerships tend to form between specific university research labs and government departments in order to collaborate on monitoring (e.g., developing genetic stock identification tools) or to answer specific questions about fish populations (e.g., effects of temperature on migration).

“As an academic researcher, my lab certainly has interests in addressing basic questions that are associated with enhancing our knowledge of the evolutionary processes and how they might act in natural populations. But it’s a feedback in that we can work closely together to address questions of immediate management concern or to help fill knowledge gaps. And again, what I really appreciate about working with [provincial government] is they will then use that information to feed into planning for future sampling, future monitoring. I know they’ve used it for changing the way that they will monitor stocks and conduct stock assessments.” – Academia, male, interview reference #52.

There was also mention of how some relationships and partnerships take form. *“Sometimes through literature review you can identify experts or people who have dealt with situations that they manage to find the time to write about and publish. We talk to the biologists who were directly involved”* (Provincial natural resources ministry, male, interview reference #24). We found that consultants can play an intermediary role, which may be a result of the nature of their position or networks. One interviewee who is a consultant described how they work to connect regional biologists with academic research results and scientists. This may take the form of email communications but can also result in the formation of working relationships. Formal collaborations tend to arise when government staff and academics apply for joint funding. These funding and project-based linkages can extend to industry partners as well (e.g., aquaculture).

Our work suggests that relationships form based on research topics and needs, rather than on geographic proximity of actors. Interviewees talked about many forms of cross-boundary working relationships. Cross-boundary may mean provincial government biologists talking to colleagues in other regions. Those types of interactions can be based on technical questions such as stocking rates or policy interpretation and implementation. Cross-boundary may also mean interactions across provincial and national lines. Those interactions can also involve practical technical questions (e.g., restoration of populations that migrate across borders), but reaching further afield can also be to seek out genetic specialists for specific issues (e.g., questions about species hybridization).

4.3. Consultation on policy direction

Mediation and interpretation of knowledge is socially and politically influenced. This knowledge mediation space refers to the ways that actors make sense of fisheries knowledge for the purpose of informing or influencing policy development.

While policy formation is part of the knowledge action dimension, consultations with actors such as scientists and resource users can take place within the knowledge mediation dimension. Consultations can involve making sense of multiple information sources and alignment with social and political priorities – these processes of knowledge mediation then feed into actual policy formation. For instance,

government staff engage resource users and Indigenous rights holders in order to address their interests, as well as political figures in order to situate recommendations within the current political climate.

“In the work that I do, when we’re building provincial-scale policies, I try to reach out to regions to make sure that we’ve got the right baseline, the right direction based on what they’re seeing on the ground. And then, from there, building up the information, policies, decision notes with the social side of things.” – Provincial natural resources ministry, female, interview reference #54.

Federal and provincial governments in Canada have a legal duty to engage in “meaningful consultation” with Indigenous groups regarding activities that affect or take place on their traditional territories (Newman, 2009). Therefore, Indigenous governments have formal processes in order to ensure that they are at the table for discussion of the potential direction of fisheries policy recommendations. Although conflicts do arise, interviewees from Indigenous governments focused on the importance of their involvement in direct dialogue with provincial and federal governments.

Interviewees also addressed the need to include and consider the interests of local angling and wildlife groups. Sometimes government will circulate policy recommendations to interest groups or public advisory committees in order to gauge their reactions and gather feedback. This is done formally on a semi-annual basis through the Provincial Angling Advisory Team and Regional Angling Advisory Committees. Other consultations are more informal (e.g., open houses, town halls, workshops). In addition to gauging perceptions, they seek information about how new policies or regulations might impact local communities and families.

“Let’s say we are implementing a particular regulatory schema because we want to be able to keep producing a high-quality fishery in a particular lake. You may have some anglers who only expect to get two or three fish a day, but they’ll want their catch to be big. And that’s providing a sort of high upper level quality fisheries scenario. You’ll also have other anglers that figure “well I want to go there and be able to catch my five trout limit every day, and I want to do it on that specific lake”. Whatever counsel we bring is often to educate the political representation so they can understand that policy directions may suite one scenario or the other.” – Provincial natural resources ministry, male, interview reference #6.

In spite of extensive consultative processes, there was skepticism among some interviewees around the application of science into policy and practice. They noted that scientists (government, industry, and university based) do good work but that political influence can push the science aside. When asked if any advice they have received has resulted in a change in decision or practice, several government interviewees were not able to offer examples. *“You know we definitely value input from outside sources for sure. And we would definitely consider those things when we’re making decisions. I can’t think of any specifically right now”* (Provincial natural resources ministry, male, interview reference #18). There was also acknowledgement that there are several entry points for science to become available to policy advisors, such as internal staff, external experts, and published reports.

