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# Knowledge users' perspectives and advice on how to improve knowledge exchange and mobilization in the case of a co-managed fishery

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ABSTRACT

Environmental scientists have long been frustrated by the difficulties involved in transferring their research findings into policy-making, management, and public spheres. Despite increases in scientific knowledge about social-ecological systems, research has consistently shown that regulators and stakeholders draw on tacit, informal, and experiential knowledge far more than scientific knowledge in their decision-making. Social science research in the fields of knowledge exchange (KE) and knowledge mobilization (KMb) suggest that one of the major barriers to moving knowledge into practice is that scientists fail to align their communication strategies with the information-seeking behaviours and preferences of potential knowledge users. This article presents findings from in-depth qualitative research with government employees and stakeholders involved in co-managing Pacific salmon fisheries in Canada's Fraser River. We investigate how members of these groups access, view, and use scientific information, finding both similarities and differences. Members of both groups express a strong interest in academic science, and self-report using scientific information regularly in their work and advocacy. However, the two groups engage in different information-seeking behaviours, and provide notably different advice to academic scientists about how to make research and communication more relevant to potential users. For example, government employees focus on the immediate applications of research to known problems, while stakeholders express greater concern for the political context and implications of scientific findings. We argue that scientists need to "go where the users are" in the behavioural and intellectual sense, and tailor their communications and engagement activities to match the habits, preferences, and expectations of multiple potential user groups. We conclude with recommendations on how this may be done.



## 1. Introduction

Surveys have shown that university-based environmental scientists want their research to have a real impact on policies and practices (e.g., Singh et al., 2014). In reality, however, the barriers to moving potentially useful research into policy-making, management, and public spheres are high. While politicians, resource managers, and stakeholders routinely express a keen interest in scientific research and findings, numerous studies have found that these groups rely far more on tacit, informal, and experiential knowledge than scientific knowledge in their opinion-formation and decision-making (e.g., Pullin et al., 2004; Sutherland et al., 2004; Roux et al., 2006; Fazey et al., 2006; Cook et al., 2010; Cvitanovic et al., 2014; Ntshotsho et al., 2015).

Understanding this disjuncture has become a key focal point of social science-based studies of "knowledge exchange" (KE) and "knowledge mobilization" (KMb). These concepts have different origins but similar emphases, with KE emerging from the business management and environmental science literatures, while KMb has been used primarily in the fields of education and social policy (Provencal, 2011; Fazey et al., 2012). Both are based on a (loosely) sociological approach to investigating knowledge movement and application. This approach conceptualizes knowledge as being

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intimately connected with social relationships, processes, and rituals. For instance, it used to be assumed that knowledge moved in a linear way from generators to users, who were separated by a clear division of labour, primarily via scientific publications (Atkinson-Grosjean, 2006: 19). In contrast, KE/KMb research looks at how people actually create, seek out, interpret, and elect to use (or not use) scientific knowledge and information – processes that are far more complex and varied than presumed by the linear model. This research has shown that knowledge typically moves in a non-linear fashion, involving iterative back-and-forth exchanges among researchers and networks of potential users who bring their own values, interests, and priorities to the table (Greenhalgh and Wieringa, 2011; Nutley 2013). Social relationships and their outcomes, such as trust, reputation, and mutual understanding among a wide variety of actors, are therefore important contributors to knowledge movement and uptake. Based on observations such as these, KE/KMb researchers conceptualize knowledge as an ongoing process rather than a thing or commodity that can be readily transferred or delivered to others (Shields and Evans, 2008; Reed et al., 2014: 342). This has led some scholars to criticize the peer-reviewed scientific paper – long the staple of communication within the scientific community – as being too static, formal, and "final" in its summary-style presentation, to really connect with non-scientists who see knowledge first and foremost as an ongoing process of providing evolving *possible* answers to difficult social-ecological questions (e.g., Jasanoff, 2003; Callon et al., 2009).

Most importantly for our purposes, KE/KMb research emphasizes the role that knowledge users play in determining outcomes of knowledge mobilization (Young et al., 2013; van Stigt et al., 2015). Rather than being passive consumers of knowledge and information, knowledge users actively compare claims to one another, to personal and collective experiences, and to other ways of knowing such as local and traditional knowledge (Boswell, 2008; Hulme, 2015). If a claim is accepted as useful and valid, knowledge users may nonetheless apply it in ways that are far removed from the original intent of the researchers (Goldman et al., 2011). As such, most KE/KMb researchers acknowledge that the lines between scientific and non-scientific forms of knowledge are often blurred in the real world of applications and use, and that this is not necessarily a bad thing (Shanley and Lopez, 2009; Adams and Sandbrook, 2013). Scientific knowledge can empower groups that have been traditionally marginalized or silenced by giving them another vocabulary to articulate their positions, while exposure to other ways of knowing can give scientists important means of feedback and "question generation" for future research (Berkes, 2009). These observations are at the core of recent calls for the "co-production" of scientific findings that involve close collaboration among scientists and potential users at all stages of research (e.g., Armitage et al., 2011; Reed et al., 2014).

