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Research article

On the architecture of collaboration in inter-organizational natural resource management networks

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ABSTRACT

This paper reviews the architecture of collaboration that exists within inter-organizational natural resource management (NRM) networks. It presents an integrative conceptual framework designed to help operationalize the multi-level interactions that occur between different dimensions of trust, risk perception, and control as key concepts in inter-organizational collaboration. The objective is to identify and justify a series of propositions considered suitable for assessing inter-organizational NRM network collaboration through empirical work. Such an integrative conceptualization goes beyond the existing trust scholarship related to collaborative NRM, and, we argue, offers a useful starting point for further exploring some of the 'inner' social dynamics affecting collaborative performance using complex systems thinking. To help establish the relevance of the conceptual framework to transboundary resource governance, a survey operationalizing different dimensions of trust, perceived risk, and control is piloted in the Salish Sea, an ecosystem that spans the Canada-US border between British Columbia and Washington State. Key challenges associated with operationalizing the framework and future research needs are identified.

1. Introduction

Within the public policy subfield of natural resource management (NRM), considerable recent research has promoted the need for networked governance approaches to facilitate the collaborative processes required to enhance collective action (Wondoleck and Yaffee, 2000; Bouwen and Taillieu, 2004; Armitage et al., 2009; Scarlett and McKinney, 2016). Collaboration is broadly understood as any joint process, by two or more (substantially) autonomous organizations, intended to create public value by working together rather than separately (Moore, 1996; Bardach, 1998; Prentice et al., 2019). Networked approaches to NRM are thought to foster legitimacy, social learning, communication, and joint understanding to achieve shared objectives and reduce unproductive conflict (Brummel et al., 2012; Stern, 2018). NRM networks can be viewed as social networks where diverse policy actors engage in formal and informal interactions (Imperial, 2005; Kim and Kim, 2008; Temby et al., 2015, 2017; Song et al., 2019) using shared rules and norms, or organizational structures (Wood and Gray, 1991; Emerson et al., 2012) to understand, plan, coordinate, and implement work that requires collaboration (Wondoleck and Yaffee, 2000; Armitage et al., 2009; Brummel et al., 2012). According to Isett et al. (2011, 158), such networks typically include "a set of public agencies, legislative offices, and private sector organizations (including interest groups, corporations, non-profits, etc.) that have an interest in public decisions within a particular area because they are interdependent and thus have a 'shared fate'." Interdependence provides the "common interest or purpose that makes cooperation among different policy actors necessary in a particular area" (Chisholm, 1989; de Arruda Leite and Buainain, 2013), requiring exchange, sharing or co-development to reach shared management goals (Gulati and Singh, 1998).

Brummel et al. (2012) note that inter-organizational networks are a particular form of social networks, where interdependent management goals become integrated and organizational and jurisdictional boundaries are challenged. In this view, inter-organizational collaboration is

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typically seen as occurring between organizations and their representatives without market or formal hierarchy mechanisms of control (Phillips et al., 2000), although it can also be mandated in the case of public agencies. According to Imperial (2005), collaborative networks involve a group of "organizations that form temporary or permanent alliances for a limited purpose or common area of involvement," where the "action set is oriented toward the collective activity of a group of organizations." Importantly, within these alliance relationships organizations maintain a considerable amount of autonomy (Imperial and Hennessey, 2000; Margerum, 2011) but are interdependent to a non-trivial degree, allowing actors to each adopt cooperative behaviour, opposite strategic behaviour and autonomous behaviour (i.e., they can be both cooperative and non-cooperative) presenting certain risks to collaborating (Gulati, 1998; Delerue, 2005). The normative basis of network organizations therefore rests on the actors' complementary strengths, and the unique means of inter-organizational control stems from norms of reciprocity and reputational concerns (Powell, 1990). Further, inter-organizational networks arise from individual participants being directed to represent their organizations and therefore only collaborate insofar as individual representatives communicate (formally and informally), share information and resources, and actively participate in the alliance (Brummel et al., 2012).

Previous research on inter-organizational collaborative networks in NRM and beyond suggests that different dimensions of trust, control, and risk perception interact in complex ways to affect their collaborative performance (Das and Teng, 2001; Hickey et al., 2021), with implications for how organizations with strategic interdependencies work together (Gulati, 1998; Imperial, 2005). For instance, due to the perceived risks of collaborating, partner organizations will need to employ specific combinations of inter-organizational structures and activities based on trust or control (sometimes discussed as "collaborative tools" or "administrative architecture") for partners to coordinate tasks and responsibilities in ways that meet their own needs while allaying concerns about the alliance (Gulati and Singh, 1998; Fjeldstad et al., 2012). While the features of NRM networks that can lead to collaborative success (e.g., knowledge sharing, learning) and their impact on trust and changed risk perceptions have been the focus of considerable research (Stern and Coleman, 2015; Hotte et al., 2019; Song et al., 2019; Feist et al., 2020), less is known about how trust, perceived risk and control in NRM inter-organizational networks function together to sustain collaborative processes over time.

This paper seeks to advance the study of trust and collaboration within the complex inter-organizational networks governing transboundary NRM systems. Drawing on organizational alliance network theory, recent developments in the theory of trust in NRM, and our own empirical research on the multi-dimensionality of trust in different collaborative governance contexts, we present an integrative conceptual framework designed to help operationalize the multi-level interactions occurring between different dimensions of trust, risk perception, and control in inter-organizational NRM networks. We refer to this as an 'architecture' that enables the people and organizations participating in collaborative networks to share resources across boundaries, resolve conflict, engage in teamwork, and coordinate tasks and responsibilities (Gulati and Singh, 1998; Fjeldstad et al., 2012; Baka, 2014;Snow et al., 2017). Our primary objective is to identify and justify a series of propositions considered suitable for assessing inter-organizational collaborative network performance in different contexts that can be tested and validated through future empirical work. To this end, we also describe the challenges associated with operationalizing such a multi-dimensional and multi-level perspective. We present an exploratory survey instrument designed to measure the different dimensions of each concept and trialed in a transboundary fisheries governance network. Then, using the survey responses, structural equational modeling is employed to assess the extent to which the survey measures were able to validly capture the different dimensions of trust, risk perception, and control distinguished in our framework, with the aim to facilitate future empirical tests of the relationships between these concepts in NRM.