“These scientists are stressed out because the government is building and delivering policy that just doesn’t work. And these guys got their 40 years experience and they got a pretty good idea of what does work. We’re in touch with colleagues across Canada and the U.S. and worldwide and they go to these conferences and they write science papers and they feel pretty secure in what they know.” – Private environmental consultant, male, interview reference #64.

Ultimately, interviewees were consistent in expressing that all actors have the same general interests in mind for healthy fisheries. *“There are some policy differences, but we look at the bigger picture on sustainability and there is a need for improvement of both legislation and regulations around those areas”* (Environmental non-governmental organization, male, interview reference #38).

4.4. Program delivery

The program delivery knowledge mediation space is quite different from the policy consultation space. This space refers to the ways that actors interpret knowledge in light of current policies and the needs of ongoing programs.

Program delivery was discussed in the context of interviewees’ roles and was broadly interpreted to include stocking programs and assessments, regulating lake water levels, species recovery program, habitat monitoring, habitat restoration, invasive species management, and other rainbow trout fisheries activities. With respect to the project level, interviewees discussed interpretation of policies and regulations.

“Advice I seek tends to be not around science as much as the management direction of where they’re going. Many of our challenges today are around understanding where our government partners are going regarding fisheries management, or lack thereof, and those kinds of things.” – Environmental non-governmental organization, male, interview reference #51.

“At this level we are interpreting the intent of provincial government and translating that into outcomes with respect to making decisions around resourcing questions, putting money or time or people into the different sort of themes or intents that the government puts in front of us. To get a sense of how to make that translation step and to really understand what a particular government is thinking about something, that’s where I tend to go to seek some support. I work with my colleagues around the province. I work with people who’ve been in the business quite a while and say you know how did you handle this issue when it came to you.” – Provincial natural resources ministry, male, interview reference #48.

It is noteworthy that there was less emphasis on technical scientific knowledge such as genomics at the project level. As one interviewee explained, genomics information more often feeds into strategic decisions.

Problem solving was another theme for program delivery. While interviewees emphasized that people involved with rainbow trout management share common interests, issues always arise due to the need to balance different groups’ needs. These needs include agricultural uses for land and water, hydro-electric developments, as well as subsistence and recreational fisheries. Interviewees also explained that government agencies can be so large and disjointed that there can be disconnections between different departments, requiring other organizations to troubleshoot and negotiate which direction to follow: *“You know, [the provincial natural resources ministry] is such a huge organization that in some cases we worked well together with parts of that organization. In some cases, other parts of the organization are contradicting what we’re trying to do”* (Environmental non-governmental organization, male, interview reference #39). Closely related to problem solving is the prevalence of internal learning and evaluation.

“We have an annual workshop where we invite a subset of our project leaders to come and tell us how they used funding. We also use those workshops as a way to improve the breed. You get a roomful of practitioners and they want to hear how a particular project went and it’s really two things we’re trying to accomplish in these evaluation workshops. One is how did the project go? If it didn’t go well, we want to hear that. We want to hear why it went poorly because there are 20 other people in the room who want to learn from those lessons. And so, as I say there’s two objectives to those things: improve the breed of practicing fisheries biologists and their conduct on the ground, and secondarily, accountability for us to understand what you did with the fifty thousand dollars or whatever that we provide you.” – (Environmental non-governmental organization, male, interview reference #39).

Working and collaborating with outside organizations is another important aspect of program delivery. Many interviewees discussed their working relationships with Indigenous rights holders.

“I work with my colleagues and senior managers in advancing our partnerships with Indigenous rights holders. We’ll work closely with them on different matters that would be fundamental to rainbow trout management or fisheries broadly that will have an influence on rainbow trout populations.” –

Provincial natural resources ministry, male, interview reference #6.

“We’re starting to engage in a little bit more of a collaborative approach with [Indigenous governments] because [Indigenous peoples] understand that with climate change there’s going to be some sustenance risks that are emerging. So, we’re trying to get in front of it and work with them on how we kind of manage both recreational and subsistence fisheries to ensure long term sustainability.” – Provincial natural resources ministry, male, interview reference #14.

Similarly, members from natural resource branches of Indigenous governments discussed the importance of the legal landscape and the ways that new mine and hydro-electric dam projects lead to them being consulted heavily.

5. Discussion

We examined the ways that government agents, stakeholders, and rights holders interact within four knowledge mediation spaces. These types of interactions are important to analyse because we know that scientific knowledge – in this case about rainbow trout – is not taken at face value, but is interpreted based on the immediate needs of actors (Fazey et al., 2014; Reed et al., 2014). Analysis of interviews revealed that there is frequent intra- and inter- organization interaction as actors seek out support for problem solving and expert advice on specialized topics related to fisheries management. The results suggested that scientific methods strongly inform the actions of fisheries actors, but science is not always the primary driver of decisions at the policy level. This is an important consideration for understanding the ways that scientific knowledge is exchanged and mobilized beyond academia and other research institutions.

