The role of scientific information sharing in polycentric governance: Ecosystem recovery in the Puget Sound, USA

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Abstract:

In complex, connected social-ecological systems, polycentric governance provides a means to coordinate actions across levels. For commons such as watersheds, the interconnectedness of human and natural system components often spur efforts to align local actions with system-wide goals. Polycentricity scholars have argued the degree to which coherence is achieved depends on information exchange among decision centers. In parallel, environmental management scholars have examined the exchange of scientific information between scientists and managers to improve performance. Cvitanovic et al (2015) identify barriers to such exchange and call for more research on the mechanisms through which scientific knowledge transfer happens. In this study I identify and compare the mechanisms through which scientific knowledge transfer happens in polycentric governance. Interviews from efforts in the Puget Sound, USA to incorporate scientific information into management reveal patterns in vertical and horizontal exchange of scientific information.

Introduction

Addressing the complexities of modern society, including environmental challenges, involves collaborative interactions among organizations and jurisdictions at multiple levels of governance – in other words, polycentric systems. Actors in public agencies engage with actors in other governmental agencies as well as non-governmental organizations, industry, and individual citizens. Collaborative interactions can include sharing funds, facilities, equipment, personnel, networks, strategies, and/or information. This study focuses on the sharing of one kind of information -- scientific findings – in polycentric governance for environmental restoration.

A rich literature in the sociology of science has described the subjective nature of scientific inquiry, while scholars in science, technology, and society have identified barriers to the use of science in public policy. We know that although greater use of science to inform policy is often prescribed, it can increase conflict in policy decision making (Jasanoff and Wynne 1998; Sarewitz 2004). We know that science can be wielded as a weapon in policy debates, with combatants cherry-picking scientific studies to support their prior beliefs. But science can also be used to make evidence-based choices about public programs and regulations (Amari et al 2004; Weiss 2005; Koontz forthcoming-a). Our understanding of the use of science is limited when it comes to multiple levels of interacting decision centers in polycentric governance. Even as science can be used as a wedge to drive stakeholders apart, might it also be used as a bridge to understanding and consensus, and to link decisions across levels for more coherent policy?

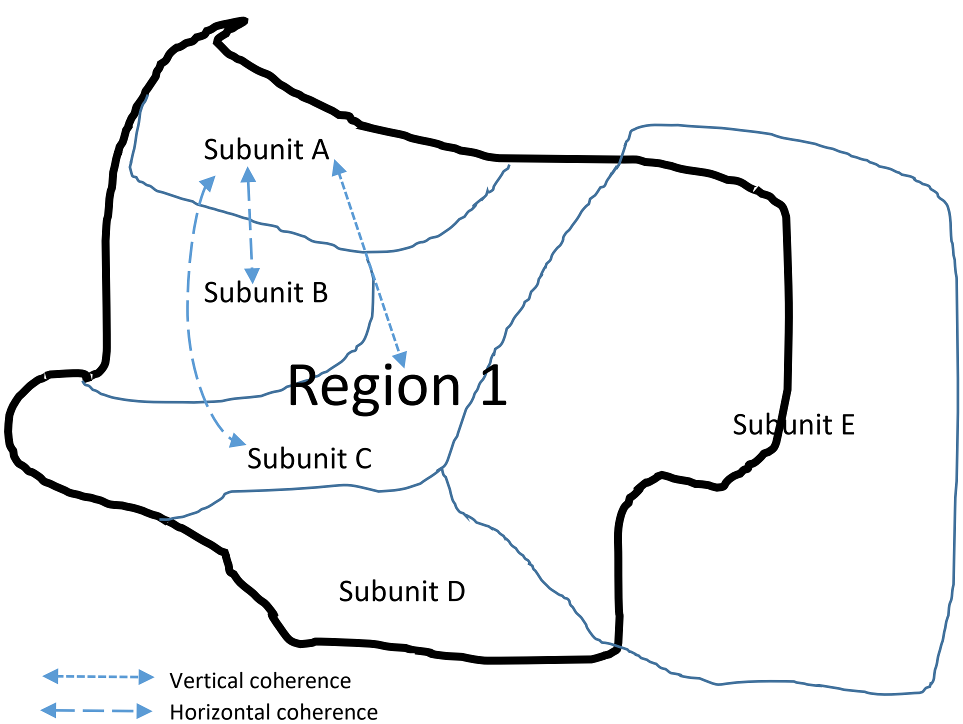
Polycentric governance involves interactions among multiple decision centers. In a foundational piece, Ostrom et al (1961) wrote that such governance occurs where formally independent decision centers interact within a system of overarching rules. Sometimes these interactions are collaborative.

