Research article

Who collaborates and why: Assessment and diagnostic of governance network integration for salmon restoration in Puget Sound, USA

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A B S T R A C T

Governance silos are settings in which different organizations work in isolation and avoid sharing information and strategies. Siloes are a fundamental challenge for environmental planning and problem solving, which generally requires collaboration. Siloes can be overcome by creating governance networks. Studying the structure and function of these networks is important for understanding how to create institutional arrangements that can respond to the biophysical dynamics of a specific natural resource system (i.e., social-ecological, or institutional fit). Using the case of salmon restoration in a sub-basin of Puget Sound, USA, we assess network integration, considering three different reasons for network collaborations (i.e., mandated, funded, and shared interest relationships) and analyze how these different collaboration types relate to productivity based on practitioner's assessments. We also illustrate how specific and targeted network interventions might enhance the network. To do so, we use a mixed methods approach that combines quantitative social network analysis (SNA) and qualitative interview analysis. Overall, the sub-basin's governance network is fairly well integrated, but several concerning gaps exist. Funded, mandated, and shared interest relationships lead to different network patterns. Mandated relationships are associated with lower productivity than shared interest relationships, highlighting the benefit of genuine collaboration in collaborative watershed governance. Lastly, quantitative and qualitative data comparisons strengthen recent calls to incorporate geographic space and the role of individual actors versus organizational culture into natural resource governance research using SNA.

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1. Introduction

“Stove-piped,” “fractured,” and “siloed,” are phrases that many environmental managers can relate to. They refer to conditions where different organizations work in isolation and avoid sharing information and strategies. Such arrangements, called governance silos henceforth, pose a fundamental problem for environmental planning and problem solving (Crowder et al., 2006). Most environmental problems are multifaceted and affected by social and ecological processes operating in different places and at different rates (Galaz et al., 2008). Therefore, effective management requires different organizations to collaborate (Ostrom, 1990; Sabatier et al., 2005).

Governance silos can be considered a particular subset of institutional fit: i.e., how well the formal and informal rules of interaction and arrangements among organizations (Ostrom, 1990; Young, 2008) address the dynamics of a given natural resource system (Crowder et al., 2006; Galaz et al., 2008). One way to overcome siloes and improve fit is through governance networks that facilitate cooperation and coordination across jurisdictions, locations, and public/private sectors. (Bodin et al., 2011). Studying the structure and function of such networks, often referred to as social network analysis for natural resource governance (SNA for NRG), has become an important topic within the field of environmental governance (Fig. 1, Bodin and Crona, 2009; Bodin and Prell, 2011; Folke et al., 2005; Janssen et al., 2006).

There are many motivations for creating network relationships
In North American NRG networks, for example, organizations interact through a variety of formal, informal, and financially incentivized institutional arrangements (Ostrom, 1990; Schneider et al., 2003; Sabatier et al., 2005; Feiock, 2013; Shrestha et al., 2014). While recent studies using SNA for NRG have focused on relationships such as knowledge exchange, political influence, labor, and resource exchange (e.g., Cassidy and Barnes, 2012; Cohen et al., 2012; Crona and Bodin 2006; Vignola et al., 2013; Weiss et al., 2011), few compare formal, informal, and financially incentivized relationships. And with some examples notwithstanding (e.g., Berardo and Scholz, 2010), relationship types are infrequently evaluated in light of specific outcomes.

Additionally, NRG studies using SNA often classify organizations in ways that might not always support solutions oriented research needed by local practitioners (Lubchenco, 1998; Brondizio et al., 2009; Defries et al., 2013; Moss et al., 2013). Categories such as local, regional, and national (e.g., Cohen et al., 2012; Vignola et al., 2013) may be apt for addressing certain questions; but, local solutions require detailed local studies (Schneider et al., 2003; Vance-Borland and Holley, 2011; McAllister et al., 2013), something we aim to provide.

In this paper, we analyze NRG network integration among a detailed typology of organizations and consider formal, informal, and financially incentivized relationships alongside collaboration productivity. We focus on salmon restoration in a sub-basin of Puget Sound in the Pacific Northwest, USA, and answer the following questions: 1) How well integrated is the salmon governance network? 2) Why do different types of organizations collaborate, specifically considering mandated, funded, and shared interest relationships? 3) How productive are the aforementioned collaboration types? 4) How can understanding these patterns enhance restoration work in the region and provide a proof of concept to be applied elsewhere?

Our study supports both theory and application. From a theoretical perspective, we relate network collaboration reasons with perceived productivity. We also engage in a critical reflection about how units of analysis (e.g., organizations and individuals) affect NRG network function, a needed and understudied research priority (Newig et al., 2010). Additionally, we discuss how geography affects the analysis of NRG silos. From an applied perspective, we identify collaboration needs and discuss how practitioners might address them. We provide a proof of concept for diagnosing and assessing governance silos and contribute to a growing literature using SNA to identify interventions, often called “network weaving,” to improve NRG networks (Vance-Borland and Holley, 2011; Belin et al., 2013; Mills et al., 2014).

2. Study area

Our study was conducted in the Whidbey Basin (WB), a large semi-enclosed coastal basin in Puget Sound, Washington State, USA. (Fig. 2). WB consists of four major rivers that drain approximately 14,850 km² of land (Beechie et al., 2001; PSP, 2014) and account for 68% of Puget Sound’s freshwater input (Yang and Khangaonkar, 2010). We focus on collaborations among organizations involved in salmon restoration, a logical case for studying NRG networks because salmon restoration requires that organizations in different locations collaborate. As a hydrologically and biophysically connected basin, any actions taken in one part of WB will affect natural resources in other locations (NRC, 1992; Stanley et al., 2012; Wilhere et al., 2013). For example, salmon spend their adult life at sea, return to spawn in specific rivers, and use the entire nearshore during their juvenile life stage (Beamer et al., 2013; PSP, 2014). Land-use, development, conservation, and restoration actions in one part of WB will affect salmon, positively or negatively, in other locations (NWIFC Member Tribes, 2012; Wilhere et al., 2013).