2. Risk, trust, and control as the architecture of collaboration in NRM networks

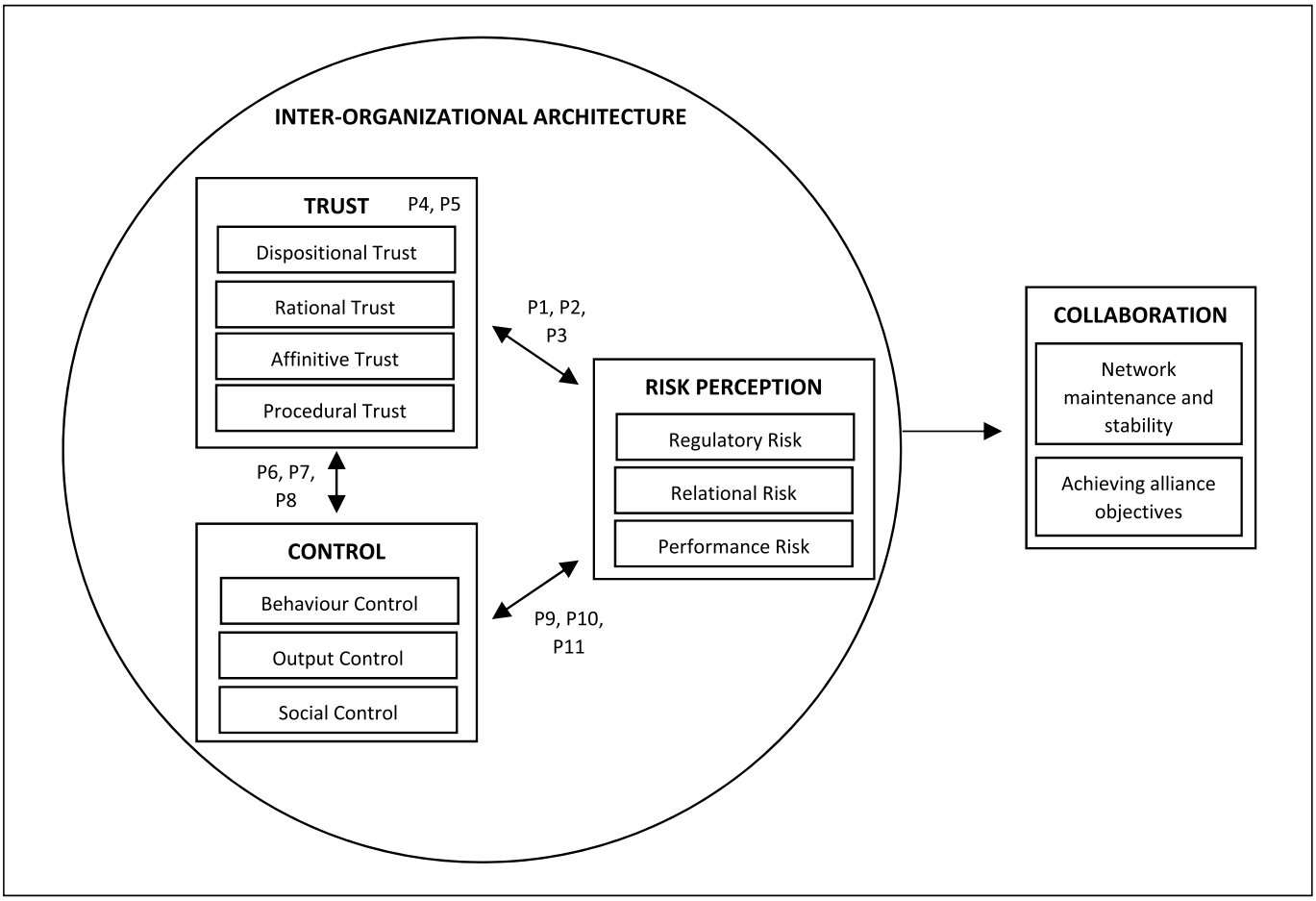
Drawing on work by Das and Teng (2001) Anderson et al. (2014) and Stern and Coleman (2015), Fig. 1 presents an integrative conceptual framework designed to help operationalize the multi-level interactions between different dimensions of trust, risk perception, and control where inter-organizational interdependencies require collaboration. These dimensions operate at different levels, playing a role at individual (organization representatives), organizational, and system, offering a multi-level perspective. Taking all three multi-dimensional and interacting constructs together, we can broadly summarize the inter-organizational collaboration dynamic as follows: recognized inter-organizational interdependencies necessitate interaction and collaboration through the formation of a collaborative network; however, if the perceived risks of collaborating are too great, actors will refuse to collaborate on certain tasks causing the network to change shape, fragment, or under-perform (Supper et al., 2015). Perceived risk is therefore the construct that brings together trust and control, where trust and control jointly determine an actor's perceived total risk of collaborating (Das and Teng, 2001). However, depending on the risk tolerance[1] of an actor, different levels of trust and control will be needed at different times, either separately or in combination (Mayer et al., 1995; Das and Teng, 2001). In what follows we review the relationships between each of the main constructs presented in Fig. 1 (risk perception, trust, and control) and associated dimensions to illuminate their inter-relationships and enhance conceptual clarity.