Collaborative governance entails efforts to increase coherence across actors and organizations, such that actions in one decision center don't export harm to another decision center or work at cross-purposes to the system as a whole (Koontz et al. forthcoming). Such coherence is, in part, a function of information shared across actors in different decision centers and at different levels (Koontz forthcoming-b).

We can conceptualize coherence in two spatial dimensions, horizontally and vertically. Horizontal coherence is akin to the concept of externality, where one party's actions spill over to affect another party. In public policy, scholars have examined synergies and conflict management across different policy areas in the same level of governance (Den Hertog and Stross 2011; Nilsson et al. 2012). For example, how do policies of one state affect conditions in a neighboring state? Vertical coherence is related to the concept of nestedness, where actions at one level aggregate up or down to affect conditions at a different level (Ostrom 1990; den Hertog and Stross 2011). For example, how do policies at the state level support or contradict policies at the national level, and vice versa? In both cases, coherence addresses the problem of scale mismatch, where actions by one set of decisions makers exacerbate, or fail to address, problems for those or other decision makers (Cash et al. 2006).

As an example, In Figure 1, Region 1 contains five subunits nested within it (subunits A, B, C, D, and E). Horizontal coherence involves the relationships between one or more subunits with one or more other subunits (e.g., subunit A with subunits B and C). Vertical coherence involves the relationships that a given subunit has with the whole region (e.g., subunit A with the Region 1 as a whole). Note that in a polycentric governance system, even though the subunits are nested within the region, the region does not have authority to dissolve the subunits. Instead, the subunits are formally independent but interact with each other as well as with region-wide rules. These region-wide rules may include funding programs where a subunit that compiles is eligible for grants, which would give the regional decision center some leverage over the subunits (but not the authority to dissolve them). Moreover, some subunits, such as E, may extend beyond the boundaries of Region 1. This is common in cases where a multi-purpose political unit, such as a county (for example subunit E), exists along with a special purpose district focused on a particular function, such as a watershed basin (for example Region 1).

Figure 1 Vertical and horizontal coherence across a region



In a collaborative governance context, a key factor affecting coherence is information sharing. Studies in collaborative watershed governance find that regional actors attempt to steer the actions of subunits through information in the form of guidance and training, along with financial resources (Koontz forthcoming-b; Koontz 2014; Nikolic and Koontz 2007). Regional actors, such as state governments, typically provide grants to local watershed organizations that commit to developing collaborative watershed management plans (Hardy and Koontz 2008; Watson et al. 2019). In developing such plans, local organizations may be required to include specific plan components or information sources that align with the regional funders' goals to increase vertical coherence (Koontz and Thomas 2018). In addition, local organizations may send information up to the regional level so that the regional level can incorporate local information into region-wide planning (Koontz and Newig 2014). At the same time local organizations may seek their own information sources from other subunits to increase horizontal cohesion.

Collaborative environmental governance draws largely on scientific information. This is evidence-based information that helps explain and predict cause-effect relationships on the landscape. An underlying aim of collaborative environmental governance efforts is to build common understanding of interconnected human-environmental systems. Science is seen as an integral part of this (Curtin 2002; Koontz et al 2004). But to build common understanding among diverse stakeholders, science must first be understood. This is no small feat, as scientific studies necessarily involve jargon, measurements, methods, and specific relationships not easily grasped by scientists outside the field, let alone non-scientists (Poteete et al.). To communicate science beyond those in a particular field, translation and boundary organizations are important (Swedlow 2017; Lemos et al. 2014; Jasanoff 1987). Even when scientific findings are understood, the incorporation of such information into policy decisions is beset with barriers (Wynne 1989; Weiss et al 2005; Ouimet et al. 2009; Cash et al. 2006b). The challenges of translation and incorporation become more complex as the number, diversity and levels of actors increase. Such increases are a key feature of collaborative environmental governance.

Tracing through how science is translated, filtered, and used in collaborative governance will shed light on horizontal and vertical coherence. In particular, I examine how local actors in a collaborative environmental governance system use science vertically and horizontally. Here I expand the definition of vertical relationships to include not only when one decision center has the authority to dissolve another (Ostrom et al 1961), but also when one decision center has the power to require another center to perform actions as a condition of receiving a grant. Such "grants with strings attached"are a common form of interaction in collaborative watershed governance (Hardy and Koontz 2008; Watson et al. 2019). In contrast, horizontal relationships refer to actors drawing on scientific information from sources without power to dissolve them or require them to perform actions. Horizontal sources could be other local subunits in their region, regional entities with no authority over them, or entities outside of the region. The following research questions frame this study:

1. How much and how do actors at the local level use scientific findings vertically and horizontally in a multi-level collaborative governance system?