WB hosts several species of salmon listed as threatened under the U.S. Endangered Species Act, which provides a legal mandate to restore salmon (Lyshall et al., 2008; Bottom et al., 2009; Wilhere et al., 2013). Because of these listing, and salmon’s important cultural and economic role in the region, many restoration and recovery efforts are state and federally promoted initiatives, often coordinated through watershed planning bodies and driven forward using competitive grant funding cycles. Additionally, numerous grassroots initiatives also exist (PSP, 2014). While the state tried for several years to advance a WB-wide recovery planning and implementation effort, it was not supported by local organizations leaving decisions in recovery planning and implementation to be made at smaller geographic scales (PSP, 2014).

Major jurisdictions in WB include four counties (a fifth overlaps in northern headwaters, but lands are in federal holding, so this county is rarely, if ever, a player), seven Native American Tribes, more than 30 towns and cities, federal and state agencies, and many special purpose districts, which are autonomous quasi-governmental entities with taxation authority that manage specific issues such as flood control or port management (Lyshall et al., 2008; MRSC, 2012; PSP, 2014). Several land trusts, numerous nonprofits, and citizen groups are also involved in salmon restoration (Lyshall et al., 2008; PSP, 2014). A very small percentage of forested headwaters cross into Canada, but we focus this study on the vast majority of the basin residing in Washington State.

3. Methods

We took a mixed methods approach, common to NRG studies using SNA, that integrates quantitative network and qualitative interview analysis (Prell et al., 2009; McAllister et al., 2013). We collected data by interviewing and surveying restoration practitioners. Our survey and interview guide were developed based on attending local and regional restoration planning meetings and

![Fig. 1. Conceptual framework. See definitions in main text. Our study addresses governance siloes, a subset of the institutional fit literature, which falls under the umbrella of environmental governance (Crowder et al., 2006; Galaz et al., 2008). We approach institutional fit from the SNA for NRG literature (also a subset of environmental governance) because networks can bridge siloes and improve fit (Ernstson et al., 2010; Bodin et al., 2011; Guerrero et al., 2013). NRG studies using SNA are often inferential, i.e., relating variables to inform theory, or diagnostic, i.e., evaluating network structure and inferring function based on theory, often for application. Our study contributes to both and is in line with wider sustainability science that seeks to unite theory and application to solve real-world problems, such as governance silos (Kates et al., 2001). Governance siloes also relate to studies of collective action, a literature that we do not specifically call out in the text, though it informs our study through associated references (e.g., Feiock, 2013; Ostrom, 1990; Sabatier et al., 2005).](image-url)
which brought together regional stakeholders to communicate the current state of knowledge about the region, 2) observing attendance at local and regional planning meetings in 2011, and 3) pilot runs.

We recruited 206 survey participants at 186 organizations using snowball sampling and had a 68% response rate \((n = 140)\). We used targeted phone and email recruitment (with a minimum of three contact attempts). We asked to speak to the person(s) best able to participate on behalf of the organization in question. We had multiple participants at several organizations to account for sub-programs and staff that split geographic regions. These were merged to form a single organizational response (Table 1). Survey participants reported who they worked with to do restoration, defined as directly or indirectly helping degraded ecosystems recover to support human wellbeing and local economies (language we adopted from state planning documents (PSP, 2008)). If an organization said they work with another, but the other did not reciprocate or participate in the survey, we assumed there was a relationship (i.e., weak symmetrization). Survey participants account for 56.67% of the total documented salmon network.

Participants were asked to indicate why they worked with each organization (i.e., mandated, because of funding, and shared interests – choices were not mutually exclusive). Participants were also asked to report the percentage of time they perceived a collaboration to be productive for meeting their organization’s restoration goals. A five point ordinal scale was used (i.e., approximately 0%, approximately 25%, approximately 50%, approximately 75%, approximately 100%, don’t know, and no response). This question had an 80.35% response rate. Non-responses include blank responses as well as the “don’t know” and “no response” options.

3.2. Network analysis

A network consists of an ensemble of nodes connected by an ensemble of edges. Nodes in our network were organizations involved in restoration. Collaboration reasons and productivity among nodes were represented as edges. We grouped nodes into categories, called network modules, based on major jurisdictional and sectoral divisions (Table 1). Following Baggio et al. (2015), we calculated each node’s network participation score \((P_i)\) to understand the extent to which nodes of one module collaborated with other modules. \(P_i\) measures a node’s overall position in the network. \(P_i = 1\) when a node has an equal number of edges to each network module and 0 when it has no edges to other modules (Guimerà and Amaral, 2005).

3.1. Social network survey

Organizations were sampled using an open-ended recall method, common to SNA. A list of groups working in the region was compiled and blank spaces were included for additional write-in responses. Write-ins were also contacted to participate. We partitioned the recall list into a simple a-priori typology to reflect major jurisdictional and sectoral categories (Table 1). The list was compiled from 1) attendance at a 2011 WB science symposium, which brought together regional stakeholders to communicate the current state of knowledge about the region, 2) observing attendance at local and regional planning meetings in 2011, and 3) pilot runs.

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### Table 1

Organizations in network and survey responses by individuals and organizations.

<table>
<thead>
<tr>
<th>Organization type</th>
<th>Nodes (organizations)</th>
<th>Responses by individual</th>
<th>Responses by organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>City &amp; town</td>
<td>37</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Citizen group</td>
<td>12</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Coordinating &amp; watershed groups</td>
<td>20</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>County</td>
<td>13</td>
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</tr>
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</tr>
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</tr>
<tr>
<td>Tribe</td>
<td>14</td>
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<tr>
<td>Education</td>
<td>5</td>
<td>0</td>
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<tr>
<td>All</td>
<td>210</td>
<td>140</td>
<td>119</td>
</tr>
</tbody>
</table>
\[ P_i = 1 - \sum_{j=1}^{N_k} \left( \frac{k_{ij}}{k_j} \right)^2 \]

where \( P_i \) is the participation coefficient of node \( i \), \( k_{ij} \) is the number of edges from node \( i \) to nodes in module \( j \), \( k_i \) is node \( i \)'s total edges, and \( M \) is the number of network modules.

We also calculated specific module-to-module participation (\( PM \)), which is the proportion of a node's total edges to nodes in a specific module (Baggio et al., 2015).

\[ PM_{i,m} = \frac{k_{i,m}}{k_i} \]

where \( PM_{i,m} \) is node \( i \)'s participation score to module \( m \), and \( k_{i,m} \) and \( k_i \) are the module specific and total edges of node \( i \), respectively.