The emphasis placed on social processes and mutual understanding in the KE/KMb literature suggests that one of the major barriers to successfully mobilizing academic science is the failure of scientists to understand the behaviours, preferences, and viewpoints of potential users of their knowledge, which contributes to missed social and intellectual connections (van Stigt et al., 2015). In this article, we present findings from interviews conducted with government employees and stakeholders involved in the co-management of Pacific salmon fisheries in Canada's Fraser River system. These interviews contained both closed- and open-ended questions about the importance of scientific information for respondents' work and advocacy, where and how they seek out scientific information, and what advice they would give academic scientists to make their research and communication activities more applicable and relevant. We use the findings from these interviews to provide recommendations to academic scientists looking to better align their research with the behaviours, preferences, and expectations of multiple knowledge user groups.

## 2. The case

The Fraser River is one of Canada's most intensely-fished rivers, and has a history of conflict among user groups (Nguyen et al., 2016). Winding 1375 km through the mountainous province of British Columbia (BC), it meets the Pacific Ocean near the metropolis of Vancouver. Three fishing sectors targeting adult migrating Pacific salmon (*Oncorhynchus* sp.) occur in or near the Fraser River: commercial, recreational, and First Nation, all with different catch allocations and restrictions. Regulation of these fisheries is complex (see Cohen, 2012a), involving both the Canadian Department of Fisheries and Oceans (DFO) and the Canada-US bi-national Pacific Salmon Commission (PSC). Once conservation goals have been met, first priority of access is given to First Nations (indigenous) people to harvest for food, social, and ceremonial purposes. Following this, allocations are made to the commercial and recreational sectors, as well as to small-scale First Nation "economic opportunity fisheries" that allow commercial sale.

DFO has a complex mandate that includes promoting economic growth in marine industries, ensuring sustainable harvests and ecosystems, conducting original research, and engaging with stakeholders. The department has a central headquarters in Ottawa, but most decisions about fisheries management occur in regional offices. In the Pacific region, DFO has approximately 460 "science staff", the majority of whom are involved in stock assessment and monitoring. As of 2012, there were 55 research scientists (holding a PhD) employed in the region, conducing research on a range of topics including fish physiology, genomics, oceanography, aquaculture, and ecosystem dynamics (Cohen, 2012a: 53). DFO scientists are expected to publish in peer-reviewed scientific journals, and many collaborate with academic scientists in major regional universities such as the University of Victoria, Simon Fraser University, and University of British Columbia (Lane, 2000). Despite these resources, scholars have long criticized DFO's slow response to new scientific tools and findings (e.g. Hutchings et al., 1997). Several observers have also lamented declines in science budgets and personnel during the tenure of Canada's Conservative government (2006–2015) which includes the study period (e.g., Canadian Association of University Teachers, 2013).

DFO describes its regulatory approach to Pacific salmon fisheries as being both "science-based" and grounded in "co-management approaches" (DFO, 2012). Co-management is multi-pronged. First, DFO consults directly and continually with First Nation groups using an informal system in which both parties can bring issues to the table for discussion (Cohen, 2012a: 77). Second, DFO maintains advisory boards with other stakeholders, including the Commercial Salmon Advisory Board, the Sport Fish Advisory Board, and the Marine Conservation Caucus (with representatives from ENGOs). Third, in 2004, DFO created Integrated Harvest Planning Committees with representatives from all four groups to review data from the prior season, identify areas of concern, and provide planning advice and recommendations for the upcoming season.