2. How does use of science affect coherence among decision centers?

Study Context

This paper examines scientific information in collaborative environmental governance interactions. The setting of Puget Sound, Washington, USA, provides a rich mix of stakeholders, institutions, and scientific research across multiple jurisdictions and organizations at varying levels.

The Puget Sound is one of the United States' largest estuaries, covering over 2,600 square kilometers. It is a complex social-environmental system, home to over 4 million people and growing by nearly 1.5% annually. The system includes abundant shellfish, endangered salmon, and a dwindling population of the iconic orca, along with 20 Native American tribes who have inhabited the region for thousands of years, and a leading technology hub that attracts workers with increasing demand for outdoor recreation. Much public policy attention in the region has been paid to ecosystem restoration over the past two decades, spurred by listing of several salmon species under the Endangered Species Act in 1999. In 1998 Washington's Salmon Recovery Act established a regional funding board and associated local watershed organizations to promote salmon habitat projects. That same year the Northwest Straits Commission was created by Federal law to catalyze local and regional ecosystem restoration efforts. In 2007 the State of Washington created a state agency, the Puget Sound Partnership, to facilitate cooperation across federal, state, local, tribal, and nongovernmental groups towards a goal of ecosystem recovery. Prior research found that there are at least 57 collaborative partnerships working on environmental restoration in Puget Sound (Scott and Thomas 2015). Since then, even more partnerships have sprung up. For example, Governor Jay Inslee created an Orca Task Force in 2018, whose recommendations were the basis for a $1 billion State budget proposal to reverse the orca population's decline in Puget Sound through ecosystem restoration projects.

The Puget Sound basin is well-resourced for scientific research, which means that these numerous collaborative partnerships have many scientific findings at their disposal to inform how they define problems and choose among alternatives. These scientific studies cover a wide range of topics, including salmon populations, water quality, ecological systems, human well-being, and ecosystem service benefits (Koontz and Thomas 2018; Puget Sound Partnership 2016; Biedenweg et al. 2017). The region is also institutionally thick with multiple overlapping federal, state, local, and tribal government jurisdictions, as well as collaborative partnerships and programs, coinciding with different political and ecological boundaries.

Power Structures of three different local decision centers

This study examines three different types of local, collaborative decision centers in the Puget Sound region: Marine Resources Committees, Local Integrating Organizations, and Salmon Lead Entities. Each of these centers interacts horizontally, with other local centers, and vertically, with a center at a regional level that wields some leverage over it.

Marine Resources Committees (MRCs) were created following enactment of the 1998 Northwest Straits Marine Conservation Initiative. Under this federal law, the Northwest Straits

Commission is a regional organization that "combines sound science and ecosystem perspective together with citizen energy and entrepreneurship to improve efforts to save Puget Sound" (http://www.nwstraits.org/about-us/overview/). The law enables county governments to create MRCs in seven counties in the northwestern part of Washington, including some in the Puget Sound region. MRCs are comprised of citizen volunteers appointed by elected county officials. They collaborate with diverse community partners for restoration, conservation, and education projects related to marine areas. Although the Northwest Straits Commission has authority to provide funding and guidance to the MRCs, it does not have authority to dissolve them. Nor is it the most important funding source for projects, as MRCs typically obtain project funding from a variety of sources. MRCs aim to ensure vertical coherence between locally relevant marine issues and broader marine conservation goals (https://nwstraitsfoundation.org/project/marine-resources-committees/).

Local Integrating Organizations (LIOs) are watershed-based organizations created by the Puget Sound Partnership, a state agency established in 2007 to foster cooperation across the region for ecosystem recovery efforts. The Puget Sound Partnership began creating LIOs in 2010, and jointly with the USEPA provided $75,000 annually for each of nine LIOs. The LIOs were given responsibility to advise the Puget Sound Partnership on local priorities, provide assistance to local groups conducting restoration work, implement strategic actions contained in the Puget Sound Partnership's Action Agenda, and evaluate progress on such implementation. LIOs involve local stakeholders in developing an Ecosystem Recovery Plan, following guidance from the Puget Sound Partnership which emphasizes the use of science in such planning. The guidance aims to ensure coherence between each LIO's local priorities and region-wide priorities. LIOs that provide such coherence receive favorable consideration for project grants from the Puget Sound Partnership. Moreover, the Puget Sound Partnership has authority to create and dissolve LIOs.