Participation scores are node level metrics that when aggregated, illustrate general network patterns through measures of centrality. Our use of participation metrics differs from other approaches used to evaluate collaborations among groups, such as edge counts (e.g., Cohen et al., 2012; Crona and Bodin 2006), because edge counts are calculated at the more generalized sub-graph level and do not provide information about individual nodes. Sub-graph approach are useful for understanding if the total number of collaborations between two organization types (e.g., nonprofit and state) are more or less than expected by chance through random simulations (Crona and Bodin 2006). However, sub-graph analysis does not explain the relative composition of a node's collaborations and its relationship to actors in different groups. We therefore summarized \( PM \) scores using quartiles and created module-to-module participation matrices to compare intra- and inter-module collaborations. We also compared \( PM \) scores to each node's total edges (Freeman's degree centrality, \( CD \)) and considered overall percentage of funding, mandated, and shared interest edges among modules.

Finally, we assessed productivity of different collaboration reasons in two ways. First, using a 1–5 ordinal scale for edge productivity (where 1 is approx. 0% and 5 is approx. 100%), we created boxplots of the raw, un-merged survey responses as merging and symmetricizing the data obscures the direct responses. We only considered complete cases (both productivity and collaboration type) and stratified them by the different permutations of combined collaboration types. Then, to control for structural autocorrelation in the data and assess how productivity varied by collaboration reason, we used Quadratic Assignment Procedure (QAP) Pearson's correlations and multiple linear regression (MRQAP) (Dekker et al., 2007). QAP simultaneously permutes the rows and columns of the dependent variable data matrix and computes the probability of obtaining the observed statistic by chance based on \( N \) permutations. This is a common and necessary statistical approach for network analysis because network data do not fit classical statistical assumptions, including independence of observations (Dekker et al., 2007; Borgatti et al., 2013). QAP tests were calculated in UCINET 6.509 (Borgatti et al., 2002), using 5000 permutations, and directed (i.e. unsymmetrized) networks to preserve survey responses. Non-responses were coded as zero. We considered two models, one based on merging individual responses into a single organizational response by maximum productivity, the other by minimum, to see how this affected results. We merged data prior to recoding non-responses to zero to preserve the productivity score when merging by minimum.

3.3. Interviews

We used qualitative interviews to ground and complement our network analysis. Semi-structured interviews were conducted with a subset of 95 participants, purposefully selected to represent the most prominent groups in the network, but also its organizational diversity and different geographic regions. Interview questions were open-ended and addressed a number of themes relating to restoration planning and implementation and inter-organizational collaborations.

All interviews were conducted by the primary author and used an interview guide for consistency (see Appendix A). Interviews were done in person or over the phone based on the participant's preference and ranged from 0.5 to 2.5 h. Interviews were voice recorded, transcribed, and thematically coded using MaxQDA 10 based on a-priori themes (i.e., deductively). For this study, quotes from two of several coding themes were used: 1) challenges and limits to doing restoration work, and 2) the role of individuals and an organization's culture in shaping collaborations.

4. Results and discussion

4.1. How well integrated is the WB salmon governance network?

The WB salmon restoration network consists of a diverse array of organizations. Several are highly central in the network (large circles signifying high degree centrality, Fig. 3, and maximum degree scores, Table 2), including a few state and federal organizations. Several tribal organizations also have high centrality. While a few organizations are more central than others, the mean and median centrality scores (Table 2) are similar for most organization types indicating a rather integrated network overall.

Participation scores show that the majority of organizations have even collaborations with nodes of other organization types (i.e., median > 0.6, Fig. 4), with the exception of business and other organizations. While most \( P_i \) scores are high, max \( P_i < 1 \) indicates that no organization has a perfectly even collaboration across organization types. Interestingly, while federal, state, and tribal organizations were more central in the network (high \( CD \), Fig. 3, Table 2), counties, public utilities, and tribes play more of an
integrating role as they have the highest participation scores, even slightly higher than coordinating and watershed groups, which, by definition, play integrating roles (Fig. 4).

Fig. 5 and Table 3 further illustrate that the governance network is fairly well integrated. The median, upper, and lower quartile \( PM \) scores are relatively homogenous for all module-to-module combinations. Had the network been overtly siloed, \( PM \) scores to one’s own module (i.e., the diagonal in Fig. 5, Table 3) would be much higher than other module-to-module combinations. Additionally, an integrated network should not have an extremely low diagonal in the \( PM \) matrix (Fig. 5, Table 3), as this would indicate a paucity of collaboration within sectors. Within sector collaborations appear healthy in WB. Educational and other organizations have no within-module participation due to their non-participation in the survey. Of course, some organization types do play a bigger role than others.

Most organizations have a high \( PM \) scores with nonprofit, state, and to a slightly lesser extent, federal and special district organizations (i.e., high scores relative to row, Fig. 5, Table 3). \( PM \) scores to public utilities, businesses, and educational organizations are much lower for most organization types (i.e., low scores relative to row, Fig. 5, Table 3). This pattern is partly a function of module size, but not entirely and illustrates an important characteristic of the network. For example, nonprofits are the largest group in the network (Table 2), so it not surprising that an organization has many nonprofits partners. Conversely, the possible collaborations to educational organizations may always be low; there are only five education nodes. An organization can clearly have more nonprofit partners than educational ones. Yet, comparing \( CD \) and \( PM \) scores shows that it is entirely possible for organizations to have much higher participation with educational organizations. For example, given the 5 educational nodes and the range of median \( CD \) scores (Table 2), \( PM \) values could be approximately 0.25–1.0 for organizations in the median \( CD \). Yet \( PM \) scores from any group to education are a magnitude smaller (i.e., 0.03 to 0.06, Table 3). While module size may alter the range of possible \( PM \) scores, the \( PM \) values we observed represent the reality of the WB network. Continuing with the original example of nonprofits, they play a big role in the network, both in number and with whom organizations engage as partners.