2.1. Perceived risk

Perceived risk (or subjective risk) relates to the estimated probabilities of several outcomes, and especially their associated negative impacts (Das and Teng, 2001). It concerns "risk taking in relationship" and can only occur in the context of a specific, identifiable relationship with another party (Mayer et al., 1995). Perceived risk is particularly relevant to managing inter-organizational networks because of the uncertainty associated with cooperation among partners (Das and Teng, 2001). Based on literature review, we suggest three dimensions of perceived risk that may be particularly relevant to inter-organizational NRM network relationships, as follows:

1. *Regulatory and Compliance Risk:* defined as the probability and consequences of a partner exposing an actor to sanctions from a third party by failing to comply with requirements, policies, or regulations (Anderson et al., 2014). Examples include the illegal or covert harvesting of resources, failure to protect endangered species, the harassment of, or use of violence against local communities, eco-terrorism activities or political corruption. This type of risk focuses on how the actions of other organizations jeopardize the organization's well-being through sanctions imposed by third parties (Anderson et al., 2014). The importance of this perceived risk to an organization is likely to be affected by having a lot at stake in the relationship, or a history of interaction with another organization.
2. *Relational Risk:* defined as "the probability and consequences of not having satisfactory cooperation" (Das and Teng, 1996). This risk perception arises from the potential for opportunistic behaviours, such as shirking responsibilities, distorting information, cheating, appropriating resources, etc. (Nooteboom et al., 1997; Das and Teng,

[1] Factors affecting a partner's acceptable risk include "risk preferences, resource profiles, competitive positions, industry dynamics" (Das and Teng, 2001).



RISK PERCEPTION

Regulatory Risk: probability and consequence of a partner exposing the firm to sanctions from a third party by failing to comply with rules.

Relational Risk: probability and consequence of not having satisfactory cooperation.

Performance Risk: probability and consequence that alliance objectives are not achieved, despite satisfactory cooperation

TRUST

Dispositional Trust: personality trait signaling one's predisposition to trust another entity.

Rational Trust: calculative assessment of expected benefits and risks informed by the past history of performance and predictability.

Affinitive Trust: hinges on emotions, charisma, shared identities or feelings of benevolence developed from longer-term interactions.

Procedural Trust: fairness and integrity of the procedures involved.

CONTROL

Social Control: focused on establishing a common culture and values.

Output Control: focused on monitoring performance.

Behaviour Control: focused on process that turns appropriate behaviour into desirable output.

Fig. 1. Potential architecture of collaboration in inter-organizational NRM networks (adapted from Das and Teng, 2001; Anderson et al., 2014; Stern and Coleman, 2015), showing the interrelation between trust, risk perception and control in relation to its NRM context. Propositions (P) are labelled and described in Section 2.

2001). Partners often have hidden agendas in the alliance which can negatively affect cooperative interactions (Das and Teng, 2001). Examples could include a lack of data transparency, the use of media smear tactics, product boycott campaigns, and 'greenwashing' by organizations in the NRM network.

3. *Performance Risk:* defined as "the probability and consequences that alliance objectives are not achieved, despite satisfactory cooperation among partners" (Das and Teng, 1996). Performance risk is not unique to inter-organizational alliances (unlike relational risk) and can arise from factors such as "intensified rivalry, new entrants, changing regulations and policies, lack of competence or just bad luck" (Das and Teng, 2001). This form of risk is particularly important to NRM networks, where the opportunity cost of engagement is likely to be a major factor affecting participation. A common example is a high-level interagency initiative that fails to gain

traction among actors because they fail to see the purpose or benefit to it, despite recognizing the value of its objectives.

Distinguishing between these different dimensions of risk is essential because, depending on which risk is perceived as being more of a threat or opportunity, actors will decide on strategies that can best acquire the resources they need from others while protecting their own - often reflected in the administrative architecture (Das and Teng, 2001; Hsieh et al., 2010). It is within the architecture that different forms of *trust* and *control* interact in complex ways to reduce the perceived probability and impact of undesirable outcomes (or alternatively, risk).

2.2. Trust

There are many complexities associated with defining trust (Cole and Cohn, 2016), however, according to Stern and Coleman (2015) it is the "psychological state in which one actor (the trustor) accepts some form of vulnerability based upon positive expectations of the intentions or behaviour of another (the trustee), despite inherent uncertainties in that expectation". Trust has also been broadly defined as "the mutual confidence that no party in an exchange will exploit the other's vulnerability" (Sabel, 1993). Despite the different definitions and conceptualizations, it is generally accepted that trust is considered a multi-dimensional and context-specific phenomenon (Das and Teng, 2001; Stern and Coleman, 2015), operating at the individual, inter-personal (i.e., dyadic), inter-organizational and institutional levels. Trust is often path-dependent, evolves over time, and is socially embedded (Nielsen, 2004).

