



# Measuring, mapping and quantifying the effects of trust and informal communication on transboundary collaboration in the Great Lakes fisheries policy network

Andrew M. Song<sup>a,b,c,\*</sup>, Owen Temby<sup>d</sup>, Dongkyu Kim<sup>e</sup>, Angel Saavedra Cisneros<sup>f</sup>, Gordon M. Hickey<sup>a</sup>

<sup>a</sup> Sustainable Futures Research Laboratory, Department of Natural Resource Sciences, Faculty of Agricultural and Environmental Sciences, McGill University, Sainte-Anne-de-Bellevue, QC, Canada

<sup>b</sup> ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

<sup>c</sup> WorldFish, Honiara, Solomon Islands

<sup>d</sup> School of Earth, Environmental and Marine Sciences, The University of Texas Rio Grande Valley, Brownsville, TX, USA

<sup>e</sup> Department of Political Science, The University of Texas Rio Grande Valley, Edinburg, TX, USA

<sup>f</sup> St. Norbert College, De Pere, WI, USA



## ARTICLE INFO

### Keywords:

Ecosystem-based management  
Fisheries governance  
Policy network  
Public administration  
Canada  
USA

## ABSTRACT

Ecosystem-based management of fisheries and other transboundary natural resources require a number of organizations across jurisdictions to exchange knowledge, coordinate policy goals and engage in collaborative activities. Trust, as part of social capital, is considered a key mechanism facilitating the coordination of such inter-organizational policy networks. However, our understanding of multi-dimensional trust as a theoretical construct and an operational variable in environmental and natural resource management has remained largely untested. This paper presents an empirical assessment of trust and communication measures applied to the North American Great Lakes fisheries policy network. Using a scale-based method developed for this purpose, we quantify the prevalence of different dimensions of trust and in/formal communication in the network and their differentiated impacts on decision-making and goal consensus. Our analysis reveals that calculation-based 'rational trust' is important for aligning mutual goals, but relationship-based 'affinitive trust' is most significant for influencing decision-making. Informal communication was also found to be a strong predictor of how effectively formal communication will influence decision-making, confirming the "priming" role of informal interactions in formal inter-agency dealings. The results also show the buffering and interactive functions of these components in strengthening institutional resilience, with procedural trust undergirding the system to compensate for a lack of well-developed relationships. Overall, this study provides evidence to suggest that informal communication and multi-dimensional trust constitute a crucial element for improving collaboration and reducing conflict in the networked governance of transboundary natural resource systems.

## 1. Introduction

Governance of natural resources involves dealing with complex and emergent properties that necessitate management strategies capable of learning, anticipating, and adapting to change across scale. In the case of large-scale, transboundary resource issues such as the multi-party allocation and pollution of river-, lake- or ocean-based resources, sophisticated approaches to mutual coordination and collective action among diverse stakeholders are often required, including tactfully managed collaboration through knowledge sharing and the integration

of relevant information into decision-making (Olsson et al., 2008; Ruckelshaus et al., 2008; Berkes, 2012; Long et al., 2015). However, governments have had limited sustained success in addressing complex and transboundary environment and resource challenges, both within and across their jurisdictional boundaries (Cash and Moser, 2000; Munton, 2006; Burch, 2010; Harries and Penning-Roswell, 2011). Public policy networks have subsequently been developed and utilized in many natural resource systems based on recognition that the knowledge needed to inform decision-making is often highly fragmented within and across bureaucratic agencies, particularly when

\* Corresponding author at: ARC Centre of Excellence for Coral Reef Studies, James Cook University, 1 James Cook Drive, Townsville, QLD, 4811, Australia.  
E-mail addresses: [andrew.song@jcu.edu.au](mailto:andrew.song@jcu.edu.au), [andrewmsong@gmail.com](mailto:andrewmsong@gmail.com) (A.M. Song).

<https://doi.org/10.1016/j.gloenvcha.2018.11.001>

Received 9 May 2018; Received in revised form 25 October 2018; Accepted 4 November 2018

Available online 20 November 2018

0959-3780/ © 2018 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

regulatory jurisdiction is shared (Temby and Stoett, 2017). These networks generally enable agencies to better share and integrate specialized knowledge and develop institutional capacity in order to address what Rittel and Webber (1973) refer to as “wicked” problems of modern governance. Their membership tends to be overlapping among issue areas, with public agencies typically participating in networks on a wide range of topics (Isett et al., 2011).

Ecosystem-based management (EBM) is a mode of resource governance that embraces the functional need to build, manage, and maintain inter-organizational networks and improve coordination between participating entities (Imperial, 1999: 452). Substantial research has focused on understanding and resolving various organization and coordination challenges in different EBM network settings (e.g., Bodin and Crona, 2009; Brondizio et al., 2009; Rosen and Olsson, 2013; van Meerkerk et al., 2015), with an increasing recognition that trust can enhance the integrative performance of policy networks (Pretty, 2003; Agranoff, 2007; Ostrom, 2010; Edelenbos and van Meerkerk, 2015; Paul et al., 2016). For example, Stern and Baird (2015), noted that allowing for positive trust diversity (via fostering different types of trust) can help to support the institutional resilience of policy networks through functional redundancy. However, despite such recognition, the conceptualization and operationalization of trust has been variably and somewhat insufficiently applied in environmental and natural resource management contexts (see, for example, Davenport et al., 2007; Vaske et al., 2007; Stern, 2008; Smith et al., 2013; Turner et al., 2016; Song et al., 2017a). According to Klijn et al. (2010: 194), trust remains, overall, “a neglected issue in research on governance networks,” despite playing a potentially significant role in both their function and outcomes.

The North American Great Lakes fisheries system offers an important case where EBM has been institutionalized (GLFC (Great Lakes Fishery Commission), 2007; Minns, 2013; Jackson, 2015) and, crucially, because of the pre-existing history of inter-jurisdictional working relationships and inter-personal networks, it represents an instrumental case through which the varied functions of trust and communication can be analyzed. Initially shaped by the urgent need to address the Sea Lamprey (*Petromyzon marinus*) invasion into the Great Lakes Basin in the middle of the 20<sup>th</sup> century (Song et al., 2017b), the fisheries of the Great Lakes have long been governed by multiple entities, including individuals with different expertise and cultural backgrounds representing different institutions and jurisdictions, through policy networks that have relied on collegial and personal relationships for success (Leonard et al., 2011). As a result, a professional epistemic community has emerged in the Great Lakes fisheries policy network (Gaden et al., 2013), with networked governance evident in both domestic and transboundary policy and management (Karkkainen, 2006; Mulvaney et al., 2015). Using this backdrop, the aim of this paper is to empirically examine the differentiated extent and impact of trust and informal communication on policy coordination with a view to informing broader efforts to enhance the effectiveness and efficiency of transboundary policy networks. The following section supplies a theoretical rationale for the multi-dimensionality of trust and informal communication, which leads to our research questions. Next, the case study is described, followed by the methodology, which includes survey research using a psychometric scale designed to measure different dimensions of trust. The remaining sections present the results of our study followed by a discussion of the implications of our findings for understanding and improving inter-organizational coordination within transboundary policy networks.

## 2. Theoretical background: multi-dimensional trust and informal communication

Trust is a concept that has been extensively researched in sociology,

psychology, political science, economics and management (for an in-depth overview of the broader trust literature, see Rousseau et al., 1998; Nooteboom, 2002; Möllering et al., 2004). A considerable understanding of its multi-dimensionality (e.g., Lewis and Weigert, 1985; Khodyakov, 2007), antecedents (e.g., Mayer et al., 1995; McAllister, 1995; Nyhan, 2000) and stages of development (e.g., Zucker, 1986; Sydow, 1998; Lewicki et al., 2006) has made trust one of the main concepts utilized in social science research. However, trust has been less integrated into the study of natural resource and environmental management – an applied science field, where trust often underpins coordination, collective action and cooperation mechanisms (Adger, 2003; Ostrom and Ahn, 2003; Vaske et al., 2007). As a result, a more modest, yet arguably simplistic approach, using uni-dimensional constructions of trust has emerged in natural resources and environmental sciences involving questions such as: “how much trust do you have in X for doing Y?” Recognizing the limitations of this approach, Stern and Coleman (2015) identified four types of trust that are generally suited to the context of analyzing collaborative natural resource management: 1) *rational trust*, which is based on a calculative assessment of expected benefits and risks informed by the past history of performance and predictability; 2) *procedural trust*, which is about fairness and integrity of the procedures involved; 3) *affinitive trust*, which hinges on emotions, charisma, shared identities or feelings of benevolence developed often, but not exclusively, from longer-term interactions; and 4) *dispositional trust*, a relatively stable personality trait signaling one’s predisposition to trust another entity. These four types of trust highlight the need to take a multi-dimensional approach when trying to understand the role of trust. Despite recent efforts to quantify the role of different dimensions of trust in natural resource management settings (see, for example, Klijn et al., 2010; Smith et al., 2013; Temby et al., 2015), the extent and relative importance of different trust types to transboundary natural resource policy networks remain unexplored.

Policy networks are also communicative networks, since interaction among members is one of their defining traits. Yet, different forms of communication based on varying degrees of formality may have different effects on outcomes. Formal policy networks are “multi-actor arrangements explicitly constituted by public managers to produce and deliver public services” (Isett et al., 2011: i162), through mechanisms such as committee meetings, memos and official verbal or written communication. Previous studies on formal networks have shown that formal communication is conducive to well-coordinated outcomes (Provan and Milward, 1995; Isett and Provan, 2005). Informal communication, which can take place via email and phone calls, spontaneous meetings, chance conversations and drinks after work, have traditionally been understood as being less important policy network dimensions, yet are increasingly recognized as playing a key role in the existence of trust among network members (Temby et al., 2017). According to Ring and Van de Ven (1994), trust enables informal understandings and commitments to replace more specific reciprocity based on one’s officially prescribed organizational role. As a result, trust and informal communication may provide an important bridge between latent and realized governing capacity by encouraging coordination, information exchange and learning. However, there is limited empirical evidence available on the relationships between formal and informal communication, different trust types and coordination outcomes in transboundary policy networks, particularly in the context of environmental and natural resource management. Building on a set of nascent studies undertaken to explore how inter-organizational/agency collaboration is shaped and enhanced by trust dimensions and informal communication (e.g., Temby et al., 2017; Coleman and Stern, 2018), this paper seeks to address this knowledge gap by addressing the following questions: 1) Which dimensions of trust (independent variables) are more important or dominant than others in influencing co-ordinated decision-making and goal-consensus (dependent variables) in

a transboundary policy network? and 2) To what extent does informal communication (independent variable) affect coordination (dependent variable)?