Finally, several organization types do not collaborate with each other (i.e., several \( PM \) scores = 0). Particularly noteworthy, is an

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Table 2

<table>
<thead>
<tr>
<th>Organization type</th>
<th>Abbreviation</th>
<th>N</th>
<th>min</th>
<th>Max</th>
<th>Mean</th>
<th>sd</th>
<th>Median</th>
<th>25th%</th>
<th>75th%</th>
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<td>5.50</td>
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<td>15.75</td>
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</tbody>
</table>

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Fig. 4. Box plot of participation scores (\( P_i \)) by organization type. Abbreviations listed in Table 2. Median values are represented by the black thick line. The box around the median value represents the range between the 25th and the 75th percentile. Circles denote outliers.

Fig. 5. Median, 25th, and 75th percentile module-to-module participation (\( PM \)) scores among different group types in the salmon restoration network (\( n = 210 \)). Colors indicate \( PM \) score. Data should be read across rows; for example, top row represents \( PM \) scores from cities/towns (CTT) to other organization types. Abbreviations listed in Table 2.
absence of collaboration between businesses and cities/towns and between educational and state organizations. These are major gaps among key sectors in WB.

4.2. Why do different organization types work together?

Fig. 6 and A.3 illustrate that focusing on specific collaborations reveals different patterns among organization types. For example, the median participation between cities/towns and most other organizations is high for funded relationship and lower for shared interests. Cities/towns also have high participation with federal and state organizations for mandated relationships. As might be expected, few organization types collaborate with nonprofits and businesses because of mandates.

4.3. How productive are different collaboration types?

Fig. 7 provides simple descriptive statistics about the productivity of different collaboration reasons. While there is no difference in median productivity, the presence of mandated relationships increases the interquartile range of collaboration productivity and negatively skews the distribution. Mandated collaborations have a lower productivity, while collaborations based on mutual interest and funding are perceived to be more productive.

QAP results confirm these patterns (Tables 4 and 5). Shared interest relationships have a stronger correlation with productivity and explain the majority of variance (correlations in Table 4, standardized coefficients in Table 5, p < 0.001). While all three edge types are positive and significant in the MRQAP, the positive effect of shared interest relationships on productivity is almost 5.5 times higher than mandated relationships. These findings illustrate that mandated collaborations are less likely to be productive for

Table 3

<table>
<thead>
<tr>
<th></th>
<th>CTT</th>
<th>CZG</th>
<th>CWG</th>
<th>COU</th>
<th>FED</th>
<th>NPR</th>
<th>OTH</th>
<th>PUT</th>
<th>BUI</th>
<th>SPD</th>
<th>STA</th>
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<td>0.000</td>
<td>0.000</td>
<td>0.143</td>
<td>0.268</td>
<td>0.143</td>
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<td>0.209</td>
<td>0.189</td>
<td>0.152</td>
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</table>

4.2. Why do different organization types work together?

Fig. 6 and A.3 illustrate that focusing on specific collaborations reveals different patterns among organization types. For example, the median participation between cities/towns and most other organizations is high for funded relationship and lower for shared interests. Cities/towns also have high participation with federal and state organizations for mandated relationships. As might be expected, few organization types collaborate with nonprofits and businesses because of mandates.

4.3. How productive are different collaboration types?

Fig. 7 provides simple descriptive statistics about the productivity of different collaboration reasons. While there is no difference in median productivity, the presence of mandated relationships increases the interquartile range of collaboration productivity and negatively skews the distribution. Mandated collaborations have a lower productivity, while collaborations based on mutual interest and funding are perceived to be more productive.

QAP results confirm these patterns (Tables 4 and 5). Shared interest relationships have a stronger correlation with productivity and explain the majority of variance (correlations in Table 4, standardized coefficients in Table 5, p < 0.001). While all three edge types are positive and significant in the MRQAP, the positive effect of shared interest relationships on productivity is almost 5.5 times higher than mandated relationships. These findings illustrate that mandated collaborations are less likely to be productive for
achieving collaborative governance objectives (i.e. salmon restoration in our specific case).

We must caution though, that we cannot infer causality. Mandated relationships could have been established (and enforced) to create collaborations among organizations that did not want to work together or believed collaborating was unnecessary. Nevertheless, helping stakeholders see possible holistic benefits of restoration, such as green infrastructure that can reduce the risk of flooding, or ecotourism that can boost local economies (Suding et al., 2015), could help them unite around shared interests, which contribute significantly more to partnership productivity. Thus, even if mandates are not causing lower productivity, but are put in place where low productivity already existed, we can still identify targeted network interventions that may lead to more productive relationships. We develop this idea further in the next section.

4.4. How understanding collaboration patterns can enhance restoration work: an example with cities and towns

Many city and town participants described how their jurisdictions lacked capacity to do restoration work. However, as independent local jurisdictions that govern a large portion of WB’s land and population, cities and towns are integral to advancing restoration in the region. The following quotes illustrate some of the challenges facing cities and towns:

The city is in transition right now. ... We just did a bunch of layoffs [and my job description changed], ... Even though the community and other [City] Council members want me to keep doing natural resources, I don’t know if I will be able to or not, to be honest. ... [Restoration] is not necessarily the highest priority. There are other priorities to the city ... health and safety is more important.

(City/town participant 1)

Money! I mean, it is really a matter of funding ... To do restoration projects you know, you got to have the money not just for the initial planning, but you got to have at least five years of maintenance and monitoring. And that is very vigorous for the first two years if you’re gonna end up with a restoration site that is worth two hoots. ... We got the sites; we just don’t have the funding.

(City/town participant 3)

Politics – I mean that’s the main thing. If we had a different political tone, we would, the city would probably be pursuing restoration projects more aggressively. And then money is obviously a factor. ... And then, the third thing, ...there isn’t leadership on that issue. So there isn’t ... a discussion happening about the benefits of restoration to people and to the city generally ... It’s not part of the culture and discussion that happens around other issues like economic development. ... It’s viewed myopically. ... The case just hasn’t been historically made here that restoration has these greater benefit than just the restoration project itself.

(City/town participant 17)

We are by necessity and purpose involved in environmental management; we are not by mandate, necessity, or purpose, involved in environmental restoration. We don’t have the budget to do anything that we are not mandated to do .... We are not a restoration agency; and we are nevertheless, happy to cooperate as we did with [that group on those] projects.