Trust is viewed as one of the most influential factors in the success or failure of relationships of all kinds and a linchpin of strategic alliances (Fulmer and Gelfand, 2012). The development of trust is integral to sustaining collaboration between interdependent actors due to its ability to increase the network's capacity to collaborate with different actors and implement sustainable solutions (Edelenbos and van Meerkerk, 2015). When trust is present, parties are linked by social bonds and shared commitments and are able to interact openly and honestly, thereby lessening concerns about opportunistic behaviour and reducing the need for formal control mechanisms (Mayer et al., 1995; Das and Teng, 2001). When trust is deficient, parties lack the bonds that permit transparent communication, and generally resort to defensive, confrontational, or insular behaviour (Lijeblad et al., 2009). Trust is therefore considered to be an essential ingredient to several types of collaborative process in NRM and their outcomes (Coleman and Stern, 2018; Davenport et al., 2007; Fulmer and Gelfand, 2012; Lijeblad et al., 2009; Lima et al., 2019; Ostrom, 2003). In addition to the positive attributions, trust has been identified as a driver of collaboration (Rousseau et al., 1998), an outcome of collaboration (Innes and Booher, 2010; McKinney and Field, 2008), or simultaneously as both a driver and an outcome (Davenport et al., 2007; Lijeblad et al., 2009). Despite these observed general relationships, the underlying mechanisms of how trust exactly relates to different aspects of collaborative NRM processes remains mostly unclear. One of the core reasons behind this opaque understanding of the role of trust in NRM processes may be the underexplored state of trust theory in this research field and its multifaceted character (Davenport et al., 2007; Lijeblad et al., 2009; Stern and Coleman, 2015; de Vries et al., 2015b). In the context of collaborative NRM networks, Stern and Coleman (2015) define four dimensions of trust, further explained below, and categorized according to their primary level of analysis[2] (individual, dyadic, institutional (system)).

Individualistic trust can be defined as the "disposition to trust" and is considered especially important in the initial stages of a relationship (McKnight and Choudhury, 2004). Within collaborative natural resource management, it sets a baseline prior to forming any other type of trust assessment (Stern and Coleman, 2015).

1. *Dispositional (or cognitive) trust:* defined as: the *"general tendency or predisposition of an individual to trust or distrust another entity in a particular context"* (Stern and Coleman, 2015) is considered a fairly stable personality characteristic (Smith et al., 2013). Studies by Song et al. (2019) and Lima et al. (2019) have reported mixed, and generally weak, relationships between dispositional trust and inter-organizational collaborative processes in NRM.

Inter-personal (dyadic) trust: relates to the beliefs about a specific other's attributes accompanied by a willingness to become vulnerable to that other (Rousseau et al., 1998). These forms of trust are considered fluid and can change through individual and joint action by the trustors and trustees (Stern, 2018).

2. *Affinitive (or relational, affective) trust:* a dyadic form of inter-personal trust defined as *"trust in an entity 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). This form of trust has been found to be particularly important in natural resource management settings (Stern and Coleman, 2015; Song et al., 2019).
3. *Rational (or calculative) trust:* is also a dyadic form of trust, defined as *"trust in an entity based primarily on a calculation of the perceived utility of the expected outcome of placing one's trust in another entity"* (Stern and Coleman, 2015). Recent studies indicate that rational trust is the most prevalent of the trust types in NRM networks, in terms of both presence and effectiveness in facilitating cooperation (Lima et al., 2019; Song et al., 2019).

Institutional trust: "(e.g., structural assurance) is the set of beliefs an individual holds about a specific context" (McKnight and Choudhury, 2004) and necessarily involves macro-level arrangements beyond the level of inter-personal interactions (see Bachmann and Inkpen, 2011). Strong institutions "can enable and inspire trust-relations among people at the interpersonal and inter-organizational level" (Fuglsang and Jagd, 2015). This form of trust is also considered fairly fluid (Stern, 2018).

4. *Procedural (alternatively systems-based) trust:* is a variant of institutional trust (Sztompka, 1999), defined as the "*trust in procedures or other systems that decrease vulnerability of the potential trustor, enabling action in the absence of other forms of trust"* (Stern and Coleman, 2015). Studies have shown that the presence of this type of trust varies substantially by region and context (Lima et al., 2019; Song et al., 2019).

It is important to note that perceived risk is not part of the definition of trust, but a precursor for trust to matter (Cole and Cohn, 2016). Risk and interdependence between individuals or an individual and institution therefore creates the necessary conditions for trust (Rousseau et al., 1998; Currall and Inkpen, 2006). Conversely, trust has a negative relationship with perceived risk where the increase of trust leads to a decrease of perceived risk (Das and Teng, 2001). Trust has been found to reduce the perceived likelihood of opportunistic behaviour and enhance feelings that others will act to protect the common good and facilitate cooperation (Delerue, 2005; John, 1984; Nooteboom et al., 1997). Therefore, to overcome risk-averse behaviour and reduce risk perception many collaborative NRM networks turn to building trust. This leads us to our first set of propositions on the impact of different dimensions of trust on risk perceptions.

Affinitive trust focuses on the "trustor's perceptions of the benevolence, integrity, and other social characteristics of the trustee and their

[2] Nielsen (2011) states the need for multi-level analysis to "include societal (institutional), dyadic (interpersonal), and individual (individualistic) elements … to stipulate the mechanisms by which individual level action affects exchange between complex social systems, such as organizations."

interactions" (Stern and Coleman, 2015), thereby enhancing the trustors belief that the other entity will act from good faith and not opportunistically (Blackburn, 1998; Das and Teng, 2001). Accordingly, affinitive trust is effective at reducing relational risk through the suggestion of good intentions and adequate cooperation between actors (Das and Teng, 2001). However, because affinitive trust focuses on the intention to cooperate and not the participant's ability, it will be ineffective at reducing performance risk. Therefore:

P1. Affinitive trust between organizations participating in a collaborative NRM network will reduce perceived relational risk in the network, but not perceived performance risk.

Rational trust is based on the predictability of past performances and perceived utility (Coleman, 1990; Hardin, 2002; Möllering, 2006; Stern and Coleman, 2015), which in turn develop confidence in the positive outcomes of the alliance. The actor's confidence in the collaborating organization reduces the performance risk of the alliance. However, since rational trust focuses on the ability of the organization to achieve the present action and not the intention of the organization, it will be ineffective at reducing relational risk (Das and Teng, 2001; Stern and Coleman, 2015). Therefore:

P2. Rational trust between organizations participating in a collaborative NRM network will reduce perceived performance risk in the network, but not perceived relational risk.