Salmon Lead Entities (LEs) are local watershed-based organizations created under the state Salmon Recovery Act of 1998. Under the law, a group of counties, cities, and tribal governments are authorized to designate together the local area for which habitat project lists will be developed to promote salmon recovery, and who shall serve as "lead entity" for submitting the project lists. (The lead entity may be a county, city, tribal government, conservation district, special district, or other entity.) The lead entity has the authority to establish a "citizens committee" of representatives from local governments, environmental groups, business interests, landowners, citizens, and other habitat interests. This committee is responsible for developing a project list, prioritizing projects on the list, and submitting the list to the Salmon Recovery Funding Board. The citizens committee is advised by a technical committee of local experts knowledgeable about watershed, habitat, and fish conditions. In addition to project lists, lead entities develop salmon habitat restoration strategies to guide project prioritization. Although the Salmon Recovery Funding Board has authority to provide funding and guidance to the lead entities, it does not have authority to dissolve them. The statute establishing the Salmon Recovery Funding Board promotes vertical cohesion, as the Board must give preference to local projects that are included in the Puget Sound Partnership's region-wide Action Agenda (RCW 77.85.130(2)). Also, the Board is required to favor projects that are based on a "limiting factors analysis" and other science-based assessments (ibid). Characteristics of salmon lead entities, other local organizations, and relevant regional organizations are summarized in Table 1.

Table 1. Characteristics of three types of local collaborative organizations and their associated regional organizations in the Puget Sound

Local organization	Regional Organization				
Name	**Name**	**Authority to give funds?**	**Authority to dissolve local organization?**	**Promotes vertical coherence?**	**How it promotes use of science in local organizations**
Marine Resources Committee	Northwest Straits Commission	Yes, but relatively small	No	Yes	funding and guidance
Local Integrating Organization	Puget Sound Partnership	Yes	Yes	Yes	Guidance in how to create local Ecosystem Recovery Plans
Salmon Lead Entity	Salmon Recovery Funding Board	Yes	No	Yes	Favors project requests supported by scientific assessments

Methods

Following prior studies of watershed networks in the region (Scott and Thomas 2015), along with additional internet searching, the research team developed a contact list of collaborative watershed partnerships in the region. We contacted over 70 of these groups between July and October, 2017. 41 of these groups expressed interest in working with us; 15 of those groups worked to establish a specific group interview time, and we selected six groups across organization type and geographic location to interview. These groups are all collaborative partnerships with members from a range of government agencies, nonprofit organizations, citizens, and industry. Two of the groups are Marine Resources Committees (MRCs), established under the Northwest Straits Marine Conservation Initiative and comprised of citizen volunteers appointed by local elected officials. Two of the groups are salmon lead entities (LEs), established under the state's Salmon Recovery Planning Act of 1998 and comprised of local government officials and citizens working to develop and manage salmon habitat protection and restoration projects. Two of the groups are Local Integrating Organizations (LIOs), watershed-based organizations established by the Puget Sound Partnership (a state agency), comprised of government agency personnel, citizens, nongovernmental organizations, and industry to facilitate local recovery efforts that matched with regional priorities.

For the group interviews, we developed a semi-structured interview protocol and digitally recorded the interview sessions, with a two-person team for five of the group interviews – one to facilitate and one to take notes. For the sixth group interview one team member (the author) facilitated and took notes. The group interviews lasted approximately one hour each and occurred between August 16 and November 7, 2017, at the location of the group's monthly or quarterly meeting. Participants numbered between 2 and 12, and most of the groups had at least 6 participants. In total we included 38 participants across the six groups, representing five counties in the region. Although we did not ask participants to identify whether they were scientists, across the six interviews each group mentioned that scientists were part of the group – in some groups agency representative members were scientists, and in some groups citizen members were retired university or agency scientists.

The digital recording of each group interview was professionally transcribed and augmented with notes taken during the interview (for example, we filled in some blanks in the transcripts and corrected some place name spellings). The author coded each interview deductively based on categories derived *a priori*, focusing on sources of scientific information and whether the information was shared horizontally or vertically. Following Miles and Huberman (1994) and Creswell and Poth (2017), codes were further divided into subcategories and then aggregated into themes. In addition, during deductive coding, additional codes emerged inductively, and these codes yielded themes that were pursued in an iterative process (Charmaz 2006). These emergent themes included concepts of scale and direct vs. indirect use of science, as described below.