While the number of adult salmon returning to the Fraser River varies each year, recent fluctuations in sockeye salmon (*O. nerka*) have been extreme, including poor returns to spawning groups associated with very low production. This has raised concern among stakeholders and the general public, and in 2009 the Government of Canada convened a Judicial Inquiry presided by retired BC Supreme Court Justice Bruce Cohen to investigate. The Cohen Commission heard from 179 witnesses, including

**Table 1**
Interview questions analyzed in this article.

| Question | Type |
|---|---|
| How important is scientific information in the conduct of your work or advocacy? | Open-ended |
| Please indicate how frequently you consult the following sources for scientific information about the Fraser River and/or its fisheries. | Closed-ended (Likert-style) with open-ended follow up |
| When looking for scientific information, where do you turn first? | Open-ended |
| What advice would you give to academic scientists about their research and how they communicate their findings? | Open-ended |

government managers and scientists, academics, First Nations people, commercial and recreational fishers, conservation groups, and landholders. Much of the testimony highlighted DFO's ongoing challenges regulating salmon fisheries in an era of environmental change. While the Cohen commission found no "smoking gun" or single cause for the fluctuations or poor production, it proposed numerous recommendations that included more research on the potential role of climate change, predation, and disease (Cohen, 2012b). Numerous witnesses also expressed dissatisfaction with DFO's approach to co-management. Several First Nations witnesses, for instance, argued that indigenous people should have separate co-management arrangements that take priority over co-management efforts with other stakeholder groups, while other stakeholders argued that the current system should be extended and formalized (Cohen 2012a: 200–1). In short, this is a case in which scientific and political issues converge, and discord and disagreement are not uncommon (Nguyen et al., 2016).

## 3. Methods

The data reported in this article were collected as part a broader study entitled "*Mobilizing New Knowledge for Fisheries Management in the Fraser River*" that examines the role of academic science in the decisions of government regulators and stakeholders involved in the co-management of Fraser River salmon fisheries. The interview schedule for this project was developed in three stages. First, a review of the literature on KE and KMb was conducted to collect information on existing empirical measures. Second, the interview schedule was sent to three collaborators at DFO for comment. Third, the schedule was pretested with two representatives of stakeholder groups and two government employees.

Given the exploratory nature of this research, the interview schedule uses a mixed-methods approach that blends closed- and open-ended questions (Axinn and Pearce, 2006). Closed-ended questions generate quantitative data useful for making direct comparisons, while open-ended questions elicit in-depth qualitative descriptions. All closed-ended questions in the interview were followed by an open-ended invitations to respondents to explain their answers. The subset of questions analyzed in this article are provided in Table 1. Quantitative data were analyzed using Stata 12 software, and qualitative data were analyzed using Nvivo 10 software. Coding of responses to open-ended questions was performed according to a three-step inductive process (Thomas, 2006). First, responses were read to identify key words, which became a list of potential codes. Similar potential codes were then grouped into themes. Responses were read a second time and sorted under these themes to provide a measure of their prevalence. A response may have multiple thematic codes if warranted.

The sample population was developed in consultation with senior managers at DFO to ensure that key government employees and stakeholders were identified. The original population was supplemented by snowball sampling from voluntary referrals by respondents. The government employees group includes a large number of people involved in fisheries management, as these are the employees most directly involved in co-management with stakeholders and in-season decision-making (see Table 2). The sample population also includes employees in DFO Science Branch who work closely with fisheries managers and stakeholder groups. Several senior managers were also interviewed, as well as employees of the PSC. The stakeholder group includes representatives of commercial and recreational fisheries, First Nations communities, ENGOs, and environmental consultants who are hired by stakeholders and play a role in co-management processes. We acknowledge that the term stakeholders is imperfect in this context, because each of the groups described in Table 2 have distinct identities, interests, and perspectives (see Nguyen et al., 2016). However, there are also important similarities among the groups in this context, as they are all involved in co-management but stand outside (and are frequently critical of) the state and its bureaucratic apparatus – thus making them a qualitatively different audience than government employees. To address this, we present two versions of our findings. The tables in the main article directly contrast the views of government employees with those of stakeholders as an imperfect category. The Supplementary material accompanying this article, however, contain full tables that present the findings according to each specific group. We also include an explicit mention in the main text whenever substantial differences within the categories of government employees or stakeholders are observed.

A total of 67 interviews were completed between November 2013 and September 2014; 33 with government employees and 34 with stakeholders. Three-quarters of the interviews were conducted in-person, and one-quarter over the telephone. Because some requests for interviews were communicated internally by DFO, we can only estimate the response rates (approximately 66% for government employees and 63% for stakeholders). Interviews lasted between 40 min and 3 h, depending on the level of detail provided by respondents.