Procedural trust is based on the perceived fairness of procedures and when "procedures are jointly agreed upon as fair, participants can place greater faith in the compliance of others" (Stern and Coleman, 2015) thereby reducing compliance and regulatory risk. Additionally, procedural trust can reduce the fear that sanctions will significantly impact a firm's well-being since procedures are viewed as fair and reasonable by actors (Stern and Coleman, 2015). Therefore:

P3. Procedural trust will reduce perceptions of regulatory- and compliance risk in a collaborative NRM network.

The different dimensions of trust are non-exclusive, with different trust types fitting different niches and serving different functions at various stages in a collaborative natural resource governance process (Nielsen, 2004; Stern and Baird, 2015). Nielsen (2004) noted on the relations between different forms of trust: "careful attention to the dynamic, recursive, and often overlapping properties of trust as it relates to alliance evolution, is warranted." For example, while "institutional trust has a positive and significant impact on interpersonal trust" (Wu and Shen, 2018) it is also "cultivated by interpersonal trust and increases organizational commitment" (Baek and Jung, 2015) all of which are expected to vary over time. According to Nielsen (2004), "as organizations make changes to their aspirations and realign their goals, the underlying role of trust may change, likely to be both a determinant and a feature of the relationship [between actors]." This leads us to our second set of propositions on the effects of different types of trust on trust.

Dispositional trust is a person's baseline trust level that is developed "prior to forming any other type of cognitive or affective trust assessment" (Stern and Coleman, 2015). If this baseline is low, then it will be difficult for alliances to develop other forms of trust to support collaboration. Therefore:

P4. Low levels of dispositional trust among NRM network participants will lead to high levels of risk perception in all types.

Procedural trust develops when a network has a "common purpose and identity" as well as a sense of legitimacy and fairness (Stern and Coleman, 2015). High procedural trust fosters affinitive trust by developing a shared identity that can improve the trustors associated judgements of the trustee. Procedural trust can also enhance rational trust by making the network more predictable and improving the trustor's ability to determine the expected outcome of an alliance. Therefore:

P5. Procedural trust in organizations will enhance affinitive trust and rational trust in a collaborative NRM network.

2.3. Control

According to Das and Teng (2001), control in inter-organizational settings involves two types: controlling the partners and controlling the alliance, and is achieved through "governance structures, contractual specifications, managerial arrangements and other more informal mechanisms." Control mechanisms are designed to influence perceived risk of collaborating and both affect trust and rely on trust to facilitate relationships (Delerue, 2005). Further, control systems can preclude collaborative actions, coerce behaviours that compete with intentions based on trust, or result in collaborative behaviour without requiring trust (Raymond, 2006; Stern and Coleman, 2015). Three modes of control relevant to inter-organizational networks have been identified by Das and Teng (2001), one based on informal measures (social control) and two that rely on external, formal measures (output and behaviour control). They are further summarized below:

1. *Social control:* aims to *"reduce discrepancies in goal preferences through the establishment of common culture and values"* (Das and Teng, 2001). It involves the development of informal institutions, primarily social norms in the form of organizational cultures, that tend to rely on social punishments such as ostracism, gossip and exclusion (Feinberg et al., 2014). Here, neither the behaviour nor the outcome is specified at the outset, with goal setting decentralized and evolving through a socialization and consensus-making process (Das and Teng, 2001). Examples common in NRM include: participatory decision-making processes, professional training and degree programs, facilitated field trips, incentives to travel and meet colleagues, social events such as dinners and receptions, retreats and shared recreational opportunities.
2. *Output control:* is exercised through close monitoring of performance and is considered most useful when knowledge about the transformation process is limited and output measures are precise (Das and Teng, 2001). It directs the attention of network managers to key performance measures that will have been negotiated between alliance members based on their preferences and bargaining power (Das and Teng, 2001). Prominent examples in NRM include monitoring and assessment reports detailing changes in resource condition and the effectiveness of measures taken by the alliance.
3. *Behaviour (or process) control: "focuses on the process which turns appropriate behaviour into desirable output"* where *ex post* deterrents such as explicit clauses regarding information exchange and usage are used to regulate the conduct of partners and prevent surprises (Das and Teng, 2001). It is most useful when the alliance managers have a high knowledge of the process and desired behaviours are known. Within natural resource management, this often happens through the institutionalization of shared policies (Imperial, 2005). Examples include: memoranda of understanding (MOUs), joint strategic plans, third party certification standards; codes of conduct; best management practices, and decision support systems, such as those developed by ISO.

Control systems may have both positive and negative impacts upon trust development and the enactment of behavioural intentions based on trust (Stern and Coleman, 2015). This leads us to our third set of propositions on the impact of control on trust.

Social control influences participants behaviour through socialization that fosters confidence in the character of the trustee and thus can

increase affinitive trust (Das and Teng, 2001). Additionally, social control can enhance rational trust through the development of socially defined standards that increase the norms-based information needed to build this trust type (Stern and Coleman, 2015; Braithwaite, 1998). Since social control does not specify any specific behaviour or output it allows participants to develop their preferred processes (Das and Teng, 2001). Through participant-driven development of fair processes, social control increases procedural trust (Stern and Coleman, 2015). Therefore:

P6. Social control will enhance affinitive trust, rational trust and procedural trust in a collaborative NRM network.

Formal control (behaviour and output control) reduces participant autonomy in collaborative networks and creates doubt regarding the goodwill of partners thereby undermining affinitive trust (Powell, 1990; Das and Teng, 2001). Similarly, the need for formal control mechanisms brings into question the ability of the alliance to achieve its goals thus reducing rational trust (Das and Teng, 2001). However, formal control mechanisms provide legitimacy to the policy network through clear structuring of network behaviour and output (Das and Teng, 2001). Through the creation of cognitive expectations and belief in a normative consensus on procedures and priorities, output and behaviour control can develop procedural trust in NRM collaboration (Stern and Coleman, 2015). Therefore:

P7. Both output control and behaviour control will undermine affinitive trust and rational trust but enhance procedural trust in a collaborative NRM network.