Results

1. Vertical and horizontal transmission of scientific findings
a. Horizontal transmission

Horizontal transmission refers to actors drawing on scientific information from sources without leverage over them. These sources could be other subunits in their region, regional entities with no authority over them, or entities outside of the region. As described below, group members draw heavily on horizontal interactions with people, and they seek documents, to obtain scientific findings. Applying such scientific findings depends on relevance to their local context. Group members in some cases not only receive, but also provide, scientific information horizontally to increase coherence of efforts across the region.

i. Scientific findings from people

Horizontal transmission of scientific information occurs frequently, and people are a key conduit. In one LE, a member said their paid position outside the partnership facilitates such transmission: “I'm working as a grant manager for the state agency… I'm trying to share information that I come across elsewhere… [and] stuff that you guys have given me… that I can share with other folks.” Numerous interviewees mentioned the importance of word of mouth and their networks of colleagues. For example, in one LE an interviewee said “I rely quite a bit on colleagues sending me papers that they've read, and thought that we would be interested in… that sort of interpersonal communication is a really important source.” Another LE interviewee said, “I reach out to all of our partners… who have been working in a certain area to see what information they have.” Similarly a member of a LIO said, “Another source that I use that’s very helpful is to call up my buddies [other scientists], and say hey, have you seen the new thing on whatever topic?” One MRC member said, “if we’re thinking about how to be well informed at the MRC, the way I think about it is, if I need to know something, I will call or get in touch with the people who are doing that work, because there’s a definite time lag [between study completion and publication].” Thus one reason to get scientific information from a person rather than from a publication is time lag. Another reason is related to level of expertise, as one MRC interviewee explained: “We don’t have any specific specialists of a certain focus. We’re all pretty generalists. But, we have lots of people we can call that can hopefully explain the really nitty, gritty details and language that I can understand.”

Another form of people as a source of scientific information is conferences. In five of the groups, interviewees described the importance of participating in local and regional conferences. One LE interviewee said, “The tribes will have – twice a year -- environmental research forums various places and they’re very well attended. People talk for 20, 30 minutes on what they’ve been doing. It’s good stuff." Another LE interviewee said, "I always enjoyed the watershed council annual meetings, and the South Sound Science Symposium. Science symposiums are good [sources of information]". Another LE interviewee said, "I just thought of another important source of this kind of information, which are conferences. I think it's a time effective way for those of us without as much time to do this as we like." A member of a MRC said, "We have found it's valuable to go to conferences -- where they have people from all over the world, and you can read their abstracts and listen to their topics, and see what they're doing that kind of relates to what you're doing, and then [build] contacts that way." A LIO interviewee said, "I try to go to at least one conference a year, and so, that helps keep me up on the field, and then give me names that I can use," and in the same interview another member of the same LIO added, "Half the value of the conferences is the hallway conversations that you have with people." In addition to conferences, one MRC invites guest speakers to meetings to provide scientific information: "It's really common for this MRC to invite somebody to come in. We had [somebody talk about] the dispersants, we had somebody come in and talk about blue carbon, I mean I think that's another way the MRC accesses that information, by bringing in a scientist to share and talk."

ii. Scientific findings from documents

Group members frequently mentioned obtaining scientific findings from documents. For some, a search strategy is to start with Google Scholar, although others hadn't heard of Google Scholar. Journal articles are important for some aspects of work, as A MRC interviewee said: "if it's in my area of expertise, I go to the scientific journals [first]." A LE interviewee said, "Scholarly journals are typically more specific, so if we're looking to justify a specific action and associate that with a specific response that we're looking for, on a really fine scale, then yeah, you might be looking into the journal articles." In contrast, some interviewees found documents from government agencies to be more helpful. One LE interviewee said, "We're working with policy and documents from the Puget Sound Partnership… and other organizations that are part of what we do, and not so much doing a lot of exhaustive literature [review]."

iii. Applicability of scientific findings

Horizontally acquired scientific information can come from nearby locations or from locations far away. Members of the collaborative organizations typically privileged information from contexts similar to their local context. One LE interviewee said, "Often for us, I guess I look at stuff that's proximate to our area of interest because it seems to have more applicability versus research done in another state or elsewhere." A LIO interviewee said, "The Nisqually tribe [nearby] have been doing monitoring of juvenile salmonid numbers, hundreds of species…One of the things that they've discovered is that there are a lot of salmon, from other watersheds, that are moving down into the South Sound… The information from the Nisqually tribe has been very useful in identifying those areas, where restoration and protection would be particularly useful." A LE interviewee said, "There are assessments, or research, or science from other parts of the state that are relevant to what we're doing. So, we probably wouldn't limit it to just work coming out of [our LE location]."