## 4. Findings

### 4.1. Importance of scientific information

As mentioned in Section 2, we expected the study population to exhibit high levels of scientific engagement. To measure this, respondents were asked the open-ended question: "How important is scientific information in the conduct of your work or advocacy?" The term "advocacy" was only used in interviews with stakeholders, because some engage in co-management activities and consultations as volunteers outside of paid work. The majority

**Table 2**
Affiliations of Respondents.

| Government employees | N | Stakeholders | N |
|---|---|---|---|
| Fisheries management branch (DFO) | 18 | Commercial fishery | 4 |
| Science branch (DFO) | 4 | Recreational fishery | 8 |
| Senior management (DFO) | 3 | First Nation fishery | 5 |
| Pacific Salmon Commission | 6 | ENGO | 8 |
| Other | 2 | Environmental consultants | 4 |
| | | Other | 5 |
| Total | 33 | | 34 |

**Table 3**
Comparison of means for sources of scientific information (0 = never, 3 = often).

| | Government employees | | Stakeholders | | Significance |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| News media | 0.83 | 0.70 | 1.71 | 1.15 | 0.008** |
| Scientific publications | 2.45 | 0.59 | 2.48 | 0.60 | 0.898 |
| Non-scientific publications | 1.29 | 0.69 | 1.75 | 0.72 | 0.068 |
| Personal contacts | 2.88 | 0.34 | 2.85 | 0.37 | 0.812 |
| Government websites | 2.17 | 0.87 | 2.24 | 0.77 | 0.864 |
| NGO websites | 1.92 | 0.65 | 1.67 | 0.80 | 0.262 |
| Websites hosted by individuals | 0.42 | 0.50 | 1.05 | 0.76 | 0.005** |
| Listserves | 0.71 | 0.86 | 1.05 | 1.00 | 0.223 |
| Social media | 0.38 | 0.58 | 1.10 | 1.12 | 0.022* |
| N | 32 | | 31 | | |

* $p < 0.05$.
** $p < 0.01$.

of respondents in both groups indicated that scientific information plays a substantial role in their work or advocacy (72% of government employees and 60% of stakeholders). A further 14% of government employees and 21% of stakeholders indicated that scientific information plays an occasional or moderately important role, while only 5% and 6% of respondents indicated that it plays no role at all. The following quotations illustrate the rhetorical commitment to scientific knowledge and information that was typical of the majority of responses to this question:

> Science plays a really big role, for sure. Maybe not so much in the day-to-day administrative stuff, but when there's a decision to make or a gap to fill, we fill it using scientific information the best we can. (Interview #58; Government employee, fisheries management branch)
>
> We are constantly utilizing the latest scientific reports that come out to help guide our programs and our directions and our initiatives moving forward. It's a foundation of how we operate [as an organization]. (Interview #12; Stakeholder; ENGO affiliation).

We also note that a healthy respect for science was evident even among respondents who indicated that scientific information was not central to their work or advocacy. These respondents either stated that they found science too complicated to use regularly, or that scientific information plays a minimal role in decisions that they see as being primarily experience-based:

> So [with] fisheries management, you've got whatever data you can afford to collect, and then it goes into the room. And the people on various [co-management] committees come with their biases, and they look at that information and get advice from whoever. I think there's a lot of sort of gut reactions or just people just sort of interpreting the information based on what they think is true and what they saw last year. And so it's not entirely a science-based decision. We [all] know that. I describe it as an art rather than a science. (Interview #36; Stakeholder; First Nation affiliation).

### *4.2. Where do government employees and stakeholders get scientific information?*

The information-seeking behaviours of respondents were assessed using both closed- and open-ended questions. The closed-ended question involved handing or reading a card to the respondent that listed nine common sources of data, information, and/or knowledge about the Fraser River, with instructions to "please indicate on this card how frequently you consult these sources for scientific information about the Fraser River and/or its fisheries." Respondents were given the option to answer "often, sometimes, rarely, or never" for each potential source. Scores were then assigned to responses (0 = never, to 3 = often) and the means for each group were subjected to a Mann-Whitney two-sample significance test for ordinal data (see Table 3). Respondents were given the opportunity to indicate an "other" source, but only three respondents did so (two government employees respectively cited "Google" and "Email distribution", while a stakeholder cited "Academics", in all cases these were "often consulted").

Table 3 shows several similarities between government employees and stakeholders. First, both groups rely heavily on personal contacts as sources of information. This is consistent with other studies that have found that social networks play a major role in the movement of information (e.g., Gainforth et al., 2014). The small standard deviations show that this is the case across most of our sample (see the supplementary tables for a full breakdown across all types of respondent). Second, Table 3 shows that scientific publications are a major source of information across both groups. This is higher than expected based on other studies (e.g., Cook et al., 2010), but the qualitative data shed some light on this. Among government employees, it was occasionally stated that some colleagues and superiors regularly circulate abstracts from new scientific publications, thus providing exposure to new science (cited by three respondents). Among stakeholders, numerous respondents stated that they had read the report or were highly aware of the recommendations of the Cohen Commission, which they considered to be a scientific publication (cited by seven respondents). Third, Table 3 shows that both groups rely on government websites as important sources of scientific information, illustrating the importance of official online resources.