(City/town participant 22)

Insufficient financial and human resources and anti-restoration

<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>QAP Pearson’s correlations between collaboration reasons and productivity. All p-values are &lt;0.001. Max and min merge refer to merging survey responses to the organizational level (n = 210) by maximum and minimum reported productivity, respectively.</td>
</tr>
<tr>
<td>Funding</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Funding</td>
</tr>
<tr>
<td>Mandated</td>
</tr>
<tr>
<td>Shared</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRQAP regression models between collaboration reasons and productivity (n = 210). There was little variation between the maximum and minimum merge models, so only maximum is displayed in the table. The difference in adjusted $R^2$ between the two models was only 0.008 (maximum model was higher). The absolute difference between standardized coefficients in the minimum model was slightly larger. Details in Appendix A.</td>
</tr>
<tr>
<td>Model: max merge $R^2 = 0.695$ adj. $R^2 = 0.695$ p &lt; 0.001</td>
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<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Unstandardized coefficient</td>
</tr>
<tr>
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<td>Mandated</td>
</tr>
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<td>Shared</td>
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<tr>
<td>Intercept</td>
</tr>
</tbody>
</table>
Politics and stovepipe thinking that put restoration at odds with economic development are formidable challenges. However, quantitative SNA results provide insight about possible opportunities to overcome such challenges.

Cities/towns are one of the few organizations that have a slightly lower participation with nonprofits as compared to other organization types (i.e., Table 3 where PM scores are compared within rows using quartile breaks to help guide comparisons). Nonprofit collaborations with cities/town are also low, only 0.004 above the nonprofit row lower quartile \( PM = 0.077, 25\text{th}\% = 0.073 \). Furthermore, cities/towns do not collaborate with businesses. They predominantly collaborate with federal and state organizations (Fig. 5, Table 3), but these collaborations are largely mandated (Fig. 6 and A.3) and may be of low productivity (Fig. 7, Tables 4 and 5). Indeed, one participant commented that cities and towns “are regulated to death,” indicating that they thought poorly of these mandated relationships. Based on the above network structures, restoration capacity might be enhanced by promoting partnerships with nonprofits and businesses.

Such network interventions, or weaving, should be targeted, however. A blanket push for nonprofit and business partnership may yield undesirable results. As one city/town participant said:

You kind of start to know who’s got the right technical background and who’s just maybe a nonprofit group that is trying to do the right thing but maybe does not have enough knowledge and shouldn’t totally be doing the project.

Network weaving should strategically match groups based on needs and capacities. However, the above quote should not overshadow the benefits of nonprofit partnerships. Another city/town participant said:

If we didn’t have these nonprofit groups stepping up to the plate, and they are really good at getting grant funding. … If it wasn’t for those groups we would have nothing going on here. … Nonprofits … have taken the lead, not the county.

While some smaller nonprofits lack the technical capacity for large restoration project, they could be instrumental in helping cities/towns overcome stagnant political will, a challenge voiced by some of the city/town participants above. Smaller nonprofits could also help with education campaigns and citizen monitoring. Collaborating with businesses might improve the link between restoration and development as discussed by city/town participant 17. While, network weaving should be guided by local knowledge of individual stakeholder needs, our participation analysis provides a coarse grained diagnostic that helps focus where more detailed study is needed for targeted interventions.

4.5. Critical reflection of the case study to inform social network approaches for studying governance siloes

In addition to illustrating network interventions, interview results allow us to reflect critically on how network diagnostics are applied to governance siloes. We constructed the network using the highest organizational level as our unit of analysis, such as the state department of ecology, or county public works. This was necessary for a consistent node unit based on the data we obtained in the survey and represents a common unit of analysis in NRG studies using SNA (Rathwell and Peterson, 2012; Bergsten et al., 2014; Kinimonth et al., 2015; Treml et al., 2015). However, using the organization as our unit has important implications for interpreting results and for conceptualizing governance networks.

Focusing on organizations may reduce participation values to modules containing large organizations and increases participation values to those containing small ones. Rather than a node having several edges to sub-units or programs of a large organization, these multiple edges are reduced to one. Aggregation may be more or less logical in different situations and poses a real challenge to SNA diagnostics. For example, one interview participant said they rarely interacted with another division of the state department that they worked for. They described it is “kind of a program unto itself.” Alternatively, a participant at a different state department described their program as “intertwined” with another. “We all work as a team,” they said.

At the conceptual level, the question of appropriate unit extends to the very notion of whether organizations or individuals should be the unit of study (Newig et al., 2010). Our interviews show how conceptualizing a “proper unit” can be quite blurry. For example, the right or wrong individuals can play a decisive role in networks creation, which would imply that individuals should be the focus of study:

You could spend a life just learning how to navigate it [government bureaucracy], and he has done an excellent job at doing that. And he has built relationships. … It has kind of been one of the cornerstones of how we approach restoration and it is one of the reasons I value staff who have been with us for a while. … I don’t go [into a] project without my guy who knows the [jurisdiction in question].

(Tribal participant)

We’ve had turnover …, complete turnover of our staff. Our old partners are kind of walking away from some of the new staff we have; they’re saying [to me], if you come work with us I will stay in this, but I am not working with that guy. He is just a pain in the butt.

(Federal participant)

[Those two people] have worked together quite a bit and it’s amazing how, I think, how far we have come in the last five years …. So sometimes, you know, it’s just getting the right individuals in the right spots from the right organizations, that can really; you got to get trust, right? And then pretty soon you’re working together. … I know these things are cliché, but it’s so true.

(Another participant)

Over the past year or so, we’ve had a major breakthrough with [that city]. … It is amazing what personnel changes can do for partnerships. The previous staff were very, sort of fearful of what that could mean for them, and the new folks are really committed to partnering. It has just completely transformed our relationship and what seems possible now.

(County participant)

Individuals are also fluid, moving from one organization to another, and take relationships with them.

People move around, too, from one organization to another, so we have this giant interconnected network of resource people …. That’s how we learn about a willing landowner or learn about a particular problem on a particular [river] reach. It’s that larger experience pool.