One benefit of drawing on scientific information from nearby locations is comparability. A MRC interviewee said, "Normally we're looking to try and come up with comparable data sets, so we can compare our eel grass to the eel grass in Padilla Bay, or we can compare our clam population with the clam population somewhere else. So, using methods that are being used throughout an area allows us to then make comparisons, and that's usually pretty important."

Sometimes scientific findings from other contexts are not relevant to the local context, for several reasons. One reason could be a difference in the biophysical context, as a MRC interviewee explained: "[They] suggested we look at this product called 'smart sponge,' which is kind of a foamy, popcorn sort of thing that in the literature…said that this is very effective at taking out metals… It turns out that sedimentation [renders it ineffective] and therefore, if I work in a lab, or I have them in places where you don't have any sediment [it works, but not our local conditions]." Another reason why scientific findings from other contexts aren't useful is political opposition. A LIO interviewee explained, "We live in a political world, where they want to know the effect of it here, so unless the science was done here, on our shorelines, it's easy for them to dismiss it… They are looking for the excuse to not [accept the scientific findings]."

iv. Two-way exchanges of scientific findings

Interviewees do more than just receive scientific information; they also share it. Sometimes helpful scientific information is exchanged with people in contexts further away, as one MRC interviewee said, "In my other hat, outside the MRC, I work for a national nonprofit [focused on estuary restoration]. And we have groups in Chesapeake Bay and out here, and actually in the ten major estuaries across the country. So, yeah, there's definitely exchanges." Another interviewee in the same MRC said, "There is a project that Wildlife [WDFW, a state agency] is doing where they can catch and band the birds… We kind of share this information back and forth… You know, what can we do to help? And they will say, well, you have to get all these birds counted before 9:00 a.m., for example, because that kind of fits in with what they're doing. So, we try to combine their needs and our needs to make it more useful." Another interviewee in the same MRC said, "What we're doing with our data on those projects is giving it to, and planning it in a way that's compatible with WDFW or the DOE." A LIO interviewee said, "Our eel grass [research] is well respected. They [group members] partner with the state. Our forage fish [research] is very well respected. They partner with the state. So we've got a lot a really well respected, applicable on our beaches, citizen science going on."

b. Vertical transmission

Vertical information sharing refers to guidance provided to the local level from decision centers at a higher level of aggregation that have leverage over them. Here the higher level entity provides information meant to steer the behavior of the local decision center. Interviewees in both of the MRCs described valuing information from people at the higher level organization. As one interviewee described, "The Northwest Straits Commission and Foundation, who, they're sort of the body above us, I guess. And then we go to them. They have scientists on their staff who are often able to help us." An interviewee from another MRC mentioned how the Commission brings science to bear on local opportunities: "The umbrella organization (Northwest Straits Commission) … does develop a strategy, it looks for the opportunities that we have. It looks at the science behind that through the science advisory committee."

Some interviewees emphasized the importance of vertical guidance in steering their activities at the local level. One LE interviewee said, "We're working with policy and documents from … the Salmon

Recovery Funding Board." One LIO interviewee said, "[W]e've got the middlemen, the organizations like the Puget Sound Partnership, that'll be able to say, inform that and turn it into policy for us, and guide us." Another member of the same LIO, who represents the Puget Sound Partnership, said, "We [the Puget Sound Partnership] provide synthesis…on for example, how to identify pressures in your ecosystem. So that is a really nice service that we can provide, that sort of creates consistency around the region, and also takes the burden off our partners to have to do individualized or smaller-scope, smaller-scale assessments or syntheses that are quite expensive."

2. Scale

The spatial scale at which science is conducted matters. In one LIO, interviewees described a complementary role between larger scale and smaller scale science, driven by the Puget Sound Partnership. First the Puget Sound Partnership provided regional guidance based on scientific studies of nearshore ecological processes. Then the Puget Sound Partnership provided funds for local organizations to conduct place-specific research: "It was a regional plan, and this provided each of us watersheds some support and we chose here to ask specific questions of the same group, and it was a contractor, and we asked them, okay, now that we have this regional, here are our questions we have [for the local level]."