Table 3 also shows some differences. Overall, stakeholders demonstrate more variety in their sources, with significantly higher mean scores for news media, social media, and websites hosted by individuals (we note that respondents involved in First Nations fisheries turn to the news media less than other stakeholders, with a mean score on this item of 0.40 versus 1.71 for all stakeholders). Stakeholders are also more likely to consult non-scientific publications (such as reports, pamphlets, and position papers) as well as content from listserves (mass email distributions). This suggests that stakeholders cast their information net more broadly than government employees, and are notably more open to considering unofficial or non-traditional materials and media as (irregular) sources of scientific information.

Respondents were also asked the following open-ended question: "When looking for scientific information, where do you turn first?" This question gives a sense of respondents' priorities, and its open-ended structure allows them to be precise

**Table 4**
When looking for scientific information, where do you turn first? (open-ended).

| Source | Government employees | Stakeholders |
|---|---|---|
| Colleagues or peers | 18 (56%) | 1 (3%) |
| Scientific publications | 3 (9%) | 4 (13%) |
| Internet (general) | 2 (6%) | 8 (26%) |
| Official documents or archives | 5 (16%) | 4 (13%) |
| Scientists or experts known by the respondent | 1 (3%) | 9 (29%) |
| Personal experience | 0 | 2 (6%) |
| NGO website | 0 | 1 (3%) |
| Unspecified others (the "grapevine") | 0 | 1 (3%) |
| Don't know/No answer | 3 (9%) | 1 (3%) |
| N | 32 | 31 |

in their answers. Results are given in Table 4. The percentage of respondents consulting scientific publications as a first source of information is 9% and 13% for government employees and stakeholders, respectively. This indicates that while both groups see scientific articles as important (see Table 3), they are rarely the first source of information. Personal contacts remain the modal category for both groups, but here we observe differences in who is serving as an information source. Government employees are turning primarily to colleagues or peers who work in the same organization as the respondent. Prior research suggests that collegial or peer-to-peer advice is often a blend of tacit (experiential) knowledge, and explicit (scientific or codified) knowledge (Collins, 2010). The qualitative data indicate that this is indeed the case – that information-seeking from colleagues is often about accessing advice and experience as much as scientific facts and findings. For example:

> Usually I just talk to colleagues, like [two names] who are good to talk to because [they] know a lot about science and also have a lot of hands-on experience. They know what's going on, on the ground. Sometimes they'll point me to a study but usually they'll just give me advice to help me figure it out myself. (Interview #44; Government employee, PSC)

Stakeholders, in contrast, rarely consult colleagues and peers as a first source of information, and instead directly consult scientists and experts who are known to the respondent personally (we use the term "experts" here because it is occasionally unclear if the person(s) mentioned are practicing research scientists). While it is possible that these experts are also sharing experience-based advice, this finding suggests that some stakeholders are accessing outside scientific knowledge and information more than many government employees. The flip side of this is that a good number of stakeholders appear to lack access to high-quality sources. For instance, a high proportion of stakeholders indicated that they rely on general Internet sources (Google searches were explicitly mentioned by eight stakeholders as the first source of scientific information). This evidently has limitations, as is shown in the following quotation:

> I use Google for the most part. For science and for policy stuff, too. It shows me who is doing what, who is getting what. I also use Twitter quite a lot. But Google is getting more and more frustrating by the year, with all the ads, it's now about who is selling what. I find that really frustrating. (Interview #12; Stakeholder, ENGO affiliation)

### 4.3. Advice to scientists

As discussed earlier, greater alignment with potential knowledge users' habits, preferences, and expectations can help improve

**Table 5**
What advice would you give to academic scientists about their research and how they communicate their findings? (Number of respondents mentioning each theme).