All dimensions of trust reduce resistance in the alliance and improve participant relationships (Das and Teng, 2001). The presence of trust also improves participants ability to "accept outcome measurements, to follow specified behaviour patterns, and to share values" (Das and Teng, 2001). Therefore:

P8. Affinitive trust, rational trust and procedural trust will enhance all management control modes (behaviour, output and social) in a collaborative NRM network.

The potential for deviance and gaming between alliance partners (i.e., the perceived risk of collaborating) necessitates control mechanisms, which, according to Stern and Coleman (2015), are relied upon by collaborators primarily to reduce perceived risk and develop common purpose and identity, rather than to coerce specific behaviours. This leads us to our fourth set of propositions on the effects of control on risk.

Anderson et al. (2014) found that compliance and regulatory risk can be reduced by behaviour control mechanisms such as "informal review of partner operations and accountability of alliance personnel". Behaviour control also regulates the conduct of participants and reduces the fear of opportunistic behaviour otherwise known as relational risk (Das and Teng, 2001). However, output control is unable to influence participant behaviour making it ineffective at reducing relational risk and compliance and regulatory risk (Das and Teng, 2001). Therefore:

P9. Perceived relational risk and compliance/regulatory risk in a collaborative NRM network will be reduced more effectively by behaviour control than by output control.

Output control mechanisms involve the close monitoring of performance and can increase confidence in the performance of the alliance through key performance measures (Das and Teng, 2001) making it effective at reducing performance risk. Conversely, behaviour control is less effective at reducing performance risk because it is often unclear what behaviours will increase the performance of an alliance (Das and Teng, 2001). Therefore:

P10. Perceived performance risk in a collaborative NRM network will be reduced more effectively by output control than by behaviour control.

Social control deters participants from acting opportunistically through the establishment of shared values, thereby reducing relational risk (Das and Teng, 2001). Social control can also reduce performance risk by encouraging participants to establish what they consider to be reasonable and achievable goals (Das and Teng, 2001). Therefore:

P11. Social control will reduce both perceived relational risk and performance risk in a collaborative NRM network.

Taken together, the propositions highlight that inter-organizational collaborative relationships develop as a complex systemic process involving "continuous (re)evaluation and (re)adjustment across multiple dimensions of the relationship simultaneously. As the nature of the relationship changes so does the nature and role of trust" (Nielsen, 2004). Fig. 2 presents a visual summary of the proposed relationships between different dimensions of trust, perceived risk and control in collaborative inter-organizational NRM networks using a complex systems diagram. Adopting a complex systems perspective on the architecture of inter-organizational collaboration offers a useful starting point from which to empirically assess the complicated inner workings of inter-organizational collaboration in NRM, including the relationships between process and outcomes to inform praxis (Koontz et al. (2020). Fig. 2 shows the potential for dynamic relations over time among the three main constructs, and is sensitive to the potential multi-directional roles that the types and levels of trust and control play in different phases of the collaborative relationship (Nielsen, 2004). Integrating different dimensions of trust, perceived risk, and control within a single framework also offers the potential for multi-level analysis, going beyond the "the isolated, unidirectional or incremental patterns often used to analyze trust" and broadening the perspective to help understand how trust "acts, simultaneously, as a cause, a moderator/mediator, and an effect at different phases of the relationship development" (Nielsen, 2004). By looking broadly at the components and relationships that make up the outlined architecture of collaboration in inter-organizational NRM networks, the capacity of participants to evaluate collaboration across organizational boundaries can be enhanced.

3. Operationalizing the different dimensions of inter-organizational trust, perceived risk and control for empirical assessments of our framework

The validity of the stated propositions and the overall relevance of our integrative conceptual framework can only be fully established by means of (future) empirical tests. However, before a full test of our framework can be performed and presented (which exceeds the purpose and scope of the current contribution), it is important to first advance on the careful operationalization of the central concepts in each of their separate dimensions. This is a challenging task as the concepts and their dimensions must be translated to generally understandable questions aimed at respondents within organizations participating in collaborative networks. A few existing studies (from both within and outside the NRM network governance context) have previously developed measurement instruments for either the different dimensions of trust (see Hamm et al., 2013; Song et al., 2019; Smith et al., 2013), the different dimensions of perceived risks (see Zhang and Li, 2015; Zhang and Qian, 2017), or the different types of control mechanisms (see Delerue, 2005; Kale et al., 2000). However, these measures have not yet been simultaneously adopted in a single integrative survey instrument. Hence, we build upon these existing studies by using several of their items in a combined survey instrument intended to measure the concepts presented in our integrative framework. With this measurement instrument we target the