(Coordinate participant)
Even though we just [hired people], there is so much work to be done. And [several nonprofits are having] financial issues. And so they have seen their restoration staffs decline, whereas ours increased, but we cannot make up for all the other stuff. So really, there has been no net increase in the number of people who are able to do restoration work in the basin.

(Conservation district participant)

I worked with [the tribes] for [many years] before I came [here]. And so some of what we have done there is related to either the work we were doing there before, or just continued on because we have working relationships with people there.

(Federal participant)

However, while individuals may change, relationships may still be maintained among organizations.

We’ve been successful because we developed a really good partnership …. The tribe has been great to work with. … Unfortunately, their lead restoration planner … left. And that took some wind out of our sails …. But we have adjusted to that.

(State participant)

Lastly, organizations also have a character of their own that affects how individuals interact.

The political reality [is that our city] is a more property rights oriented place. And its leadership, Mayors and city council in the past, and I would say it’s still true, haven’t focused a whole lot on environmental issues generally, and so that has filtered down … to the staff level, …that’s created some tension at times between us and other cities and the county.

(City/town participant)

Every director has a focus, an interest. And you know, my background, my education is in natural resources or environmental studies. … I think country wide, the consciousness is growing …. but I think I brought in a natural resource kind of bend, I guess, to what we do.

(County participant)

We try, at least at my level, to get along really well with the tribal biologists, and doing [restoration] projects like that. But it is the upper, you know, management that are sometimes butting heads on issues. … So, there is a somewhat lack of consistency on where the county should be on some of these restoration issues. …. So, at our level, it’s just, you know, chug-along and try and get things when you can.

(County participant)

These quotes illustrate that both individuals and organizations are able to affect network structure and function. To date, the SNA for NRG research community has not addressed these complex interactions in a quantitative structural manner. A logical way forward would use multilevel network analysis where both the individual and the group are represented as nodes of different levels (Lomi et al., 2015; Bodin et al., 2016). Edges may exist within and among levels and interdependencies among levels are explicitly assumed (Lomi et al., 2015). Our results highlight the need for multilevel network analysis and for researchers to test how, where, and when individuals and organizations shape NRG processes and outcomes.

Attention to the units of analysis can also help explain certain differences in our findings as compared to other recent Puget Sound network analysis, which is important for contributing to a unified body of knowledge around governance networks. In a recent study about scientific collaborations in Puget Sound, Hoelting et al. (2014) found that academics made up the largest part of the network, at 34% (this includes researchers working on topics other than salmon; further details in appendix A). We found that educational organizations made up a small part of the network, both in number (2.4% of the network) and in terms of PM (i.e., an organization’s collaborations). In part, this difference is not surprising given that Hoelting et al. (2014) surveyed individual researchers, many of whom would work at one of the few universities in our study area. Differences in study foci (i.e., research vs planning and practice networks) may also explain some differences, but here we focus on how study units affect conclusions.

Simply writing off the differences between our study and Hoelting et al.’s (2014) as a units issue might overlook important patterns and possible network interventions. First, as noted above, comparing median CD and PM scores in our study illustrates that participation to universities and colleges could have been higher. There is a notable gap in the collaboration network that should not be dismissed as a units issue. Second, only one community college was nominated as a write-in response in our study, but there are others in the region. While academics at community colleges may be less involved in research and more involved in teaching than their university counterparts, teaching field courses could be integrated with activities such as citizen monitoring. These field courses could help address some of the monitoring challenges voiced by city/town participants.

While we found academics to be less prevalent in the network than Hoelting et al. (2014), our results confirm their conclusions about collaboration challenges between the applied and academic sectors. Our network consists largely of practitioner organizations, and as mentioned, there is a notable collaboration gap with academic institutions (Fig. 5, Table 3). Indeed, one of our study participants said:

[That academic] speaks a language that is really difficult to translate on the ground. That’s a huge impediment …. you can be all published and everything, but if it doesn’t result in a change on the ground it’s [participant pauses], you know what I mean? … There is a big disconnect between the academic community and the people that are doing the work.

(State participant)

However, another participant did comment that the universities were vital to their work.

[We are] trying to think a lot about and work with meteorologists and folks in the climate impacts group and others at the University of Washington for what [climate change] means for hydrology and the available supply of water. … We partner quite a lot with scientists from the [university].

(Public utility participant)

If universities play a vital role, as the second participant says, one possible explanation for their low prevalence in our data could be that people use academic research outputs (i.e., data, models, research reports, and articles) without considering the academic organizations producing these documents as direct
collaborators. Alternatively, there may be a genuine disconnect between academics and practitioners due to communication challenges and cultural differences as stated in the first quote. In that case, WB and Puget Sound may benefit from a focused study on how boundary organizations can best unite practitioners and academics.

A final consideration to properly interpret our data is the spatial arrangements of organizations in the network. Our participation analysis does not account for space, but space likely affects collaboration patterns. For example, PM scores from city/town to county are lower than those from county to city/town (Fig. 4, Table 3). Both cities/towns and counties are independent local jurisdictions. A city or town is likely to collaborate only with the county organizations of the county in which it resides, as well as those of a neighboring county in cases where a watershed is bisected by county lines. Collaborating with a neighboring county in the same watershed is important because an ecosystem based management approach requires collaborations to be organized around biophysical boundaries, not jurisdictional ones. Alternatively, a county organization would interact with the many cities within its borders and those of a neighboring county if they share a watershed. While the PM scores provide insight about sector and jurisdictional integration, future work must incorporate spatial arrangements. This challenge is not unique to our study. Cassidy and Barnes (2012) note a similar limitation when analyzing node level variables to understand household resilience in Botswana.

Spatial arrangements have rarely been incorporated into NRG studies using SNA. When they have, it has been to compare entire networks or small sub-networks (i.e., motifs or building blocks) (Bodin and Tengö, 2012; Gallemore and Munroe, 2013; Bergsten et al., 2014; Bodin et al., 2014; Sayles, 2015; Tremi et al., 2015). There is no standard method to incorporate spatial arrangements into node level metrics such as PM. When calculating PM, for example, the module specific and total edges of a node (i.e., $k_{mod}$ and $k_i$) would need to be spatially weighted. PM would depend on spatial modules relating to a spatially explicit network (e.g., depicting location in one or more watersheds), and organizational modules relating to an organizational network (e.g., depicting jurisdictions and public/private sectors). Such a spatially explicit PM metric could be developed using tools developed to analyze multiplex networks (De Domenico et al., 2013, 2015a; 2015b). Multiplex tools allow nodes to participate in different “networks,” called layers, which can be analyzed simultaneously without losing information often lost when aggregating different relationships. This approach would essentially overlay a collaboration and spatial proximity network to assess an integrated PM score. Participation metrics, however, have not been developed for multiplex networks and multiplex networks have yet to be assessed and analyzed in relation to NRG and social-ecological systems more generally.