| | Government employees | Stakeholders |
|---|---|---|
| Admit limits of data and findings | 3 | 1 |
| Avoid being overly critical/dismissive | 1 | – |
| Be a public figure/promote yourself | 1 | 1 |
| Be aware of political realities | 2 | 5 |
| Be aware of the "real world" | 3 | 8 |
| Be certain before communicating | 1 | – |
| Be independent/ignore outside pressures | 1 | 6 |
| Be persistent/determined | 5 | 1 |
| Be transparent/share data | 1 | 1 |
| Communicate directly to users | 4 | 4 |
| Conduct "relevant" research/avoid irrelevant questions | 6 | 2 |
| Describe potential uses explicitly | 3 | 3 |
| Engage in co-production/close collaboration | 8 | 2 |
| Focus on quantitative/numerical data and findings | 2 | – |
| Make data and findings "comparable" with other/prior studies | – | 1 |
| No advice to give | 5 | 5 |
| Publish more | 2 | – |
| Put yourself in shoes of potential users | 2 | 3 |
| Tell stories (visual, oral, and/or in texts) | – | 6 |
| Ensure timeliness of data and findings/don't sit on important findings | 5 | – |
| Train good students | 1 | 1 |
| Use a knowledge broker | 1 | – |
| Use lay terms and/or descriptions | 3 | 5 |
| Total number of respondents | 33 | 34 |

KE and KMb outcomes. As part of our study, we asked respondents the following open-ended question: "What advice would you give to academic scientists about their research and how they communicate their findings?" Asking for or about advice is an important technique in qualitative research, because it encourages respondents to reflect on their experiences and talk freely about their normative expectations of specific others (Maxwell, 2012). Findings are presented in Table 5.

Several tendencies are notable in this table. The first is the variety of answers provided. Some respondents focused their advice on the selection of research questions, others on the conduct of research, and still others on communication. Among the latter, some talked about specific communication strategies – such as advice to publish more, or to use lay terms and descriptions – while others talked about communication in more general terms, such as advice to "be a public figure" and "put yourself in the shoes of potential users".

Second, there are observable differences in the advice provided by the two groups. Government employees focused more than stakeholders on issues of relevance and timeliness, for instance. This is consistent with other research that has found that authorities judge scientific knowledge and information based in large part on its immediate utility for addressing known problems (e.g., Bainbridge, 2014). Several government employees also offered the advice to "be persistent" or "be determined" in the communication of research findings. This particular theme was usually accompanied by an explicit or implicit recognition of bureaucratic barriers to KE/KMb, as shown in the following quotations:

> Hang in there! If you have accurate, relevant information, then persevere, be bold, and communicate your findings to anyone in DFO who will consider it. (Interview #32; Government employee, fisheries management branch)
>
> Keep it up. I know it's hard because few people [in government] have an incentive to try something new. Speak loudly and try to reach as many people as you can. (Interview #34; Government employee, science branch).

Government employees were also more likely to suggest close collaboration or co-production arrangements, in which scientists and government employees work together on research design, execution, and interpretation. Again, this was seen as a way of enhancing relevance (see quotation below). Interestingly, collaboration and co-production was only mentioned by two stakeholders despite this group's strong interest in scientific information and reliance on personal connections to outside experts.

> Any researcher who is interested in having a real impact on fisheries management should try to establish a direct connection with DFO. We'll work with them, we'll start with a scoping exercise with [the researcher] that would guide the direction of their research. Then we'll follow [the research] through and at the end be confident [that] it's good and usable work. (Interview #29; Government employee, senior management).

The advice from stakeholders generally had a different emphasis. Several responses focused on politics and the (presumed) role that scientific information plays in political decision-making. For example, five stakeholders cautioned scientists to "be aware of political realities" – specifically, to be cognizant of the potential for their claims and data to be used for illegitimate political purposes that run counter to the public interest:

> Knowledge about the salmon should be a public good, it should be in the public domain. Unfortunately, though, that knowledge is going to be politicized unless the scientist fights and fights against it. If [politicization] happens, the knowledge is corrupted and is no longer a public good. It happens a lot. (Interview #31; Stakeholder, "other" affiliation).

Politics also play into the advice to "be independent of outside pressures" and "be aware of the real world." On the first point, a number of stakeholders advised academic scientists to ignore scientific claims or instructions coming from authorities, including DFO, which they view as being tainted by political directives. This was particularly the case when conversation turned to salmon aquaculture. Stakeholders have long been critical of DFO's involvement in salmon farming in British Columbia, which includes research and monitoring support (Young and Matthews, 2010). For several respondents, DFO's support for aquaculture calls into question all of its science-based activities, which makes the independence of university-based scientists critical for determining the "truth". For example:

> Peer-reviewed science is still important, although it's not as great a driver as I once imagined it [to be] in terms of decision making. In fact, it can be ignored and twisted and subverted even as we've seen in the aquaculture debate. . . . That's why it's critical for scientists to be independent and to ignore the party line coming from government. Scientists have to be independent and speak the truth over and over again. If they keep doing that, I'm hopeful that eventually [the truth] will stick. (Interview #55; Stakeholder; ENGO affiliation).