The knowledge mediation dimension is the most complex and opaque of the dimensions in the Nguyen et al. (2017) knowledge-action framework, but it is also critical for the overall process of knowledge exchange and mobilization. We situate this discussion with a recollection of knowledge as socially constructed and influenced by social norms, values, and power (Nurse-Bray et al., 2014; Fazey et al., 2014; Clark et al., 2016). We also emphasize the importance of interpersonal relationships and social networks for analysis of processes of knowledge exchange and knowledge mobilization (Crona and Parker, 2011; Gale and Cadman, 2014; Alexander et al., 2016).

We argue that this article offers five main contributions that are relevant for improving understanding of knowledge mediation, especially in relation to the field of conservation science. First, by building on the knowledge-action framework, we help to tease out the distinction and differences between knowledge production, knowledge mediation, and knowledge action as discrete dimensions. Second, we demonstrate how knowledge mediation is an inherently social and political process. Neither of these contributions are novel (c.f., Fazey et al., 2014; Nurse-Bray et al., 2014; Rose, 2015; Rose and Parsons, 2015; Clark et al., 2016), but they are sometimes overlooked and oversimplified within conservation science literature. Calls for evidence-based decision-making are common in conservation, yet many papers do not acknowledge the social dimensions of such ‘evidence’ (e.g., Sutherland et al., 2004; Rose et al., 2018).

The remaining contributions of this article reveal some practical applications of the knowledge-action framework. The third contribution is an appreciation of how and why relationships form based on actors’ needs. The social networks literature tends to rely on structural analyses of existing relationships – who is connected to who – but does not capture how those relationships were formed (c.f. Bodin and Prell, 2011; Alexander et al., 2016). The rainbow trout case study revealed that when actors reach out for advice, they frequently contact former classmates, coworkers, and mentors. The movement of individuals from one organization to another throughout their career resulted in broadening of social networks, which was critical for the ways that knowledge moves among actors in both the short and long term. These qualitative insights point to the importance of professional relationships due to the ways

that people tend to form preferential communication with certain individuals. When analysing the influence of knowledge intermediaries or gatekeepers, we can now consider these specific types of professional relationships to learn more about how they shape knowledge sharing transfer. This rainbow trout case study suggests that private environmental consultants may play important roles as evidence bridgers in conservation – identifying research topics based on the priorities of fisheries managers; synthesizing evidence; preparing and distributing easy-to-use evidence summaries; and developing and maintaining networks of connections with researchers and fisheries managers (c.f., Segan et al., 2011; Kadykalo et al., 2021a).

The fourth contribution is the demonstration of specific pathways for knowledge mediation. Knowledge can flow through formal advisory teams and meetings, and through informal advice-seeking. The *program delivery* knowledge mediation space showed that actors grapple with combining cutting-edge science and in-situ knowledge within broader policy contexts. For instance, individuals may draw on a combination of advice from formal advisory teams and from within their own organization in order to make decisions regarding a particular rainbow trout stock (e.g., angling regulations, funding of habitat restoration projects). These types of knowledge mediation processes may not often be directly noticed by actors because they are indirect and nonlinear (see also Meyer, 2010; Young et al., 2016b). Identifying the knowledge mediation spaces was also useful for recognizing differences in spatial and temporal scales. The *Program delivery* knowledge mediation space is relatively short term and localized. The types of knowledge and expertise that actors rely upon for program delivery are mostly practical and hands-on. Comparatively, *research partnerships* and *consultations on policy direction* can have broader geographic and time horizons. Nonetheless, there are no clear, singular mechanisms within the rainbow trout conservation and management knowledge mediation dimension to facilitate the efficient flow of scientific knowledge from academic research to practical application.

The fifth contribution of this article is a call for better appreciation of whose knowledge counts in relation to fisheries management. Scientific knowledge is only one among many knowledge streams within knowledge mediation spaces, and ultimately policy direction and program delivery. Our interview respondents discussed the influence of politics and interest groups on fisheries regulations, but they fell short of referencing how dominant groups can dictate the kinds of issues that are deemed important. It is not a novel conclusion to point out that science is inherently political and value-laden (c.f., Backhaus, 2019; Öberg et al., 2020), but our article points to an ongoing gap in the ways that scientists are trained (Evans and Cvitanovic, 2018; Rose et al., 2018) and understand this interface between science and policy.