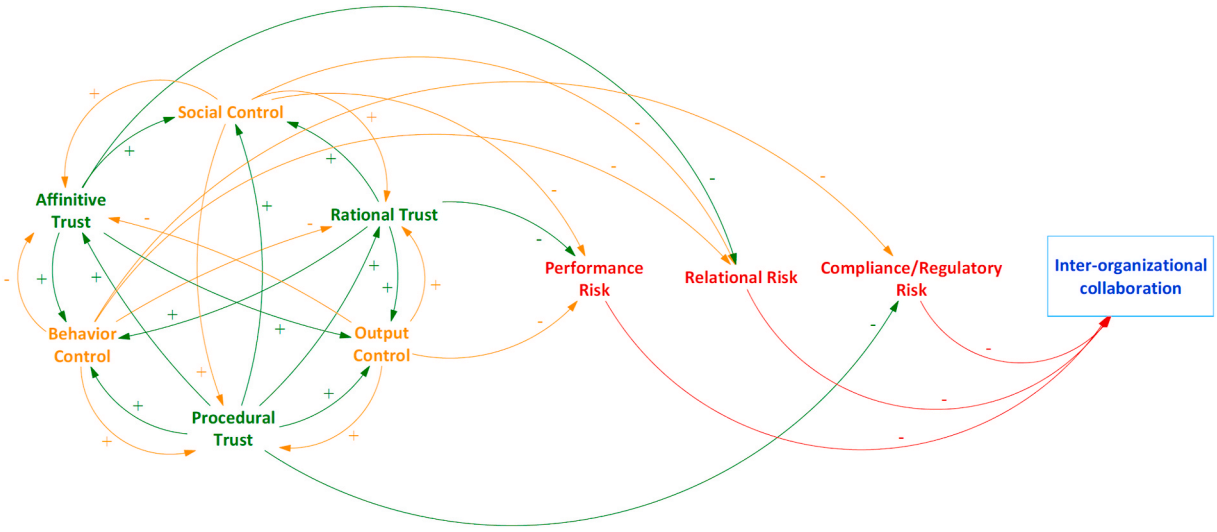


Fig. 2. A systems thinking diagram depicting the proposed inter-relationships and feedbacks between the different dimensions of trust, perceived risk and control in collaborative inter-organizational NRM networks. '+' indicates the two nodes change in the same direction; '–' means the two nodes change in opposite directions. Dispositional trust is omitted from this diagram because it is considered a stable personality characteristic that sets a baseline for other collaborative trust assessment (Stern and Coleman, 2015).

specific relations between pairs of organizations (dyads), with each organization (i.e., its representatives) being able to assess their relationship with multiple other specified organizations within its network. This approach simultaneously targets relationships between different types of actors at various institutional levels within a network (Song et al., 2019).

For each identified inter-organizational relation, respondents are presented with a series of trust statements on a five-point scale (1 = strongly disagree to 5 = strongly agree). The specific items (see Table 1) have previously been developed and validated in the context of dyadic relations in NRM networks (see Song et al., 2019; Lima et al., 2019). We also included items measuring respondents' (non-dyadic) dispositional and procedural trust. Next, a set of five-point scale items were included (Table 2) as supposed observable indicators for one of the three (relational, performance, regulatory) theoretically distinguished latent dimensions of risk perception. The relational- and performance risk items were adapted from Zhang and Li (2015) and Zhang and Qian (2017). The two regulatory risk items were adapted from Zhang and Qian (2017) and Katznelson (2020). Finally, to measure which control mechanisms are utilized by one's organization with a specific other organization in the dyadic relation, we presented respondents with a nine-item list of potential control mechanisms (Table 3) and asked whether each mechanism was present or absent in the relationship. These nine (dummy) items are supposed to be manifest indicators of the three theoretically distinguished latent dimensions of behavioral, output, and social control (three items for each control type) and were adapted from Das and Teng (2001) and verified as relevant to NRM networks through literature review (see Norman, 2015; Stern, 2018; Wondolleck and Yaffee, 2000).

By applying our survey instrument to a typical case of an inter-organizational NRM network, we further sought to validate that the different dimensions of trust, risk-perception, and control can not only theoretically, but also empirically be distinguished from each other using the proposed operationalization of these concepts. To this end, the survey was sent to individuals working in organizations concerned with fisheries-related issues in the Salish Sea. The Salish Sea is a trans-boundary marine ecosystem that spans the Canada-US border between British Columbia and Washington State, with straddling fish stocks necessitating inter-organizational collaboration on fishery governance involving local, Indigenous, state/provincial and federal government agencies, an international commission, NGOs, industry, fishery associations and local community groups. The survey was conducted using Qualtrics between November 2021 and February 2022. We received responses from 142 individuals working for 35 distinct organizations from the Salish Sea fishery network.

The survey first asked respondents to select the organization to which they belong and then asked them to list the organizations with

Table 1
Trust survey questions adapted from Song et al. (2019).

Variable Type	Variable Name	Survey Question	Question Type
Affinitive Trust 1	AFFIA	Because we have been working with this organization for so long, all kinds of procedures have become self-evident.	Dyadic
Affinitive Trust 2	AFFIB	In our relationship with the people in this organization, informal agreements have the same significance as formal contracts.	Dyadic
Rational Trust 1	RATIA	This organization can be relied upon to perform its objectives.	Dyadic
Rational Trust 2	RATIB	In our relationship with this organization, both sides treat each other in a consistent and predictable manner.	Dyadic
Dispositional Trust 1	DISPA	You can't be too careful dealing with people.	Non-Dyadic
Dispositional Trust 2	DISPB	People are almost always interested only in their own welfare.	Non-Dyadic
Dispositional Trust 3	DISPC	Most people would try to take advantage of you if they got the chance.	Non-Dyadic
Procedural Trust 1	PROCA	In the fishery management of this region the strongest side is expected not to pursue its interest at all costs.	Non-Dyadic
Procedural Trust 2	PROCB	When managing fish in this region it is expected that any unfair dealings will be avoided or rectified by existing regulatory, legal, or reputational measures.	Non-Dyadic
Procedural Trust 3	PROCC	When managing fish in this region people are expected not to make demands that can seriously damage the interests of others.	Non-Dyadic

Table 2
Risk survey questions adapted from Zhang and Li (2015); Zhang and Qian (2017) and Katznelson (2020).