On the second point, a number of stakeholders advised scientists to "get out of the lab" and see how fishing actually takes place, as well as how different stakeholders relate to one another in the field. Several stakeholders argued that these real world experiences would help academic scientists to improve how they conduct research and communicate findings, as shown in the following quotations:

> You need to get out of the lab and see how the world is changing. Pure research in natural resources often has important role to play in development of future policy [but] understanding the real world brings a greater understanding. (Interview #40; Stakeholder, environmental consultant)
>
> I would ask scientists to take a greater accounting for the real world, for the realities on the ground. Lots of times, there are gaps between the assumptions about – behind a particular study or analysis, and the conditions in which was done. For example, I saw a study on fisheries that made assumptions [about] fishermen's behavior. But the assumptions don't hold in reality. . . . If the [researchers] had come down to the river they'd have seen that. (Interview #16; Stakeholder, recreational fishery affiliation).

Finally, some stakeholders encouraged scientists to "tell stories" – a theme that was absent from the advice given by government employees. By telling stories, respondents suggested that scientists ought to narrate or otherwise illustrate the meaning of their findings to better connect them with the interests and priorities of potential audiences. These stories could take multiple forms, as respondents mentioned visual stories (using images), telling stories orally, and in texts and pamphlets. For example:

> I think a lot of people have trouble understanding research. The more [scientists] can clearly communicate with images, visuals, maps and colours, then the better they can make connections between elements. It's about telling stories that can simplify complex issues so that average people can relate to the science. (Interview #28; Stakeholder; ENGO affiliation).
>
> [I would say] stop being such a scientist and be a better storyteller. Lots of people . . . do better with stories that have protagonists and plots – it's a much more natural way of speaking, but researchers aren't good at that. (Interview #52; Stakeholder, "other" affiliation).

## 5. Discussion and recommendations

What can scientists looking to improve KE/KMb outcomes learn from these findings? At the most general level, our research suggests that the potential for successful KE/KMb in this case is high, as key audiences are well equipped to receive and act on scientific information. The interviews found that potential users self-report that scientific information plays a substantial role in their work and advocacy. However, the interviews also uncovered some key difficulties and inequities in accessing science. Furthermore, the advice-giving exercise uncovered a range of suggestions from both groups – some superficial and others fundamental – for changing how scientists create and communicate knowledge. Overall, this suggests a need for diverse strategies for scientists to "go where the users are" in the intellectual and behavioural sense. No single strategy is likely to suffice.

In our view, efforts to improve KE/KMb outcomes in this case ought to start with the finding that the two groups have different behavioural and normative profiles. Government employees, for instance, appear to have more specific and concentrated information-seeking behaviours. For the most part, they do not consult unofficial sources of scientific information – particularly news media, social media, and non-governmental websites – instead showing preference for scientific publications, official documents, and personal contacts. The influence of the latter, however, may be overwhelming, as government employees appear to share scientific information primarily within closed networks of colleagues, suggesting a lack of direct communication with sources outside their organization. Stakeholders are behaviourally more heterogeneous, drawing on a wider variety of sources. In practice, however, information-seeking among stakeholders is highly unequal. While some stakeholders enjoy direct access to scientists via personal connections, others rely on general Internet searchers as their first source of scientific information.

With respect to the normative advice-giving, it is notable that government employees focus on issues related to practical utility. This group talks more about relevance, timeliness, and bureaucratic obstacles than do stakeholders. Preference is also expressed for information that can be directly applied to known problems. Interestingly, this group is also more interested in direct collaboration and co-production of scientific research. While the literature on co-production often describes it primarily as a means of engaging with non-expert stakeholders (e.g, Armitage et al., 2011), government employees in our study see it predominantly as a means of extending DFO influence over research focus and design. This is viewed as a way of ensuring relevance and giving an organizational stamp of approval on findings, and thus enhancing its potential for use in management decision-making.

In contrast, stakeholders' advice generally focuses on the political dimensions of scientific knowledge and information. Scientific information is seen as a source of political power, but is also open to political interference and cooptation. Stakeholders advise scientists to be protective of scientific inquiry and processes, and the advice to "be independent" can be interpreted as an argument against the kind of collaboration and co-production proposed by some government employees. But stakeholders do not argue that science is acceptable as is. They advise scientists to connect their knowledge more directly with the "real world" of actual social and ecological conditions, and to tell better stories as a way of relating their findings to the experiences and thinking of non-expert audiences. In our view, this reflects a different understanding of utility. For stakeholders, the utility of scientific information is not based on its applicability to known management problems, but its ability to convince audiences of a truth (or truths) about the river and its fisheries.