### 3. Case study: North American Great Lakes fisheries

The Great Lakes fishery has long suffered from depletion, extinction and substitution of native species brought by land-based pollution, overfishing, as well as the introduction of non-native species (McCrimmon, 2002; Hudson and Ziegler, 2014). The main target species in the region have included Yellow Perch, White Perch, Rainbow Smelt, Walleye, Cisco, Lake Whitefish, Lake Trout and chubs. Commercial fishing, which is now dominated by Yellow Perch, has been generally declining, while recreational fishing has grown to become an economically significant industry, with its annual net value estimated to be as high as 1.47 billion USD (Poe et al., 2013; Hudson and Ziegler, 2014). Since the 1960s, aboriginal fisheries have also been an important policy actor as their fishing rights have become reaffirmed through a series of landmark court decisions in both Canada and the United States (Brenden et al., 2013; Lowitt et al., 2018).

Forming a transboundary basin, four of the five Great Lakes are bisected by the international border (Lakes Superior, Huron, Erie and Ontario, with Lake Michigan entirely within the United States). In addition to the oversight of federal fisheries agencies, within each lake, there are state and provincial governments, along with inter-tribal organizations in some cases, who apply management authority in their apportioned waters through establishing and enforcing harvest regulations, issuing fishing licenses, stocking fish, and implementing habitat restoration plans (Gaden et al., 2013). Overall, the Great Lakes are a complex mosaic of over 650 jurisdictional units encompassing all scales from municipal to supra-national (McCrimmon, 2002). Addressing many issues facing the fishery in the basin requires an EBM approach predicated on inter-organizational, inter-jurisdictional coordination and collaboration. For instance, the policy response to the Sea Lamprey invasion that decimated the Lake Trout fishery by the late 1940s exemplifies a case of successful transboundary coordination, which also saw the formation of an influential binational organization, the Great Lakes Fishery Commission [GLFC] in 1954 (Gaden et al., 2013). Similarly, water quality is approached as a regionally integrated issue through the cross-border negotiations of the 1972 Great Lakes Water Quality Agreement (most recently amended in 2012) (Grover and Krantzberg, 2015). Such examples have contributed to the Great Lakes becoming a model site of EBM (Gaden et al., 2008; Minns, 2013; Grover and Krantzberg, 2015). As several recent studies have also identified (e.g., Leonard et al., 2011; Kalafatis et al., 2015; Mulvaney et al., 2015; Song et al., 2016), the Great Lakes system has become a popular and fitting “living laboratory” for studying how inter-organizational networks can address complex environment and natural resource-related issues, including fisheries.

## 4. Methodology

### 4.1. Scale approach to measuring networked trust

We employed a scale approach to measure trust in the Great Lakes fisheries policy network using survey research (see Rotter, 1967; Cummings and Bromiley, 1996; Song et al., 2017a). Trust was considered a latent construct, represented by Likert-scale type items that formed measurable (i.e., observed) variables. Once the psychometric properties of the scale were validated (see Furr, 2011), survey responses served as a proxy representation of quantified trust, which could then be used for comparison among groups and subjected to further analyses to test its effects on dependent variables. Despite the many variations in the trust scales that have been developed (e.g., Dietz and Den Hartog, 2006; Lewicki et al., 2006; Seppänen et al., 2007; Möllering et al., 2004; McEvily and Tortoriello, 2011), there has been surprisingly little

repeat-use of the same instrument. Diverse theoretical assumptions associated with multi-disciplinary interests in trust have led to varying operational interpretations and outlooks. Trust is also context-dependent, which only becomes meaningful when the specific characteristics of trustors and trustees are explicitly stated and accounted for (Rousseau et al., 1998; Kramer, 1999; Hardin, 2002). It follows that trust measurement is typically too idiosyncratic to enable generalizations to other contexts beyond which it was developed (Lewicki et al., 2006; Möllering et al., 2004; Seppänen et al., 2007; McEvily and Tortoriello, 2011).

Our approach to measuring and analyzing trust using a scale approach is novel in at least two aspects (see Temby et al., 2015, 2017; Song et al., 2017a,b for more details on scale construction and past applications). First, it focuses on the network context, meaning that the scale is concerned with assessing not only the specific trust relations between pairs of entities, but also seeing how these paired relations would connect with each other to form an overall distributed pattern. Existing trust scales have generally been limited to measuring one-to-one dyadic trust (see, for example, Rempel et al., 1985; McAllister, 1995; Cummings and Bromiley, 1996; Nyhan and Marlowe, 1997; Nyhan, 2000; Lambright et al., 2010) which results in a narrower, more focused relation (e.g., between a resource user and a government officer, between a practitioner and a professional network as a whole, or between a community group and the government). Subsequently, these scales are not designed to target a large number of actor groups operating within a transboundary policy network. Second, our scale incorporates the multi-dimensionality of trust (as recommended by Lewis and Weigert, 1985; McEvily and Tortoriello, 2011) in order to differentiate between types of trust and their varying impacts on coordination and collaboration, going beyond the more simplistic uni-dimensional representations of trust or directly questioning “whether one trusts another”.

### 4.2. Inter-agency trust scale and survey design

Our inter-agency trust scale was originally adapted from Nooteboom et al.’s (1997) survey, intended for measuring inter-firm trust in private sector alliances and validated for use in public policy networks (see Song et al., 2017a,b for full details). We further operationalized the typology of Stern and Coleman (2015), as well as other relevant work, to account for the four trust dimensions (affinitive, procedural, rational and dispositional) (see Table 1). Applying it to the public sector, we first identified a list of relevant public agencies that formed the broadly-defined Great Lakes fisheries policy network, i.e., those with a role in the management and science of the fisheries, directly or indirectly. Totalling 45, they included binational organizations such as the International Joint Commission and the Great Lakes Fishery Commission, tribal organizations such as the Great Lakes Indian Fish and Wildlife Commission, federal agencies such as Fisheries and Oceans Canada, Natural Resources Canada, the U.S. Geological Survey and the U.S. Fish and Wildlife Service, and sub-national entities at the province/state level including the Ontario Ministry of Environment and Climate Change and the Michigan Department of Natural Resources (see Supplementary material Table S.1 for a full agency list). The survey begins by asking respondents to select an agency to which s/he belongs from the list and then asking to select all the agencies that they communicate with formally and informally in their professional role. This communicative history forms an essential basis for establishing a “working relationship,” however banal or sporadic. The respondents were then prompted to complete the trust-related questions (i.e., trust scale items) for all the relationships they specified in the previous step. Because a respondent is answering the questions for the several agencies listed in the survey, the survey generates information on one-to-many trust relations. By collating all responses, this survey design permits capturing the shape and extent of trust distributions across a group of organizations, in addition to being able to separate the level of

**Table 1**  
Question items that measure four trust dimensions (note the use of the same identifier in Fig. 3).

Identifier	Scale items	Corresponding trust dimension	Key references in developing the items
ATrust1	Because we have been working with this organization for so long, all kinds of procedures have become self-evident	Affinitive trust	Nootboom et al., 1997
ATrust2	In our relationship with this organization, informal agreements have the same significance as formal contracts		
ATrust3	Because we have been working with this organization for so long, we can understand each other well and quickly		
PTrust4	In our relationship with this organization, the strongest side is expected not to pursue its interest at all costs	Procedural trust	Nootboom et al., 1997
PTrust5	In our experiences with this organization, we have never had the feeling of being misled		
PTrust6	In our relationship with this organization, both sides are expected not to make demands that can seriously damage the interests of the other		
RTrust7	This organization can be relied upon to perform its objectives	Rational trust	Dietz and Den Hartog, 2006
RTrust8	In our relationship with this organization, both sides treat each other in a consistent and predictable manner		
RTrust9	Working with this organization can contribute to our agency's success		
	<i>Non-scale items</i>		
DTrust10	You can't be too careful dealing with people	Dispositional trust (not part of the trust scale)	Smith et al., 2013; Hamm et al., 2013
DTrust11	People are almost always interested only in their own welfare		
DTrust12	Most people would try to take advantage of you if they got the chance		

trust for each dyadic relationship (see Supplementary material Table S.2 for all survey questions).

The trust scale used in this study consisted of nine items designed to operationalize affinitive, procedural and rational trust. As shown in Table 1, items ATrust1, 2 and 3 together represent *affinitive trust* by eliciting the informal and characteristic-based aspects of relationships such as familiarity and shared experiences. These items deliberately focus on longer-term interactions as a basis of affinitive trust. This is due to our focus on inter-agency collaboration in the public sector, where professional interactions tend to begin through formal processes, following bureaucratic lines of hierarchy and accountability. Shorter-term and inter-personal intuitions that can hinge on charisma, likability or impressionistic assumptions of similar values/identity were therefore not included in our measures of affinitive trust in this study. Items PTrust4, 5 and 6 characterize *procedural trust*, as they pertain to process-based notions such as integrity, fairness and perception of equity and justice. For *rational trust*, we hypothesized that Items RTrust7, 8 and 9 would comprise the “instrumental” dimension of trust based on calculated risks and expectations of performance and utility. *Dispositional trust* was operationalized as a personality trait rather than a relational attribute, with the three items therefore separated from the scale questions in the survey. All items were measured on a five-point Likert scale (i.e., strongly agree to strongly disagree). As a final step, the survey solicited qualitative information in the form of an open-ended question asking respondents' additional observations, insights and opinions on the topic.