Applying participation metrics ($P_i$ and $PM$) in a novel way and analyzing different relationships types in terms of perceived productivity advances our understanding of collaborative governance from a structural perspective. Simply “collaborating” may not be sufficient if, for example, the collaboration is mandated, but not funded or born from shared interest. The difference in perceived productivity between mandated relationships and those based on funding and shared interest is striking and has important consequences for success in NRG. This is novel evidence for the literature focused on structural patterns for NRG (i.e., SNA for NRG) and supports ideas developed in the wider commons and governance literature (e.g., Ostrom, 1990; Sabatier et al., 2005; Brondizio et al., 2009). Collaboration is not a silver bullet; how collaborations are established and evolve is a key factor to understand success and failure in NRG.

With this knowledge in mind, our participation analysis provides a coarse-grained assessment to improve NRG collaboration networks (Vance-Borland and Holley, 2011; Beilin et al., 2013; Mills et al., 2014). Integrating structural network and interview data shows how collaborations can be built to overcome challenges identified by study participants. Participation metrics provide another tool in the “network weaving” toolbox. However, there is still much work to be done. NRG research using SNA must strive to analyze how NRG network outcomes are shaped by 1) interactions among individuals and organizations as well as 2) spatial arrangements among organizations. To date, these issues have not found adequate space in the literature; but, recent methodological advances provide a promising outlook. Multilevel network methods may be one way to simultaneously evaluate the roles of individuals, organizations, and their interactions (Lomi et al., 2015; Bodin et al., 2016). Multiplex methods may lead to spatially weighted or mediated participation metrics (De Domenico et al., 2013, 2015a; 2015b). Unfortunately, these methods have yet to be developed for many NRG concerns such as assessing governance silos (however, see Guerrero et al. (2015) and Bodin et al. (2016) for other NRG applications). Future work that combines these recent advances in network theory with carefully collected empirical data to uncover relationships between structural properties of networks and measures of performance — whether social, such as productivity, or ecological, such as restoration outcomes — will advance natural resource management and sustainability science.

### Acknowledgements

We would like to thank B.L. Turner II, Dan Childers, Marco Janssen, Karina Benessahia, and members of the Center for Behavior, Institutions and the Environment at Arizona State University for their invaluable help and insight in preparing this manuscript. In particular, Karina’s help was above and beyond. Two anonymous reviewers also provided valuable comments and advice. Marina Alberti and the Urban Ecology Lab at the University of Washington provided instrumental support during field work. And it goes without saying that this research would not have been possible without the generous participation of the Puget Sound and Whidbey Basin restoration communities. Various aspects of this research were supported by research and travel grants from Arizona State University’s School of Geographical Sciences and Urban planning (Mathew Bailey and Melvin Marcus Scholarships), Graduate and Professional Student Association, and Graduate College, as well as NSF Grant GEO-1115054.
Appendix A

A.1. Supplemental results for PM scores and MRQAP regression

Fig. A.1. Lower quartile module-to-module participation (PM) scores among different group types in the salmon restoration network. Colors indicate PM score. Data should be read across in rows; for example, top row represents PM scores from cities/towns (CTT) to other organization types. When analyzing different relationships types, isolates were removed. \( N = 151, 119, 200, \) and \( 210 \) for funded, mandated, shared interest, and all respectively.

Fig. A.2. Upper quartile module-to-module participation (PM) scores among different group types in the salmon restoration network. Colors indicate PM score. Data should be read across in rows; for example, top row represents PM scores from cities/towns (CTT) to other organization types. When analyzing different relationships types, isolates were removed. \( N = 151, 119, 200, \) and \( 210 \) for funded, mandated, shared interest, and all respectively.
A.2. Interview guide consisting of questions and probes used in semi-structured interviews

The following text outlines the interview guide for the semi-structured interviews. Interviews were voice recorded and transcribed. Notes were also written during the interview itself. Questions were asked in sequential order to increase consistency across interviews and to ensure that questions were not skipped. However, participants were allowed to speak freely on a topic that was to be addressed later in the interview. Their response was

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Table A.1
MRQAP results for both maximum and minimum merge models (n = 210). The models show little difference. Therefore, the decision to merge responses to the program level by minimum or maximum has little effect on the results.

<table>
<thead>
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<th>Model name, fit, and significance</th>
<th>Variable</th>
<th>Unstandardized coefficient</th>
<th>Standardized coefficient</th>
<th>p-value</th>
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</tbody>
</table>

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Fig. A.3. Percent edge type among modules for all organizations in the network (n = 210). Bars depict the percentage of edges between two modules that are because of funding, mandated, or shared interest (left to right, and in dark, medium, and light grey, respectively). Bar height represents percentage of total edges. Collaboration types are not mutually exclusive; funding, mandates, and shared interests can each be 100% (i.e., top of box). Y-axis of each box has been ticked at 25, 50, and 75%. Abbreviations are listed in Table 2 of the main text. This figure shows similar and complementary information to Fig. 6 in the main text. Because the data are grouped as total percentage (as opposed to median PM score), the resulting data matrix is symmetrical (i.e., row and column i j = row and column j i). Therefore, only the upper half of the matrix is shown for clarity. Shared interests characterize most edges followed by funding. The high role of mandated edges between cities/towns and federal and state organizations is clearly visible in the top row.
recorded in the notes. When it came time to address the given question in the interview script, the participant was told that while they had provided information, the question was going to be asked to make sure that they did not have anything more to add. When and where appropriate, question phrasing was modified to match the participant’s organization and its role in restoration work (e.g., an organization that focused exclusively on restoration vs. more general natural resource management). All questions were open ended and allowed for specific lines of inquiry to be further investigated. Participants were often probed for specific examples. The interview guide was developed as part of a wider project (Sayles, 2015) and thus, only a subset of questions in the guide are directly relevant for this paper.