Interviewees noted differences in scientific rigor, usability, and political defensibility between local and regional scales. One LIO interviewee said, "How much of this is anecdotal evidence, and how is that – is it quantitative? Is it qualitative? I mean, there's traditional knowledge that can be synthesized and put forward as science, and so, I think there's a threshold that's tolerable for what we produce as far as the regional scale, and that may be a higher threshold than what happens on the local scale." In other words, larger scale scientific research is held to higher standards than smaller scale scientific research. And yet, usability and political defensibility of scientific findings may be greater at the local scale. As one MRC interviewee said, "In the area of ecology, just because you have information from scientific, peer-reviewed literature doesn't mean you have a whole lot of answers, because so much is site specific." This comment is similar to those described above, where interviewees questioned the applicability of scientific studies done elsewhere to the local context. Similarly, political defensibility of scientific findings may be greater at the local level. As one LIO interviewee said, "The more local you can get your science, the more defendable it is, and the harder it is to politically get around it. But that's harder for smaller communities to get peer-reviewed scientific scholarly journal [studies] that were done here."

3. Direct vs. Indirect use of scientific findings

Members of local collaborative organizations may use science directly, by accessing a peer reviewed journal article or government study. Or they may use science indirectly, relying on the expertise of somebody who has read the study, or a synthesis of scientific studies provided by a government agency. Interviewees in our study indicated both.

i. Direct: peer reviewed journal articles and government studies

Peer reviewed journal articles are widely trusted among interviewees. A LE interviewee said, “I would have the most confidence, I think, in something that had been peer reviewed.” A LIO interviewee said, “the more peer review a study had before it’s actually published, then the more I will trust it. “ A LE interviewee said, “If it’s a scientific peer reviewed journal, then we’re going to trust that.” An MRC interviewee said, “the peer-reviewed journals, I mean you figure they're peer-reviewed, and have that credibility to it.” Another MRC interviewee said, “From my perspective, there is an added level of scientific credibility that I will take from a published journal.” Interviewees described particular instances when peer reviewed journal articles helped guide their decisions, for example in knowing the density of abalone to establish a breeding population, or in providing local officials with answers about whether salmon net pens are safe after a high-profile net pen failure occurred in the area. A MRC interviewee described when they seek peer reviewed journal articles: “if it's in my area of expertise, I go to the scientific journals [first].” A LE interviewee said, “Scholarly journals are typically more specific, so if we're looking to justify a specific action and associate that with a specific response that we're looking for, on a really fine scale, then yeah, you might be looking into the journal articles.”

Government studies were mentioned less frequently as an important source of scientific findings, and with mixed views. One LIO interviewee said, “The best source is government websites. Those are almost always publicly accessible, and you can find information that’s directly related to what we are interested in.” A MRC interviewee said, “I tend to trust the government probably more than anything else, simply because most of the agencies, especially if they’re a regulatory agency, they tend to have to make sure that they’re doing things that are legally defensible. So, they’re very conscious about the information that they’re putting out there.” On the other hand, one LE interviewee thought that government websites are less useful: “I've run across information on websites – government websites, and such, that just have findings, and I can't mine into it to understand how they actually got there.”

ii. Indirect

Indirect use of science involves an intermediary. That is, the end user isn’t directly accessing the peer reviewed journal article or government report. As described above, talking with a colleague who has expertise in a given area – presumably from directly accessing scientific studies -- is a common way that members of these local organizations obtain scientific information. In addition, government reports provide guidance, and local organization members may recognize or assume that these documents have directly incorporated scientific findings. As one LE interviewee said, “A lot of times… when we're developing a project, we're relying on planning documents that have been fed by science, previously. So, we look at – for the most part – just a select few guidance documents.” Another LE interviewee said, “We point back at this strategy document to justify a project that’s being proposed and there’s science behind and data behind the strategy document.” Several interviewees said such guidance documents and government synthesis documents are useful. A MRC interviewee said, “If it's something totally new, then the first place to go would be the government agencies and other organizations that have information summarized. And then you get an idea what's going on. And they very often will have references added. And so, then if you need to go any further, then you would go to the primary sources. But… I wouldn’t start with the primary sources. I would start with summaries.”

But getting scientific findings indirectly, like from a government agency synthesis report, is not the same as getting them directly. One LIO interviewee cautioned, “There's a lot of…data that could lead to a scientific publication, but it's just points of data, and I find that's often useful to make conclusions about status and trends, or whatever. But perhaps not having gone through that scientific analysis, tying back to best-available science, unfortunately, what I see is that gets incorporated into…a synthesis of information, and conclusions are reached, but it wasn't really done in a scientific manner."

Discussion

Cash et al (2006) and other scholars have emphasized problems of scale mismatch in governance of complex socio-ecological systems. Interactions across levels is one way to address scale mismatch -- in other words, to increase cohesion. An important form of interaction is the sharing of information, in this case scientific information. In the study at hand, examining how different local collaborative organizations obtain and use scientific information yielded several themes across the six group interviews.