#### 4.3. Data collection

The survey was conducted using an open-source online tool (Limesurvey) between October and November 2015. The survey broadly targeted civil servants working on fish and fisheries-related issues in the Great Lakes who were formally affiliated with binational organizations, federal or state/provincial government agencies in Canada and the United States. The names and email addresses of key individuals within these organizations were identified from publicly accessible government reports and online documentation. We paid special attention to their professional titles, whenever such information was available, in order to increase the potential relevance of the survey to those solicited for participation. For instance, middle-level managers or researchers were typically selected over administrative staff or junior lab technicians for the former's presumed greater networking impetus in their prescribed role. This involved a largely intuitive and manual

inspection process. Potential respondents were then contacted via email to introduce the study and were provided with the online survey instrument's web-based URL. In total, 2086 email addresses were compiled to form a non-randomized convenience sample, resulting in 226 completed surveys. Because defining a governance network by identifying all relevant civil servants was less than perfect (in fact, estimating the contours and the density of a network is typically one of the major aims of network analysis, including this study), and also because the completion of the survey relied on respondents' voluntary participation, the survey was designed without pre-set quotas or strata of respondents. All responses were anonymous with no names or other identifiable information collected other than professional affiliation. There were 13 jurisdictional categories used in the analysis: U.S. federal, Canadian federal, eight Great Lakes states, Ontario (province), binational organizations and tribal authorities. Civil servants from all 13 jurisdictions participated in the survey, with wide variation in the number of generated responses (Fig. 1[a]). Survey respondents had a diverse range of years of experiences and professional roles in the transboundary policy network (Fig. 1[b–c]).

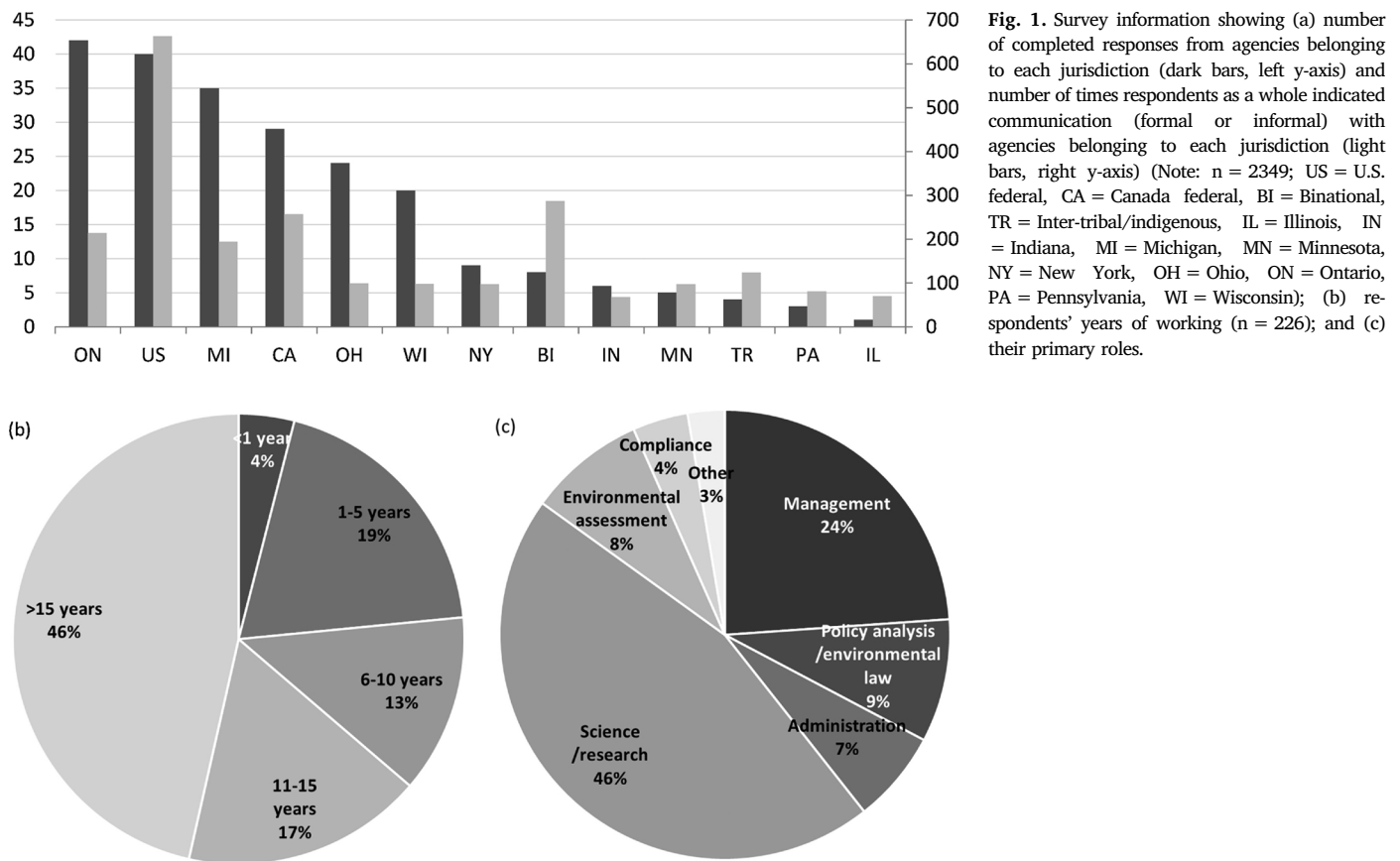
#### 5. Analyses and results

We present our analysis of the survey data in four sequential steps. First, self-reported communication practices among respondents from various Great Lakes fishery jurisdictions were quantified and visualized to illustrate the prevalence and spatial patterns of both informal and formal communication. The subsequent two steps focus on trust-specific insights – first validating the trust scale and confirming trust dimensionality and then displaying the inter-jurisdictional and multi-dimensional trust patterns reported by respondents. The final step brings the communication and trust components together into a hierarchical regression analysis to measure their varied and interactive effects on goal consensus and coordinated decision-making.

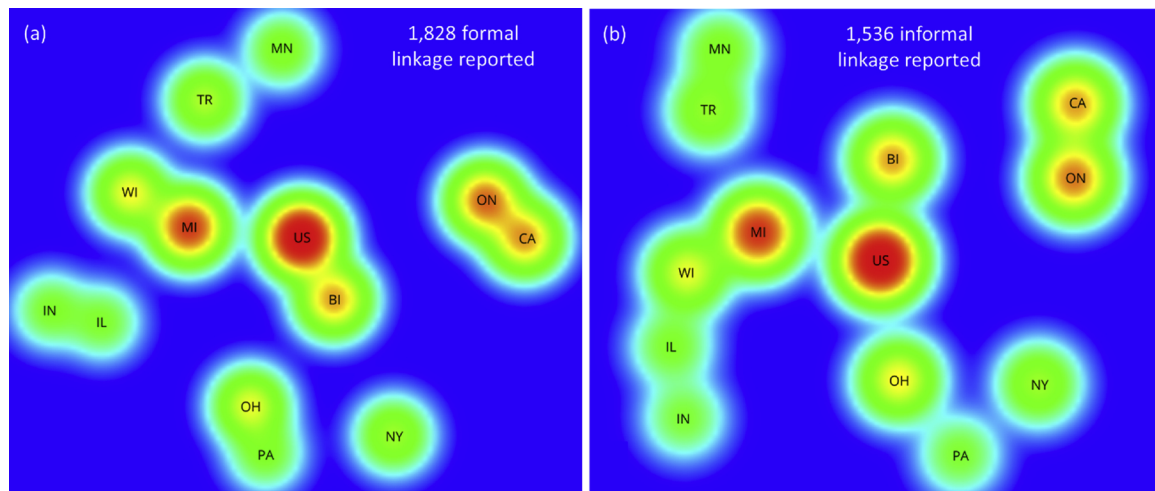
##### 5.1. Communication patterns among the Great Lakes jurisdictions

The frequency of formal communication indicated by each respondent (i.e., 2 = regularly, 1 = occasionally, 0 = never) was tallied. For the 226 civil servants who participated in our survey, a total of 1828 formal communication linkages were reported, 19% greater than the number of informal communication linkages (1536). When the linkages were weighted by each reported frequency (1 = occasionally; 2 = regularly), the occurrence of formal communication over informal





**Fig. 1.** Survey information showing (a) number of completed responses from agencies belonging to each jurisdiction (dark bars, left y-axis) and number of times respondents as a whole indicated communication (formal or informal) with agencies belonging to each jurisdiction (light bars, right y-axis) (Note:  $n = 2349$ ; US = U.S. federal, CA = Canada federal, BI = Binational, TR = Inter-tribal/indigenous, IL = Illinois, IN = Indiana, MI = Michigan, MN = Minnesota, NY = New York, OH = Ohio, ON = Ontario, PA = Pennsylvania, WI = Wisconsin); (b) respondents' years of working ( $n = 226$ ); and (c) their primary roles.



**Fig. 2.** Density visualization of inter-jurisdictional communicative networks for the Great Lakes fisheries – (a) formal communication; (b) informal communication (Visualization tool: VOSviewer 1.6.0).

communication increased by 32% (weighted tally of 2571 and 1,944, respectively), indicating a comparative prevalence of formal communication in the transboundary fishery policy network.

To help analyze the distribution of communication, both the agencies with which each respondent was affiliated and with which she communicated were noted and classified according to the jurisdiction to which the agencies belong. Having included 13 jurisdictions in the study meant that a  $13 \times 13$  adjacency matrix was used to create the inter-jurisdictional communication network (i.e., 13 nodes). The same process was repeated for informal communication generating a second adjacency matrix. Fig. 2 presents the network distribution of inter-jurisdictional communication in the form of density visualization using

VOSviewer 1.6.0 (note: inter-organizational data were grouped as inter-jurisdictional). Node colour denotes the level of inter-jurisdictional communication reported for each jurisdiction (i.e., the redder the colour, the greater number of weighted communication linkages each jurisdiction is associated with other jurisdictions). The distance between nodes indicates the intensity of communication, such that closely located nodes imply a higher frequency of communication between them, proportionally speaking. As suggested by the node colour, the patterns for both formal and informal communication reported by respondents highlight a high degree of inter-jurisdictional communication occurring at the U.S. federal level and in the state of Michigan (e.g., 803 and 515 reported instances of formal communication linkages,

respectively), followed by the agencies representing Ontario (406) and Canada federal (369), and binational organizations (349). The centrality of the U.S. federal and Michigan agencies in the reported communication network is represented by their spatially focal position in relation to other jurisdictions in Fig. 2. For our respondents, it appears that the binational agencies (e.g., GLFC), U.S. federal and Michigan appeared to play the role of “hub” or “broker” through which inter-jurisdictional, inter-agency communication was carried out. By contrast, the positions of the Canadian federal and Ontario agencies were reported to be less central despite their role in managing four of the five Great Lakes. Interestingly, the overall patterns of communication reported by survey respondents closely mimic the geographical layout of the region itself, with adjacent jurisdictions shown to communicate most frequently with each other. The reported patterns of formal and informal communication, and the importance of these to policy network coordination, were further contextualized by the comments provided by respondents as part of the survey:

*“There is an increased sense of respect and mutual professionalism that usually increases the communication and the value of each communication. Informal and formal are both necessary to facilitate my role here and cooperation with other agencies is essential.”* Ontario Ministry of Natural Resources and Forestry

*“Understanding your own mandate and the mandated requirements of other agencies and their staff makes inter-agency interactions easier and often allows everyone to get the necessary information/work done in a more collegial manner.”* Environment Canada

## 5.2. Scale validation establishing trust dimensions

Before analyzing the trust data, it was first necessary to verify, *a priori*, the theoretical postulation used to structure our 9-item trust scale. Structural equation modelling (SEM) was employed, which takes a confirmatory approach to factor analysis and also allows an estimation of measurement errors in observed variables. Coinciding with the number of items, input for the model consisted of a  $9 \times 9$  variance-covariance matrix. These relationships were then converted into structural equations. We ran a structural model estimating both the loadings and the goodness of fit for the proposed model. To enable estimation, we constrained one loading of an observed variable for each latent construct. This means that the loading for the constrained observed item will be 1 and the other items for each latent construct are free to vary. Covariances between the different trust dimensions were also estimated. This setup places very few restrictions on the data and allows for the estimation of the parameters of interest while still being over-identified. In addition to the standard goodness of fit measures for the proposed structural equation, Root Mean Squared Error of

Approximation (RMSEA), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI) and Chronbach’s Alpha were calculated to verify internal consistency.

The results of SEM depicted the linkages among the observed and latent constructs, graphically represented in Fig. 3. All of the observed variables loaded significantly on the proposed latent constructs ( $p < .05$ ). The covariance between the three trust types is positive and also significant at the  $p < .05$  level despite being fairly small ( $\Phi_{AT,PT} = 0.13$ ,  $\Phi_{AT,RT} = 0.21$ ,  $\Phi_{PT,RT} = 0.16$ ) (see Supplementary material Table S.3 for full SEM results).

While the structural equation model explored a specific structure for our scale, the Cronbach’s Alpha coefficient provides insight on the overall scale properties. The resulting coefficient of 0.799 suggests that, as a single construct, the scale is quite robust. The coefficients for each dimension of trust (affinitive, procedural and rational) also produced acceptable numbers: 0.742, 0.634 and 0.687, respectively. We posit inter-organizational trust as a second-order or macro-level construct of trust composed of three first-order factors – affinitive, procedural and rational trust, which are positively and significantly correlated. The SEM results support this interpretation as the best model.

Next, the results for three practical fit indices, RMSEA, CFI and TLI, indicate the model’s goodness of fit. As a rule of thumb, given our relatively small sample sizes for SEM, we propose that a RMSEA fit smaller than the cut-off value of 0.10 is acceptable, while  $RMSEA < 0.05$  would indicate a well-fitting model (Browne and Cudeck, 1993; see also Hu and Bentler, 1999). We also aver that CFI and TLI values around 0.95 or higher provide relative assurance that our model is a good fit for the observed data. This specification of the model returned reasonably acceptable goodness of fit measures ( $CFI = 0.937$ ,  $RMSEA = 0.081$ ,  $TLI = 0.905$ ), suggesting that the observed variables are satisfactory to use in the structural model and that the trust scale composed of the proposed sets of three dimensional items is sufficiently reliable and internally consistent.

## 5.3. Trust patterns among the Great Lakes jurisdictions

The following procedures were applied to the Likert-scale scores of the nine trust questions to descriptively assess and display the prevalence of the rational, procedural and affinitive trust types among the responding members of the Great Lakes fisheries policy network. The trust scores of a respondent for each of his/her target agencies were first grouped according to the jurisdiction to which the agencies belong. These jurisdictionally grouped scores were then averaged so that each respondent had three trust dimension scores assigned to them for each target jurisdiction. Next, these respondent-specific scores on each target jurisdiction were categorized by the home jurisdiction of the respondent and averaged. This step produced trust scores to and from

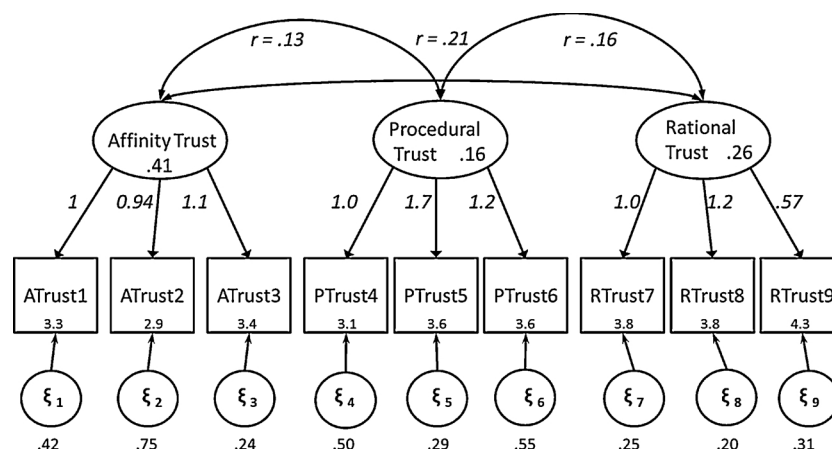


Fig. 3. Structural equation model showing standardized parameter estimates.

**Table 2**  
Results of the Friedman test for finding differences between trust dimensions (N = 226).

Trust dimension	Mean	Std. deviation	Mean rank	Test statistics	
Rational trust	2.071	0.4542	1.20	Chi-square	246.3
Procedural trust	2.568	0.5417	2.19	Df	2
Affinitive trust	2.856	0.6108	2.61	p-value	0.000

each jurisdiction. These scores were standardized to a -1 to 1 scale, such that 1 implies all respondents for a particular pair of home and target jurisdictions “Strongly Agreeing” to trust items (i.e., high trust), while -1 would imply a unanimous survey response of “Strongly Disagree” to indicate a lack of trust. In conjunction with the above procedures, the Friedman test was used to confirm the statistical independence of the three trust dimensions.

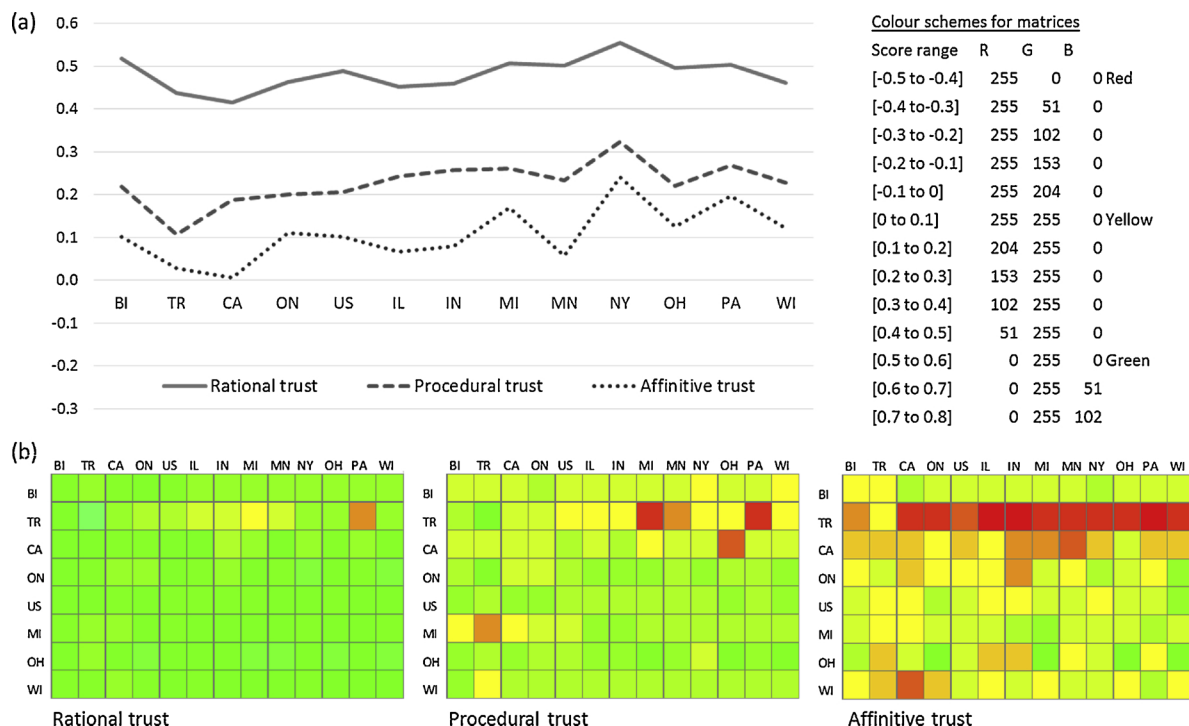
The results of the Friedman test, based on the averaged item scores of the respondents, showed that the three dimensions of trust belong to significantly different response groups, reaffirming their conceptual distinction (Table 2). Fig. 4 summarizes the distribution of trust reported by civil servants among the jurisdictions comprising the Great Lakes fisheries policy network. Fig. 4(a) reveals an overall positive pattern of trust in the policy network for all three trust types. *Rational trust* was consistently found to be the most prevalent type, while *Affinitive trust* was the weakest type reported among the groups. Fig. 4(b) presents disaggregated results in matrix form, revealing one-to-one trust relations (limited here to the seven jurisdictions that together accounted for 84% of survey responses, plus the tribal authorities, for emphasis). Notably, the communication patterns reported with tribal authorities (TR) exhibited an acute lack of *affinitive trust* towards the state and federal agencies in their professional working relationships (i.e., red and near-red).