Recognizing the legal and ethical status of Indigenous rights holders (Reo and Whyte, 2012; Reid et al., 2020) and their position as stewards (Popp et al., 2020) can be part of the way forward. Fisheries researchers could see more meaningful impacts from their research if they actively engage Indigenous rights holders within knowledge mediation spaces. Principally, this means viewing Indigenous rights holders not only as interested actors or potential recipients of scientific insights, but as leaders to work with to set the agenda for research topics and questions (see Chapman and Schott, 2020). Knowledge co-assessment, co-evolution, and co-production approaches may lead to better management and governance of fisheries resources that benefit fish and people (Cooke et al., 2021). There is also a need for deeper consideration of the relationship of people with rainbow trout and their habitat (Todd, 2018). Then we can further ask how scientific research and knowledge may fit into these relationships.

On a final note, some consideration must be given to the wider applicability of this rainbow trout case study. We suggest that different cases will contain different types of knowledge mediation spaces. Indeed, the interviewer and data analyst, consciously or otherwise, may influence the direction of interviewee responses, or the coded emergent themes, through underlying personal biases or preconceptions. We

anticipate that other studies that make use of this knowledge-action framework will identify different types of knowledge mediation spaces, unique sets of actors, and ultimately arrive at new insights into the processes of knowledge mediation. This is both a limitation of our analysis and a central argument in this article: as knowledge mediation is social process, it is inherently context specific.

6. Conclusion

This article has used the case study of rainbow trout in British Columbia to explore knowledge mobilization and exchange from scientific research to policy and programs. Research has shown the importance of political, economic, and social influence on the ways that scientific research is adopted and used. Analysis of in-depth interviews with government staff and other stakeholders and rights holders illustrates this to be true in this case study, especially when it comes to policy and practice decisions. We found that combining insights into both structures and processes of this actor network within the knowledge mediation dimension are important for understanding how, where, with whom, and when knowledge exchange and mobilization occurs (and does not occur). Attention to people and processes in this article demonstrates how better appreciation of the interplay between the values and interest of actor groups influences the ways that knowledge is interpreted and used for fisheries management. We close with a call to action for rainbow trout researchers to become more engaged in relationships with stakeholders and rights holders, especially Indigenous communities who have long term interactions with rainbow trout populations. These relationships can inform more socially just research agendas and will have greater potential to contribute to rainbow trout management and conservation for the benefit of fish and people.

CRedit authorship contribution statement

M. Andrachuk: Methodology, Analysis, Writing – original draft, Writing – review & editing. **A.N. Kadykalo:** Conceptualization, Methodology, Data collection, Writing – review & editing. **S.J. Cooke:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing. **N. Young:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing. **V.M. Nguyen:** Conceptualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Interview Guides

Participant Name: _____.

Interview Date: _____.

Interviewer Name: _____.

Oral consent? _____ Anonymity requested? _____.

Preamble: Thank you for agreeing to participate in this research. As you know, we are interested in hearing your views on the current and future status of rainbow trout populations and fisheries in British Columbia. We are also interested in your views on fisheries management, different types of knowledge about rainbow trout, and decision-making. Let's start with some questions about your position and

background.

Section A: BACKGROUND.

Can you please tell me a bit about your current position[s]? [*Prompts: What do you do in a given week/month/season? What are your responsibilities?*].

1. How long have you held your current position[s]?
2. How did you come to be involved with [organization?] [*Job history may be important*]

Section B. ORGANIZATION AND ROLE.

Preamble: I'd like to speak to you now about your work and role within [your organization]. [*If appropriate*] The purpose of these questions is to learn a bit about your routine – they are not intended as an evaluation of your performance or the quality of your work.

1. Can you please walk me through a typical fishing season? [alternate wording: what you do in a typical season, from start to finish?]
 11. What is your role during the pre-season planning?
 12. What is your role during in-season management?
 13. What is your role during post-season evaluation?
2. Please tell me about the mandate [purpose] [goals] of your organization.
3. Does [your organization] have any formal or informal partnerships, alliances, or collaborations with any other group or organization? [*Probe for details*]
 31. What is the purpose of this partnership/alliance? [repeat for each mention]
 32. [*If necessary*] What do you collaborate on, specifically? [repeat for each mention]
4. Does your organization have any direct contact with the BC Ministries of Environment; Forest, Lands and Natural Resource Operations and Rural Development [FLNRORD]; Agriculture, or any other government bodies? [*Probe for specifics*]
 41. [If yes] How would you describe your relationship with FLNRORD [or other relevant government bodies – e.g., Department of Fisheries and Oceans Canada]?

Section C: NETWORKS AND KNOWLEDGE CHANNELS

5. Who do you typically turn to for advice about your work? [*Probe for importance of individuals named / who is consulted first*]
 51. Inside your organization? [*Probe for specifics*]
 52. Outside your organization? [*Probe for specifics*]
6. What kind of advice are you typically seeking out? [*Probe for specifics: On issues relating to science? Procedures? Law? Stakeholder issues?*]

Has this advice ever led you to change a decision or practice? [*Probe for specifics*].

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