First, members of local collaborative groups most often obtained and used scientific information from horizontal transmission, largely from communicating with experts. This suggests that research on the use of scientific findings for policy should include not only documents, but also experts whose views can shape collaborative group decisions. A practical implication is that providing opportunities for managers to meet with scientists can help transmit scientific findings, as many scholars have identified (Healey and Ascher 1995; Cerveny and Ryan 2008). One way to do so is through conferences, which allow collaborative group members to learn who is doing what research related to their work. Thus funding for personnel to attend conferences is helpful, and organizing conferences can be impactful for management. Given that there are a variety of formats to use in conferences, careful consideration of conference design is warranted. A theoretical implication is that research could fruitfully examine who attends which conferences, which scientific findings make their way to conferences that collaborative group members attend, and how influential these conferences are.

Second, applicability of scientific findings to actions at the local level depends on context. There are two dimensions to this: biophysical and political. In complex systems of cause and effect, biophysical differences between the study setting and the setting at hand can reduce applicability. Politically, scientific findings from a different context are more easily dismissed by actors who prefer actions that go against what the scientific findings suggest. Moreover, there is a tension between scientific applicability and rigor at local versus regional scales. While larger-scale scientific research may be held to a higher standard (e.g., peer review) and thus seen as more rigorous and trusted, it may be less useful to answer place-specific questions due to contextual differences, and it may be harder to defend politically since it's from a different context.

Third, guidance documents are widely regarded as helpful for local-level collaborative group decisions. Interviewees noted these document reduce the necessity to reinvent the wheel, and they provide comparable data for comparison. In some cases, incorporation of information from these documents increases the opportunities for local groups to receive funding. Thus the widespread use of information as a means for higher-level decision centers to shape lower-level decision centers, as noted in the literature on collaborative watershed management, appears to be influential as the higher-level decision centers intended. Such documents are assumed to be supported by scientific findings, which means they provide scientific findings indirectly to local groups. This can be beneficial for streamlining the process and reducing effort on the part of local organizations to obtain and synthesize scientific studies directly. But it can also lose something in translation, which can reduce the scientific basis for local organization actions. It also means local organization members likely trust the science less than they do highly trusted peer reviewed journal articles. The translation of scientific findings thus warrants further study, to examine the original source material and compare it to its characterization in regional guidance documents and ultimately in local organization actions.

Fourth, coherence was increased through scientific findings in a number of instances. In horizontal information sharing, members of several groups noted they coordinate with other entities in the region to ensure their data collection efforts are comparable and usable to others. This comparability facilitates information exchange and allows organizations to manage coherently in light of other organizations' actions. In vertical information sharing, members of several groups noted the importance of the organization at the higher level, whether that be the Puget Sound Partnership which provides guidance and funds to LIOs that increase coherence between local management strategies and region-wide goals, or MRCs which turn to the Northwest Straits Commission for scientific advice, or LEs that follow documents from the Salmon Recovery Funding Board to decide which local projects to prioritize for funding requests. Interestingly, such vertical cohesion illustrated here is from the top down, rather than the bottom up. Since our interview questions focused on how local organizations obtain science, we did not delve into questions about how these organizations may provide scientific findings from the bottom up to organizations that have leverage over them. Future research on this question is warranted.

Finally, although our six local groups represent an array of authority and funding relationships with vertical decision centers (e.g., for LIOs, the Puget Sound Partnership has the power to create the LIOs and have substantial control over their funding, while for MRCs the Northwest Straits Commission does not – recall Table 1), interview responses didn't differ along these lines. This doesn't mean that authority structures are irrelevant, but that they may not be manifest in interviewees perceptions – at least not in our small sample. Analysis of a larger number of groups, and going beyond interviews to examine outputs of the groups, could identify any systematic differences.

Conclusion

This study set out to examine how much and how actors at the local level use scientific findings vertically and horizontally in a multi-level collaborative governance system, and how use of science affects coherence among decision centers. Results from six group interviews among three types of local organizations in the institutionally- and science- thick Puget Sound region suggest several themes. These themes highlight the importance of horizontal transmission of scientific knowledge, via people and documents, including the role of conferences. They also highlight biophysical and political dimensions of applicability of a scientific study to a local context, and how these are in tension with the rigor attached to a broader scale. Finally, guidance documents from higher-level decision centers are influential in steering the behavior of lower-level decision centers. The higher-level documents are assumed to be informed by scientific findings, thus providing an indirect route for scientific findings to be transmitted and used across levels.

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