#### 5.4. Impact of trust and communication on goal consensus and coordinated decision-making

##### 5.4.1. Model description

This final and most substantive step of the analysis measures the predictive effects of trust on the respondent’s communication-mediated decision-making. More specifically, the two dependent variables were the degree to which inter-organizational communication – formal and informal – had led the respondent to make professional decisions they would not have otherwise made (survey question 2.3 and 2.5 in Supplementary material Table S.2). A third dependent variable was targeted at determining which trust variables are most associated with predicting goal consensus in the network (survey question 3.10). It is envisaged that trust can reduce uncertainty in collective decision-making and enable agencies to engage in cooperative behaviors towards shared goals and conflict reduction (Hardy et al., 1998; Gray et al., 2012). Three distinct hierarchical regression models were constructed (one for each dependent variable), namely: (1) impact of informal channel communications with specific target agencies on the participant’s decision-making; (2) impact of formal channel communications with specific target agencies on the participant’s decision-making; and (3) impact on goal consensus with specific target agencies.

To investigate the synergistic effects of trust with formal and informal modes of communication, our models included two-way interaction terms. These enabled the analysis to determine whether communication type and trust interact for additive or subtractive effects on decision-making. Most relevantly, they enabled an unravelling of the effects of informal communication and trust that are often conflated (see Isett et al., 2011) to see if they operate as master variables insofar as they partially determine the effects of other variables in addition to exhibiting an independent effect. Following the recommendations by Cohen et al. (2003), a centering technique (i.e., subtracting the mean of the estimator from each participant’s score) was first applied on variables involved in the interaction. Then, the resulting centered variables were multiplied to generate interaction terms. Eight interaction terms



**Fig. 4.** (a) Average rating of each trust dimension towards target jurisdictions comprising the Great Lakes fisheries policy network; (b) the degree of the three trust dimensions dyadically described between the eight most notable “home” jurisdictions (rows) and all 13 “target” jurisdictions (columns). Rating and colour coding are both based on normalized scores.

**Table 3**  
Summary of the hierarchical regression predictor sets and the order in which they entered each of the three regression models.

Predictor Sets (Independent variable otherwise noted)	Models (# = order in which it enters)		Logic for Ordering of Predictor Set
	(a) Impact of Informal Communication	(b) Impact of Formal Communication	(c) Goal Consensus
Participant Agency Jurisdiction (5 dummy-coded variables <sup>1</sup> )	1	1	Codes the most general way of classifying survey participants by jurisdiction of agency they work for, irrespective of target agency they relate to.
Dispositional Trust (DT)	2	2	Reflects “the general tendency or predisposition of an individual to trust or distrust another entity in a particular context” (Stern and Coleman, 2015: 122). Based on innate tendencies or personal histories.
Criterion-scaled Participants predictor	3	3	Codes individual participants to control for individual differences in rating relationships with individual agencies.
Target Agency Jurisdiction (5 dummy-coded variables <sup>1</sup> )	4	4	Codes the jurisdiction of the specific agency that is a target for trust development and communications for an individual participant.
Frequency of Informal Communication (FI)	5	5	Assesses how frequently the individual participant informally communicates with a specific target agency – an antecedent of trust (Edelenbos and Van Meerkerk, 2015).
Rational Trust component (RT)	6	6	Based on “evaluations of information about the prior performance of [the target agency] and the subsequent predictability and assessment of likely outcomes” (Stern and Coleman, 2015: 122). Transactional, based on perceived utility.
Procedural Trust component (PT)	7	7	Assesses trust in the procedures underpinning a relationship with a specific target agency that decrease vulnerability of the trustor. Presumably a precursor to building an inter-agency relationship (see Shapiro et al., 1992). In our formulation, based on assessments of fairness in past experiences with the target agency.
Affirmative Trust component (AT)	8	8	Assesses the level of affirmative trust associated with a specific target agency, effectively built up over a duration and “based primarily on the emotions and associated judgments resulting from either cognitive or subconscious assessments of the qualities of the potential trustee (Stern and Coleman, 2015: 122).
Trust Component Interactions 1 (FI*DT, FI*PT, FI*RT, and FI*AT)	9	9	2-way interactions between trust components and frequency of informal communication, entered after the relevant main effects have been accounted for.
Impact of Informal Communication (II)	Dependent variable	10	Assesses the impact of informal communication on individual participant’s own choices and decision-making, after trust has been established and frequency of informal communication has been accounted for.
Frequency of Formal Communication (FF)	–	11	Given trust levels and informal communication frequency and impact have been accounted for, assesses how frequently the individual participant formally communicates with a specific target agency.
Trust Component Interactions 2 (FF*DT, FF*PT, FF*RT, and RC*FF)	–	12	2-way interactions between trust components and frequency of formal communication, entered after the relevant main effects have been accounted for.
Impact of Formal Communication (IF)	–	Dependent variable	Assesses the impact of formal communication on individual participant’s own choices and decision-making, after trust has been established, after informal communications have been accounted for, and frequency of formal communication has been accounted for.
Goal Consensus	–	–	Assesses the impact of all types of trust and both informal and formal communication on inter-agency goal alignment.

<sup>1</sup>Binational, Canada Federal, Canada Ontario, U.S. Federal and U.S. State.



were created for incorporation into hierarchical regression models (see Table 3).

The survey's hierarchical design, in which respondents were invited to score multiple agencies on several questions, introduced a repeated measures property to the data. Controlling for this in the regression analysis would have required 225 dummy variables, an untenable analytical strategy. Instead, we used criterion scaling, an alternative approach for encoding predictors with a large number of categories when analyzing data with repeated measures designs (see Pedhazur, 1977; Gibbons and Sherwood, 1985). By using the participant's mean score on the dependent variable as the predictor value for all target agencies she rated, each individual participant in a single predictor was effectively identified (for an application of criterion scaling with similarly structured data, see Temby et al., 2017).

For ease of incorporation into analyses and interpretation, both participant and target agencies were aggregated into six groups: (1) Binational agencies, (2) Canada Federal agencies, (3) Canada Ontario agencies, (4) U.S. Federal agencies, (5) U.S. State agencies, and (6) Inter-Tribal authorities. These aggregated Participant and Target agency categories were then dummy-coded for use as regression predictors, in each case using Inter-Tribal authorities as the reference category. This process yielded five dummy-coded predictors for Participant agencies and five for Target agencies.

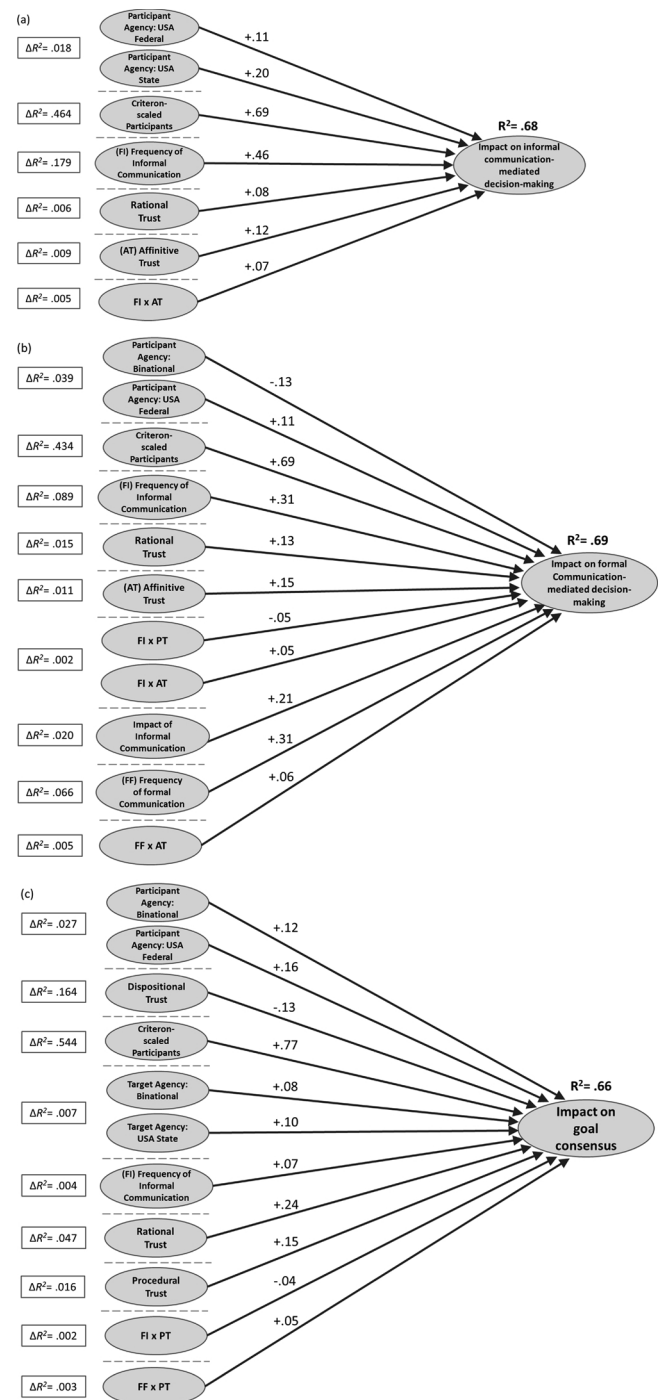
Predictor sets were defined and entered into each hierarchical regression model in a pre-determined order using the following general logic: (1) control variables, (2) independent variables, and (3) interactions, which were entered after all their constituent main effects had been entered and accounted for. The specific order and rationale for each predictor set are listed in Table 3.

#### 5.4.2. Model results

Fig. 5 presents a summary of the significant results from the three hierarchical regression models (see Supplementary material Table S.4 for full model summary tables and predictor-specific coefficients). The arrowheads point to the dependent variable in each regression model and the overall  $R^2$  associated with each model is shown in bold. The strength and direction of each relationship is shown by the standardized regression coefficient attached to each predictor-dependent variable link; all coefficients shown are significant at  $p < .01$ . The order of set entry is presented down the left side of the figure.

Fig. 5(a) presents the impact of predictor variables on the ability of informal communication to influence decision-making in the policy network. After controlling for participant jurisdiction and the criterion scaled predictor, three independent variables had a significant effect on inter-agency influence. The frequency of informal communication had a substantial effect on influence through informal communicative channels. Rational trust and affiliative trust both displayed significant effects, with the latter having the largest effect. Procedural trust did not exhibit an effect. One interaction variable (FI x AT) was found significant: with the increase in the frequency of informal communication, the impact of affiliative trust on decision-making through informal communication significantly increases. The entire regression model predicted about 68% of the variability in the impact of informal communication on decision-making.