**Interview Guide**

Introduction: [Provide greetings and explain research] Through this research, I am trying to understand how restoration is coordinated and implemented in the Whidbey Basin, with specific attention to the roles that borders and collaborations play in these processes.

[Share/show map of WB to make sure participant understand geography of focal area. Discuss questions. In the case of phone interviews, confirm that they got map as email attachment and ask if they have questions.]

[In cases where a group is not focused specifically on restoration, modify phrasing of question. E.g., “what are your group’s natural resource management goals and how do they relate to restoration?”]

**Introduction and overview questions**

1. What are your group’s restoration goals? Please explain.
2. How long has your group worked in Whidbey Basin?
3. Does your organization see itself as part of a Whidbey Basin wide effort? Please explain.

**Specific questions about location and timing of activities**

4. Where does your group have jurisdiction? (Are there any habitat, or land-use restrictions on where you can work?) Please explain.
5. Would you describe your restoration efforts as opportunistic, or strategically planned? Please explain.
7. Why are [activities] carried out in these places? Can you list the factors that affects where you do projects/do restoration planning? [Ask for specific examples.]
8. Do jurisdictional boundaries affect where you do projects/planning? Please explain. [If relevant, ask for specific examples.]
9. Do jurisdictional boundaries affect how you do projects/planning? Please explain. [If relevant, ask for specific examples.]
10. What time frame does your group operate under? Do you have a long term plan? Do you have interim goals, or some other temporal deadline?

**Specific question about climate change, sea level rise, and population growth**

11. Do you consider climate change or sea level rise in your restoration planning? If so, do you use a specific projection?
12. Do you consider population growth [or demographic change] in your restoration planning? If so, do you use a specific projection?

**Specific question about limitations to doing restoration**

13. What limits your group’s ability to do restoration work? Please explain.

**Questions about the participant’s observations about governance processes**

Introduce topic: My final set of questions focuses on collaborations. Over the past years, there have been various efforts to create systems of collaboration among different groups in the Whidbey Basin.

14. What do you think, in general, about restoration coordination efforts in the Whidbey Basin?
15. Do the current coordination efforts help you meet your restoration goals? Please explain.
16. Do you think the current system of collaboration was made in a fair and just manner? Please explain.
17. Do you think the outcomes of these collaborations are fair and just? Please explain.
18. Do you partner because of specific projects, or do you do specific projects because of your partners? Please explain. [If relevant, ask for specific examples.]

**Concluding questions**

19. What would you like to see in the future of Whidbey Basin restoration?
20. What else do you think I should I know; is there anything that I perhaps did not think to ask?

**A.3. Further comparison to Hoelting et al. (2014)**

Hoelting et al. (2014) studied collaborations among individuals conducting research on a variety of nearshore restoration and recovery issues. While they limited their analysis of sectors and jurisdictions to percent representation in the network and used a slightly different classification, several informative direct comparisons can be made (Table A.2). Differences in academic representation are discussed in the main text. Other major differences include a smaller prevalence of federal and state organizations and larger prevalence of city/county and nonprofit organizations in our network. This may be a function of different units. State and federal organizations employ many individuals and combining these individuals into a single organization would lower state and federal prevalence in the network while increasing percent representation of other entities. While other explanations are possible such as study focus, sampling approach, and response rates (Table A.2), comparing these studies illustrates how network units may affect research conclusions.
Table A.2
Comparison to Hoelting et al. (2014).

<table>
<thead>
<tr>
<th>Organization type</th>
<th>Hoelting et al.’s (2014) study based on individuals</th>
<th>This study based on organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% nodes in network</td>
<td>% nodes in network</td>
</tr>
<tr>
<td>Academic</td>
<td>34%</td>
<td>2.4%†</td>
</tr>
<tr>
<td>Federal</td>
<td>23%</td>
<td>5.7%</td>
</tr>
<tr>
<td>State</td>
<td>16%</td>
<td>6.2%</td>
</tr>
<tr>
<td>City/County</td>
<td>5%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Tribe</td>
<td>6%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Nonprofit</td>
<td>6%</td>
<td>5.2%</td>
</tr>
<tr>
<td>Industry/small business</td>
<td>1.4%†</td>
<td>30.4%</td>
</tr>
<tr>
<td>Nonmatching categories between studies</td>
<td>7.1%†</td>
<td></td>
</tr>
<tr>
<td>Study focus</td>
<td>Nearshore research broadly defined (salmon is one of several Salmon restoration broadly defined foc)</td>
<td>WB watershed continuum from headwaters to nearshore</td>
</tr>
<tr>
<td>Geographic range</td>
<td>Puget Sound nearshore</td>
<td></td>
</tr>
<tr>
<td>Sampling</td>
<td>5 to 10 most frequent collaborators</td>
<td>All collaborators</td>
</tr>
<tr>
<td>Network size (nodes)</td>
<td>522</td>
<td>210</td>
</tr>
<tr>
<td>Survey response rate</td>
<td>65.2%</td>
<td>68.0%</td>
</tr>
<tr>
<td>Percent of network represented by survey respondents</td>
<td>48.5%</td>
<td>56.7%</td>
</tr>
</tbody>
</table>

Notes:
- † Includes 3 universities, 1 community college, 1 high school.
- ‡ Combines cities/town (17.6%) and counties (6.2%) to be consistent with Hoelting et al.
- § Industry (18) and small business (0.4%) were reported separately in Hoelting et al. and combined to match this study, which did not separate private sector based on size.
- ¶ Includes consultants (5%), Canadian researches (1.1%), public outreach and education (0.4%), interagency partnerships (0.4%), and funders (0.2%).
- © Includes special districts (11.4%), coordinating and watershed organizations (9.5%), citizen group organizations (5.7%), public utilities (1.9%), other (1.9%).

References


Kininmonth, S., Bergsten, A., Bodin, O., 2015. Clos[ing the collaborative gap: aligning social and ecological connectivity for better management of interconnected wetlands. AMBIO 44 (suppl. 1), S138–S148.