Numerous other studies have made recommendations to scientists looking to enhance outcomes related to KE/KMb processes (sometimes using different terms). These studies have, *inter alia*, recommended that scientists use lay language in their communications with non-expert audiences, demonstrate the relevance of research directly by incorporating potential uses into publications, make use of knowledge brokers and "boundary organizations" that bridge academic and non-academic worlds, build relationships with potential end users, and embrace co-production to work on research problems of mutual concern (Roux et al., 2006; Fazey et al., 2012; Cook et al., 2013; Reed et al., 2014; Bainbridge, 2014; Cvitanovic et al., 2015; Hulme, 2015). Rather than re-tilling this soil, our recommendations focus on the unique contributions of this qualitative study of knowledge users, and the potential additions and qualifications our findings make to the established corpus.

### *5.1. Recognize the uniqueness of different knowledge user groups. In our case, recognize that government employees and stakeholders are separate audiences, with distinct behaviours, preferences, and expectations*

A multi-pronged engagement strategy is essential to match the habits and thinking of these two audiences. Personal connections are likely a key to reaching both groups, although there are unique organizational obstacles to connecting directly with cautious and peer-oriented government employees. On the other hand, government employees are accustomed to blending tacit and scientific knowledge, so scientists should not shy away from this type of advice-giving, even though it may violate strict interpretations of scientific norms to stick to facts. Scientists should embrace the omnivorous information-seeking habits of stakeholders, who are more attuned to non-standard means of scientific communication, including Internet and social media sources. A strong online presence is essential, coupled with personal availability and active networking.

### *5.2. Engage in collaboration and co-production, but cautiously and transparently*

Collaborations with willing government employees are a promising way of accessing closed knowledge-sharing networks and overcoming bureaucratic obstacles. However, others who value the political and intellectual independence of academic scientists are watching and may be skeptical of these arrangements. It is essential to be transparent and to clarify the nature of collaboration and co-production relationships, as much for those who are *not* participating as for those who are. When possible, government partners in co-production should also agree to be as transparent as possible about how research findings might be used in policy- and decision-making.

### *5.3. Be seen in the field, including the social/political field*

Experience in the "real world" matters, especially to stakeholders. Being seen in the field enhances credibility and provides opportunities for personal connections. While not all fisheries-related science involves nature-based fieldwork, ideas about what constitutes the field should be expanded to include social and political events, such as community meetings, stakeholder forums, and consultations. Our own experience in hosting annual multi-participant workshops to discuss scientific findings has been highly successful in simultaneously communicating knowledge and building credibility among multiple groups (see Branchlines, 2016). The presence and visibility of academic scientists in a

neutral mediating role has helped bridge academic and non-academic worlds.

### 5.4. Explore options for narration and story-telling

Story-telling is a unique form of communication that goes beyond substituting jargon with lay terms. Story-telling means using narrative devices such as plots, characterizations, and in-depth descriptions that connect scientific findings with the interests, values, and priorities of potential users. Some scientists have resisted story-telling because of suggestions (erroneous, in our view) that it masks, degrades, or changes the meaning of scientific findings. The idea that science can *either* be communicated in an expert *or* a narrative form is out-dated, and should be replaced with *both/and* strategies. It is important to remember that story-telling can take multiple forms, including the visualization of data and ideas, orally telling stories about field challenges and experiences, and creating text narratives about the research process and potential uses for findings (Minke-Martin, 2016). Story-telling also fits with stakeholder ideas that the utility of knowledge resides largely in its ability to convince others, and compelling stories are likely to be shared and repeated within stakeholder knowledge networks.

### 5.5. Conclusion

This article has presented research from in-depth interviews with government employees and stakeholders involved in co-management of Fraser River salmon fisheries in Canada, focusing on the information-seeking habits and preferences of these groups, as well as their advice to academic scientists on how to improve KE/KMb outcomes. The KE/KMb literature tells us that audiences matter tremendously in determining research impact on policy and management decision-making. If knowledge is indeed an ongoing process rather than a thing or a commodity that can be transferred from one person or setting to another, enhancing that process means meeting potential knowledge users on their intellectual turf. Understanding the habits and preferences of users is a first step in that direction, as is listening to the substance of their advice on how to better connect with willing but still somewhat skeptical audiences.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2016.09.002.

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