Fig. 5(b) presents the significant results of the hierarchical regression analysis predicting the impact of trust and formal and informal communication on the ability of formal communication to influence the coordinated decision-making among network members. After controlling for participant jurisdiction and the criterion-scaled predictor, five independent variables had a significant effect on inter-agency influence. The results were similar to those of the previous model. Higher frequency of informal communication predicted greater impact of formal communication on coordinated decision-making. Again, higher levels of rational trust and affiliative trust were shown to predict a greater impact of formal communication on coordinated decision-making, with affiliative trust having a stronger effect. We also observed



**Fig. 5.** Summary of significant hierarchical regression relationships for predicting impact on (a) informal communication-mediated decision-making (b) formal communication-mediated decision-making; and (c) goal consensus. The hierarchical predictor sets are separated by short dotted lines and the change in  $R^2$  associated with the addition of that predictor set to each regression model is shown in solid-line boxes. Note:  $N = 226$  respondents;  $n = 2349$  Target Agency ratings; contribution of predictor set shown as  $\Delta R^2$ ; path coefficients are standardized regression coefficients; only significant ( $p < .01$ ) relationships are shown.

an effect of the dependent variable of our prior model (informal communicative impact) on the impact of formal communication. Lastly, we observed a substantial independent effect of formal communication frequency predicting the impact of formal communication on coordinated decision-making. The interaction effect between the

frequency of informal communication and affiliative trust (FI x AT) on inter-agency influence (this time, through formal channels) was once again confirmed. An interaction between affiliative trust and formal communication (FF x AT) was also observed. Affiliative trust's observed additive effect across both models, independent and synergistic with informal and formal communication, suggests that it operates as a master variable in facilitating coordinated decision-making. Notably, procedural trust was found to interact negatively with the frequency of informal communication (FI x PT), such that the less informal communication reported among agencies, the greater the impact of procedural trust. The entire regression model predicted about 69% of the variability.

Fig. 5(c) presents the regression results on the predicting the impacts of trust and communication on goal consensus among agencies. After controlling for participant jurisdiction, target jurisdiction, and the criterion scaled predictor, three independent variables and two interaction variables had a significant effect on goal consensus. Frequency of informal communication exhibited a small effect, while formal communication did not. Rational trust had the largest effect on goal consensus among the trust types, followed by procedural trust. Procedural trust also interacted with communication frequency; as in Model (b), it displayed a negative interaction with informal communication (FI x PT) while it displayed a positive interaction with formal communication (FF x PT). Affiliative trust exhibited no statistically significant effect. The entire regression model predicted about 66% of the variability.

These findings confirm the importance of both informal communication and the multiple dimensions of trust in facilitating learning and adjustment in inter-organizational policy networks. In each analysis, the frequency of informal communication was found to have a pronounced effect on coordinated decision-making between agencies through formal and informal channels. Furthermore, informal communicative impact, itself largely determined by informal communication frequency, substantially influenced decision-making through formal channels. These findings were also supported by qualitative data provided by respondents:

*"We have found informal and networking (even socializing) with staff from other agencies to be very important to building trust and familiarity. I work more closely with some staff from other agencies than I do with many of the staff from our own agency. The collaboration is one of the more enjoyable parts of my job but generally it hasn't prevented us from disagreeing professionally at times. The trust does help afford us opportunities to work out issues before getting to more formal impasses."* Michigan Department of Natural Resources

*"Good planning, governance etc. is important, but the success of Great Lakes management has more to do with positive relationships between agencies. The informal process is key. Without a good relationship the small issues can result in stalled initiatives."* Ontario Ministry of Natural Resources and Forestry

The findings also show the relative importance of different types of trust for collaborative processes. On the one hand, for one member of a network to influence another (vital for what Agranoff and McGuire, (2001) call "mutual learning and adaptation"), affiliative trust is crucial. On the other hand, for achieving goal consensus and conflict reduction among agencies, procedural trust is a significant contributor while affiliative trust does not appear to have a direct effect. Rational trust is important across both types of collaborative processes examined in this paper, but most relevant for goal consensus. We found no evidence that an individual's propensity to trust others (i.e., dispositional trust) affects the degree to which their inter-agency interactions influence their self-reported behavior towards coordinated decision-making. Responses to the open-ended questions in our surveys supported the finding that the long-term professional relationships leading to affiliative trust are particularly important for inter-agency collaborative processes:

*"Personal relationships are very important and the Great Lakes tends to*

*attract domain experts who stay with the portfolio for long periods of time or even their entire career. [...] However, there is a large cadre of people retiring or nearing retirement which will put a big dent in continuity and potentially trust."* Ontario Ministry of the Environment and Climate Change

*"Struggles with [...] losing staff positions and losing program resources. It is extremely difficult to work with fewer people and with other agencies that have staff rotating through roles just to get something done. New contract workers do not have the background they need to perform the duties. This strains working relationships and reduces the amount of work that can be accomplished."* Environment Canada

## 6. Discussion and conclusion

The Great Lakes fisheries policy network offers an instrumental case where ecosystem-based management has been formally operationalized, characterized by a long history of agencies working together across jurisdictional boundaries to tackle inter-connected environmental and natural resource management issues. Despite some successes, the capacity of this transboundary policy network to collectively learn, adapt, coordinate and innovate in response to rapid environmental change across scale is being increasingly questioned (Henquin et al., 2006; Krantzberg and Manno, 2010; McLaughlin and Krantzberg, 2011, 2012), with recent calls to enhance "transboundary governance capacity" in the Great Lakes (see Great Lakes Policy Research Network, 2015; Song et al., 2016). The results of our study shed new light on how such transboundary governance capacity might be enhanced, revealing the different effects of trust and mode of communication on coordination across boundaries and providing a basis for developing more diversified strategies of inter-organizational interaction within the Great Lakes fisheries policy network. The findings also have global relevance to governance network praxis, empirically confirming the multi-dimensionality of trust and communication in function and form and extending the qualitative work of Coleman and Stern (2018) by quantifying the impact of trust and communication on coordinated decision-making and goal consensus, as reported by network members.

Our results revealed a greater prevalence and influence of rational trust in the geographically dispersed inter-organizational Great Lakes policy network (see Fig. 4), which supports existing theory that at the outset of new or infrequent interactions, or when based on shallower working relationships, rational trust will be dominant, while longer, repeated interactions and deeper relations would go on to involve more affiliative, "identification"-based elements (Dietz and Den Hartog, 2006; Lewicki et al., 2006; Pirson and Malhotra, 2011). According to Coleman and Stern (2018), rational trust can similarly help facilitate the recruitment of new people into voluntary collaborative initiatives. The influence of rational trust on coordinated decision-making and goal consensus was also not unexpected, with believing that working with a given organization can contribute to your agency's success (one of rational trust's components) being, to a degree, coterminous with being influenced by that organization or believing that its goals align with yours. Our more interesting findings concern the other trust types.

On coordinated decision-making, affiliative trust was found to be the most important, enhancing the likelihood of both informal and formal communication to have an impact (see Fig. 5[a–b]). This finding supports the results of previous research conducted in other transboundary policy networks (see Temby et al., 2015, 2017), and is noteworthy for two reasons. First, our measure of coordinated decision-making operationalizes Agranoff and McGuire's (2001) concept of mutual learning and adaptation, the process that provides the impetus for the development of networks, and a substantial component of the "groupware" (Agranoff and McGuire's term) that facilitates 'value-adding' network outcomes. Second, affiliative trust was the most under-reported in our survey of civil servants working in the Great Lakes fisheries policy

network (see Fig. 4), suggesting that there may be institutional barriers to developing longer-term and more informal working relationships. Such relationships often require time to develop and money spent on activities that can appear to have minimal measurable benefit (e.g., conference attendance, face-to-face meetings with colleagues located at great distances, socializing outside of work hours). Affinitive trust is thus expensive, and the need to develop it arguably runs against the grain of contemporary public management trends, such as incentivized early retirement, travel restrictions, staff rotations and turnover and private contracting.

On goal consensus (or, its obverse, conflict), our data did not show that affinitive trust had an effect. Yet procedural trust, which had no observable influence on coordinated decision-making, had a sizeable effect on shaping mutual goals. These findings illustrate the differential influence of trust. Affinitive trust is important for enabling agencies in inter-jurisdictional networks to coordinate decision-making, but procedural trust helps achieve shared aims and lower conflict. This is intuitive. Because procedural trust is the institution- or system-based trust one has on the overall system, comprising formal or legalized mechanisms such as protocols, professions and licences, confidence to trust another entity rests on the existence of legitimated structures that transcend personal characteristics or past history of interaction (see “institution-based trust” in Zucker, 1986; Shapiro, 1987; Stern and Coleman, 2015). Our data shows higher levels of procedural trust than affinitive trust in the policy network (see Fig. 4), likely due to our focus on surveying civil servants who often share a public service ethos and associated bureaucratic safeguards against unethical or unprofessional behavior. Since such safeguards are normatively embedded as legal-institutional requirements, they can facilitate goal consensus and act as a ‘backstop’ against procedural distrust and inter-agency conflict.

Results also highlighted the relative prevalence of formal communication over the informal. Given that this study focused on a public sector policy network, this is perhaps not a surprising finding. Isett and Provan (2005) identify that formal contracts and structures play an important role in carrying out public-sector functions and maintaining organizational stability, but they also note that formal and informal interactions are not necessarily mutually exclusive in government. When taken into account in a single model, the effects of informal and formal communication frequency on coordinated decision-making were approximately equal (Fig. 5[b]). Yet only informal communication was shown to influence goal consensus. These results suggest that, similar to affinitive trust, there may be opportunities to enhance transboundary governance capacity in the Great Lakes region through increased informal interaction among policy network members.

According to Stern and Baird (2015), the social interactions afforded by trust diversity can help to drive institutional resilience through functional redundancy. Some of the ways in which the varied functions of different trust dimensions compensate for a lack/loss of certain other forms of trust and communication are nicely highlighted in our survey findings, particularly via the results of the two-way interaction terms used in the hierarchical regression models. Most notably, the finding of procedural trust interacting negatively with the frequency of informal communication (from both model [b] and [c]) shows that when people communicate less informally, procedural trust has a larger effect. In other words, procedural trust associated with fair and transparent processes becomes more important when relationships are poorly developed, compensating for a lack of inter-personal trust in maintaining coordination and enabling collaboration. On the contrary, but still consistent with the theory, procedural trust interacted positively with the frequency of formal communication (model [c]), suggesting when formal communications are more prevalent, the effect of procedural trust is synergistic. Such interactive results substantiate the (empirical) importance of considering and applying the multi-dimensional view of trust and communication in natural resource governance. That procedural trust was more prevalent than affinitive trust among the surveyed members of the Great Lakes fisheries policy network

(Fig. 4) further highlights the buffering potential of one type of trust in the case of a weaker other. On this point, Stern and Baird (2015: 3) noted, “Individuals can work together with less interpersonal trust if systems-based [procedural] trust is high.”

Gaining a deeper understanding of the mechanisms that can ‘unlock’ the collaborative functioning of transboundary policy networks remains an important area for research and policy attention. Insights from this study add to the growing body of evidence that informal interactions and relationship-based trust are crucial factors in motivating and facilitating coordinated decision-making across organizational and jurisdictional boundaries. Future research to further test the various dimensions of trust and communication together with the concomitant refinement of psychometric scales to more accurately and consistently operationalize these concepts is warranted. Ultimately, the nuanced ways in which networked governance strategies accommodate and encourage informal communication and trust-building among diverse network members (including public, private and civic organizations) may prove to be a breakthrough in realizing the degree of mutual co-ordination required to match the complexity of transboundary natural resource systems.

## Declaration of interest

None

## Acknowledgements

This work was supported by the Social Sciences and Humanities Research Council of Canada (grant number 430-2011-0644; 435-2014-0970) and the IBM Center for the Business of Government. The authors acknowledge Jean Sandall and Ray Cooksey for their important contribution to the original survey design and analysis methods, and Gail Krantzberg for her insight and advice on the Great Lakes governance system. An earlier version of this article was presented at the 2018 conference of the New England Political Science Association. The authors thank Natasha Altema McNeely, James Buthman and two anonymous reviewers for their helpful and constructive feedback and the anonymous survey participants who generously donated their valuable time, experience, and knowledge to the study.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.gloenvcha.2018.11.001>.

## References

- Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. *Econ. Geogr.* 79 (4), 387–404.
- Agranoff, R., 2007. *Managing Within Networks: Adding Value to Public Organizations*. Georgetown University Press, Washington DC.
- Agranoff, R., McGuire, M., 2001. Big questions in public network management research. *J. Public Adm. Res. Theory* 11, 295–326.
- Berkes, F., 2012. Implementing ecosystem-based management: Evolution or revolution? *Fish Fish.* 13 (4), 465–476.
- Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: What relational patterns make a difference? *Glob. Environ. Change Part A* 19 (3), 366–374.
- Brenden, T.O., Brown, R.W., Ebener, M.P., Reid, K., Newcomb, T.J., 2013. Great Lakes commercial fisheries: historical overview and prognoses for the future. In: Taylor, W.W., Lynch, A.J., Leonard, N.J. (Eds.), *Great Lakes Fisheries Policy and Management*. Michigan State University Press, East Lansing, pp. 339–397.
- Brondizio, E.S., Ostrom, E., Young, O.R., 2009. Connectivity and the governance of multilevel social-ecological systems: the role of social capital. *Annu. Rev. Environ. Resour.* 34, 253–278.
- Browne, M.W., Cudeck, R., 1993. Alternative ways of assessing model fit. In: Bollen, K.A., Long, J.S. (Eds.), *Testing Structural Equation Models*. Sage, Beverly Hills, CA, pp. 136–162.
- Burch, S., 2010. Transforming barriers into enablers of action on climate change: insights from three municipal case studies in British Columbia, Canada. *Glob. Environ. Change Part A* 20 (2), 287–297.



- Cash, D.W., Moser, S.C., 2000. Linking global and local scales: designing dynamic assessment and management processes. *Glob. Environ. Change Part A* 10 (2), 109–120.
- Cohen, J., Cohen, P., West, S., Aiken, L., 2003. *Applied Multiple regression/correlation Analysis for the Behavioral Sciences*, 3rd ed. Lawrence Erlbaum, Mahwah, NJ.
- Coleman, K., Stern, M.J., 2018. Exploring the functions of different forms of trust in collaborative natural resource management. *Soc. Nat. Resour.* 31, 21–38.
- Cummings, L.L., Bromiley, P., 1996. The organizational trust inventory (OTI): development and validation. In: Kramer, R.M., Tyler, T.R. (Eds.), *Trust in Organizations: Frontiers of Theory and Research*. Sage, Thousand Oaks, CA, pp. 302–330.
- Davenport, M.A., Leahy, J.E., Anderson, D.H., Jakes, P.J., 2007. Building trust in natural resource management within local communities: a case study of the Midewin National Tallgrass Prairie. *Environ. Manage.* 39 (3), 353–368.
- Dietz, G., Den Hartog, D.N., 2006. Measuring trust inside organisations. *Pers. Rev.* 35 (5), 557–588.
- Edelenbos, J., van Meerkerk, I., 2015. Connective capacity in water governance practices: the meaning of trust and boundary spanning for integrated performance. *Curr. Opin. Environ. Sustain.* 12, 25–29.
- Furr, M., 2011. *Scale Construction and Psychometrics for Social and Personality Psychology*. SAGE Publications, London.
- Gaden, M., Krueger, C., Goddard, C., Barnhart, G., 2008. A joint strategic plan for management of Great Lakes fisheries: a cooperative regime in a multi-jurisdictional setting. *Aquat. Ecosyst. Health Manage.* 11, 50–60.
- Gaden, M., Goddard, C.I., Read, J., 2013. A history of multi-jurisdictional management of the shared Great Lakes fishery: transcending conflict and diffuse political authority. In: Taylor, W.W., Lynch, A.J., Leonard, N.J. (Eds.), *Great Lakes Fisheries Policy and Management*. Michigan State University Press, East Lansing, pp. 305–337.
- Gibbons, J.A., Sherwood, R.D., 1985. Repeated measures/randomized blocks ANOVA through the use of criterion-scaled regression analysis. *Educ. Psychol. Meas.* 45 (4), 711–724.
- GLFC (Great Lakes Fishery Commission), 2007. *A Joint Strategic Plan for Management of Great Lakes Fisheries (adopted in 1997 and Supersedes 1981 Original)*. Retrieved from: <http://www.glfc.org/fishmgmt/jsp97.pdf>.
- Great Lakes Policy Research Network, 2015. *The Great Lakes Case Study* (Accessed 15 August, 2018) Available online. <http://www.greatlakespolicyresearch.org/research/great-lakes>.
- Gray, S., Shwom, R., Jordan, R., 2012. Understanding factors that influence stakeholder trust of natural resource science and institutions. *Environ. Manage.* 49 (3), 663–674.
- Grover, V.I., Krantzberg, G., 2015. Transboundary water management: lessons learnt from North America. *Water Int.* 40, 183–198.
- Hamm, J., Pytlík, Zillig, L., Herian, M., Tomkins, A., Dietrich, H., Michaels, S., 2013. Trust and intention to comply with a water allocation decision: the moderating roles of knowledge and consistency. *Ecol. Soc.* 18 (4).
- Hardin, R., 2002. *Trust and Trustworthiness*. Russell Sage Foundation, New York.
- Hardy, C., Phillips, N., Lawrence, T., 1998. Distinguishing trust and power in inter-organizational relations: forms and facades of trust. In: Lane, C., Bachmann, R. (Eds.), *Trust in and between Organizations*. Oxford University Press, Oxford, pp. 64–87.
- Harries, T., Penning-Rowsell, E., 2011. Victim pressure, institutional inertia and climate change adaptation: the case of flood risk. *Glob. Environ. Change Part A* 21 (1), 188–197.
- Henquinet, J.W., Dobson, T., 2006. The public trust doctrine and sustainable ecosystems: a Great Lakes Fisheries case study. *NYU Environ. Law J.* 14, 322–339.
- Hu, L.-T., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model. A Multidiscip. J.* 6 (1), 1–55.
- Hudson, J.C., Ziegler, S.S., 2014. Environment, culture, and the Great Lakes fisheries. *Geogr. Rev.* 104 (4), 391–413.
- Imperial, M.T., 1999. Institutional analysis and ecosystem-based management: the institutional analysis and development framework. *Environ. Manage.* 24 (4), 449–465.
- Isett, K.R., Provan, K.G., 2005. The evolution of dyadic interorganizational relationships in a network of publicly funded nonprofit agencies. *J. Public Adm. Res. Theory* 15, 149–165.
- Isett, K.R., Mergel, I.A., LeRoux, K., Mischen, P.A., Rethemeyer, R.K., 2011. Networks in public administration scholarship: understanding where we are and where we need to go. *J. Public Adm. Res. Theory* 21 i157–73.
- Jackson, S.A., 2015. *A Fresh Perspective for Marine Fisheries: Ecosystem Based Fisheries Management in the Laurentian Great Lakes*. Unpublished doctoral thesis. University of Washington.
- Kalafatis, S.E., Lemos, M.C., Lo, Y.J., Frank, K.A., 2015. Increasing information usability for climate adaptation: the role of knowledge networks and communities of practice. *Glob. Environ. Change Part A* 32, 30–39.
- Karkkainen, B.C., 2006. Managing transboundary aquatic ecosystems: lessons from the Great Lakes. *Pac. McGeorge Global Bus. Dev. Law J.* 19, 209–240.
- Khodyakov, D., 2007. Trust as a process: a three-dimensional approach. *Sociology* 41 (1), 115–132.
- Klijn, E.-H., Steijn, B., Edelenbos, J., 2010. The impact of network management on outcomes in governance networks. *Public Adm.* 88 (4), 1063–1082.
- Kramer, R.M., 1999. Trust and distrust in organizations: emerging perspectives, enduring questions. *Annu. Rev. Psychol.* 50 (1), 569–598.
- Krantzberg, G., Manno, J.P., 2010. Renovation and innovation: it's time for the Great Lakes regime to respond. *Water Resour. Manage.* 24, 4273–4285.
- Lambright, K.T., Mischen, P.A., Laramée, C.B., 2010. Building trust in public and nonprofit networks: personal, dyadic, and third party influences. *Am. Rev. Public Adm.* 40, 64–82.
- Leonard, N.J., Taylor, W.W., Goddard, C.I., Frank, K.A., Krause, A.E., Schechter, M.G., 2011. Information flow within the social network structure of a Joint Strategic Plan for Management of Great Lakes Fisheries. *N. Am. J. Fish. Manage.* 31 (4), 629–655.
- Lewicki, R.J., Tomlinson, E.C., Gillespie, N., 2006. Models of interpersonal trust development: theoretical approaches, empirical evidence, and future directions. *J. Manage.* 32 (6), 991–1022.
- Lewis, J.D., Weigert, A., 1985. Trust as a social reality. *Soc. Forces* 63 (4), 967–985.
- Long, R.D., Charles, A., Stephenson, R.L., 2015. Key principles of marine ecosystem-based management. *Mar. Policy* 57, 53–60.
- Lowitt, K., Johnston-Weiser, D., Lauzon, R., Hickey, G.M., 2018. On food security and access to fish in the Saugeen Ojibway Nation, Lake Huron, Canada. *J. Great Lakes Res.* 44, 174–183.
- Mayer, R.C., Davis, J.H., Schoorman, F.D., 1995. An integrative model of organizational trust. *Acad. Manage. Rev.* 20 (3), 709–734.
- McAllister, D.J., 1995. Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Acad. Manage. J.* 38 (1), 24–59.
- McCrimmon Jr., D.A., 2002. Sustainable fisheries management in the Great Lakes: scientific and operational challenges. *Lakes Reserv. Res. Manage.* 7 (3), 241–254.
- McEvily, B., Tortoriello, M., 2011. Measuring trust in organisational research: Review and recommendations. *J. Trust. Res.* 1, 23–63.
- McLaughlin, C., Krantzberg, G., 2011. An appraisal of policy implementation deficits in the Great Lakes. *J. Great Lakes Res.* 37, 390–396.
- McLaughlin, C., Krantzberg, G., 2012. An appraisal of management pathologies in the Great Lakes. *Sci. Total Environ.* 416, 40–47.
- Minns, C.K., 2013. The science of ecosystem-based management on a global scale: The Laurentian Great Lakes, Lake Ontario, and the Bay of Quinte as a nested case study. *Aquat. Ecosyst. Health Manage.* 16 (3), 229–239.
- Möllering, G., Bachmann, R., Lee, S.H., 2004. Introduction: Understanding organizational trust-foundations, constellations, and issues of operationalisation. *J. Manage. Psychol.* 19 (6), 556–570.
- Mulvaney, K.K., Lee, S., Höök, T.O., Prokopy, L.S., 2015. Casting a net to better understand fisheries management: an affiliation network analysis of the Great Lakes Fishery Commission. *Mar. Policy* 57, 120–131.
- Munton, D., 2006. Transboundary air pollution: dependence and interdependence. In: Le Prestre, P.G., Stoett, P.J. (Eds.), *Bilateral Ecopolitics: Continuity and Change in Canadian-American Environmental Relations*. Ashgate, Aldershot, England, pp. 73–92.
- Nooteboom, B., 2002. *Trust: Forms, Foundations, Functions, Failures and Figures*. Edward Elgar Publishing, Cheltenham, UK.
- Nooteboom, B., Berger, H., Noorderhaven, N.G., 1997. Effects of trust and governance on relational risk. *Acad. Manage. J.* 40 (2), 308–338.
- Nyhan, R.C., 2000. Changing the paradigm: trust and its role in public sector organizations. *Am. Rev. Public Adm.* 30 (1), 87–109.
- Nyhan, R.C., Marlowe, H.A., 1997. The psychometric properties of the organizational trust inventory. *Eval. Rev.* 21, 614–635.
- Olsson, P., Folke, C., Hughes, T.P., 2008. Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. *Proc. Natl. Acad. Sci.* 105 (28), 9489–9494.
- Ostrom, E., 2010. Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Change Part A* 20 (4), 550–557.
- Ostrom, E., Ahn, T.K., 2003. *Foundations of Social Capital*. Edward Elgar Publishing, Northampton, MA.
- Paul, C.J., Weinthal, E.S., Bellemare, M.F., Jeuland, M.A., 2016. Social capital, trust, and adaptation to climate change: evidence from rural Ethiopia. *Glob. Environ. Change Part A* 36, 124–138.
- Pedhazur, E.J., 1977. Coding subjects in repeated measures designs. *Psychol. Bull.* 84, 298–305.
- Pirson, M., Malhotra, D., 2011. Foundations of organizational trust: What matters to different stakeholders? *Organ. Sci.* 22 (4), 1087–1104.
- Poe, G.L., Lauber, T.B., Connelly, N.A., Creamer, S., Ready, R.C., Stedman, R.C., 2013. *Net Benefits of Recreational Fishing in the Great Lakes Basin: a Review of the Literature*. Cornell University, Ithaca.
- Pretty, J., 2003. Social capital and the collective management of resources. *Science* 302 (5652), 1912–1914.
- Provan, K.G., Milward, H.B., 1995. A preliminary theory of interorganizational network effectiveness: a comparative study of four community mental health systems. *Adm. Sci. Q.* 40, 1–33.
- Rempel, J.K., Holmes, J.G., Zanna, M.P., 1985. Trust in close relationships. *J. Pers. Soc. Psychol.* 49 (1), 95–112.
- Ring, P.S., Van de Ven, A.H., 1994. Developmental processes of cooperative inter-organizational relationships. *Acad. Manage. Rev.* 19 (1), 90–118.
- Rittel, H.W., Webber, M.M., 1973. Dilemmas in a general theory of planning. *Policy Sci.* 4 (2), 155–169.
- Rosen, F., Olsson, P., 2013. Institutional entrepreneurs, global networks, and the emergence of international institutions for ecosystem-based management: the Coral Triangle Initiative. *Mar. Policy* 38, 195–204.
- Rotter, J.B., 1967. A new scale for measurement of interpersonal trust. *J. Pers.* 35 (4), 651–666.
- Rousseau, D.M., Sitkin, S.B., Burt, R.S., Camerer, C., 1998. Not so different after all: a cross-discipline view of trust. *Acad. Manage. Rev.* 23 (3), 393–404.
- Ruckelshaus, M., Klinger, T., Knowlton, N., DeMaster, D.P., 2008. Marine ecosystem-based management in practice: scientific and governance challenges. *BioScience* 58 (1), 53–63.
- Seppänen, R., Blomqvist, K., Sundqvist, S., 2007. Measuring inter-organizational trust—a critical review of the empirical research in 1990–2003. *Ind. Mark. Manage.* 36 (2), 249–265.
- Shapiro, S.P., 1987. The social control of impersonal trust. *Am. J. Sociol.* 93 (3), 623–658.
- Shapiro, D.L., Sheppard, B.H., Cheraskin, L., 1992. Business on a handshake. *Negot. J.* 8 (4), 365–377.



- Smith, J.W., Leahy, J.E., Anderson, D.H., Davenport, M.A., 2013. Community/agency trust and public involvement in resource planning. *Soc. Nat. Resour.* 26 (4), 452–471.
- Song, A.M., Hickey, G.M., Temby, O., Krantzberg, G., 2016. Assessing transboundary scientific collaboration in the Great Lakes of North America. *J. Great Lakes Res.* 42 (1), 156–161.
- Song, A.M., Saavedra Cisneros, A., Temby, O., Sandall, J., Cooksey, R.W., Hickey, G.M., 2017a. On developing an inter-agency trust scale for assessing governance networks in the public sector. *Int. Public Manage. J.* <https://doi.org/10.1080/10967494.2017.1370047>.
- Song, A.M., Temby, O., Krantzberg, G., Hickey, G.M., 2017b. Institutional features of U.S.-Canadian transboundary fisheries governance: organizations and networks, formal and informal. In: Temby, O., Stoett, P. (Eds.), *Towards Continental Environmental Policy? North American Transnational Networks and Governance*. SUNY Press, Albany, NY, pp. 156–179.
- Stern, M.J., 2008. The power of trust: toward a theory of local opposition to neighboring protected areas. *Soc. Nat. Resour.* 21 (10), 859–875.
- Stern, M.J., Baird, T.D., 2015. Trust ecology and the resilience of natural resource management institutions. *Ecol. Soc.* 20 (2), 14.
- Stern, M.J., Coleman, K.J., 2015. The multidimensionality of trust: applications in collaborative natural resource management. *Soc. Nat. Resour.* 28 (2), 117–132.
- Sydow, J., 1998. Understanding the constitution of interorganizational trust. In: Lane, C., Bachmann, R. (Eds.), *Trust Within and between Organizations: Conceptual Issues and Empirical Applications*. Oxford University Press, Oxford, pp. 31–63.
- Temby, O., Stoett, P. (Eds.), 2017. *Towards Continental Environmental Policy? North American Transnational Networks and Governance*. SUNY Press, Albany, NY.
- Temby, O., Rastogi, A., Sandall, J., Cooksey, R., Hickey, G.M., 2015. Interagency trust and communication in the transboundary governance of Pacific Salmon fisheries. *Rev. Policy Res.* 32 (1), 79–99.
- Temby, O., Sandall, J., Cooksey, R., Hickey, G.M., 2017. Examining the role of trust and informal communication on mutual learning in government: the case of climate change policy in New York. *Organ. Environ.* 30 (1), 71–97.
- Turner, R.A., Addison, J., Arias, A., Bergseth, B.J., Marshall, N.A., Morrison, T.H., Tobin, R.C., 2016. Trust, confidence, and equity affect the legitimacy of natural resource governance. *Ecol. Soc.* 21 (3), 18.
- Van Meerkerk, I., Edelenbos, J., Klijn, E.H., 2015. Connective management and governance network performance: the mediating role of throughput legitimacy. Findings from survey research on complex water projects in the Netherlands. *Environ. Plann. C Gov. Policy* 33 (4), 746–764.
- Vaske, J.J., Absher, J.D., Bright, A.D., 2007. Salient value similarity, social trust and attitudes toward wildland fire management strategies. *Hum. Ecol. Rev.* 14 (2), 223–232.
- Zucker, L.G., 1986. Production of trust: institutional sources of economic structure, 1840–1920. In: In: Cummings, L.L., Staw, B.M. (Eds.), *Research in Organizational Behavior* Vol. 8. JAI Press, Greenwich, CT, pp. 53–111.