Variable Type	Variable Name	Survey Question	Question Type
Relational Risk 1	RELAA	We think that the people in this organization may break promises.	Dyadic
Relational Risk 2	RELAB	We think that the relationship with this organization will deteriorate in the foreseeable future.	Dyadic
Relational Risk 3	RELAC	We think that the people in this organization will take advantage of us when the opportunity arises.	Dyadic
Performance Risk 1	PERFA	We think that the performance of this project is likely to decline in the foreseeable future.	Dyadic
Performance Risk 2	PERFB	We think that our objectives in the project with this organization will not be achieved	Dyadic
Performance Risk 3	PERFC	We think that this organization has no ability to offer us support when faced with difficulties in the management of this fishery	Dyadic
Regulatory Risk 1	REGUA	We feel that in opposing this organization we would be negatively affected in the future	Dyadic
Regulatory Risk 2	REGUB	The actions of this organization may expose my organization to additional regulations if relevant rules are not followed.	Dyadic

Table 3
Control survey questions adapted from Das and Teng (2001).

Control Type	Acronym	Control Mechanism	
Behaviour Control	PP	The creation of shared policies and procedures that outline appropriate behaviour (e.g. Memoranda of understandings)	Dyadic
	RS	The collaborative creation of a reporting structure that outlines supervisory and monitoring roles	Dyadic
	ST	The staffing and training of members to ensure appropriate behaviour during collaboration	Dyadic
Output Control	OS	The objective setting between organizations (e.g. creation of performance measures for organization members)	Dyadic
	PB	Collaborative planning and budgeting to provide appropriate resources to achieve goals	Dyadic
	JIC	Joint information collection (e.g. monitoring of fish stocks and sharing data between organizations)	Dyadic
Social Control	PDM	Joint participation in decision-making process (e.g. discussions between organizations to determine shared goals and plans)	Dyadic
	RCN	Attending community events, ceremonies, and networking events	Dyadic
	EMI	Informal communication and meetings (e.g. work Happy Hour)	Dyadic

whom they communicate the most from a list of different stakeholder categories, with an option to select none. For each of the selected organizations, the respondent was then presented with the dyadic trust/risk questions, resulting in a dataset with a dyadic respondent-target (one-to-many) structure. Two randomly chosen organizations from those selected by the respondent were used as referents for the control mechanism question due to survey length constraints. Finally, respondents answered non-dyadic questions for procedural and dispositional trust. As most respondents evaluated their relations with more than a single organization, our final dataset contained 360 organization-organization dyads and 662 unique individual-organization dyads. Although this leaves some potential for clustering effects in the data, we are confident that a pooled approach to our scale validation effort is sufficient as the number of clusters is very large (both at the level of the number of unique home organizations as well as at the level of the organization-organization dyads) compared to the limited number of observations within clusters. Furthermore, interpretation of the intra-cluster correlation coefficients on several of our core variables shows that the existing variance within those variables is equally divided between and within clusters (we checked at different levels of clustering and retained ICC values ranging between 0.3 and 0.6).

Using Stata 16.1, structural equation modelling (SEM) was used to perform confirmatory factor analyses (CFA) to verify the seven-item trust scale, the eight-item risk scale and the nine-item control mechanism scale. CFA is commonly used to test whether the observed measures of an unobserved construct are consistent with a hypothesized understanding of the nature of that construct (Schreiber et al., 2006). Fig. 3 depicts the results of our CFA for the trust scale. All of the seven observed variables loaded significantly on their proposed latent dimensions of trust ($p < .05$). The coefficients depicting how much the observed variables change when the latent variable changes by one standard deviation range from 0.34 to 0.84. The covariances between the three trust dimensions are positive, although the covariance between the affinitive and the procedural-trust dimension has a relatively small value of 0.12 which is not significant at the $p < .05$ level. The other covariances have acceptable levels of 0.59 and 0.42 and are significant, which overall indicates that the different dimensions of trust that were theoretically presupposed to exist are empirically validated to be substantially different from each other.

Next, we report the comparative fit index (CFI: >0.90 acceptable, >0.95 excellent), the root mean square error of approximation (RMSEA: <0.08 acceptable, <0.05 excellent), and the Tucker-Lewis Index (TLI: >0.90 acceptable, >0.95 excellent) to evaluate our model's goodness of fit. The current specification of the model returns acceptable goodness of fit values (CFI = 0.931, RMSEA = 0.084, TLI = 0.869), suggesting that the model specification created a reasonably good fit between the model and the observed data (Schreiber et al., 2006). Finally, we investigated the internal consistency of the three trust dimensions validated through our CFA. Cronbach's alpha scores of 0.49 for affinitive trust, 0.59 for procedural trust, and 0.75 for relation trust show that the internal consistency of the affinitive trust subscale and the procedural trust subscale may benefit from further refinement through future research (conventionally alpha coefficients above 0.6 are considered robust).

The model resulting from our CFA of the risk-perception scale is presented in Fig. 4. All eight observed variables loaded significantly on their proposed latent risk-perception dimension ($p < .05$). The covariances between the three latent risk-perception dimensions are positive and significant ($p < .05$). The value of 0.83 for the covariance between the relational risk-perception dimension and the performance risk-perception dimension is somewhat high. But those dimensions are

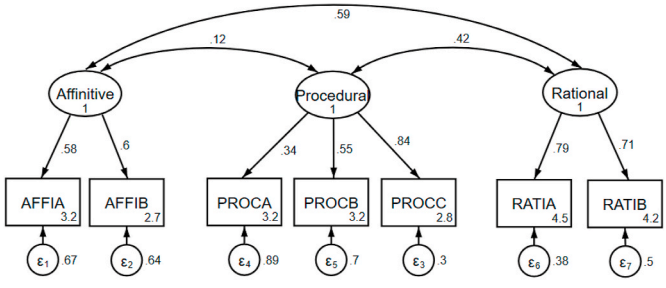


Fig. 3. Structural equation model showing standardized parameter estimates for the trust scale.

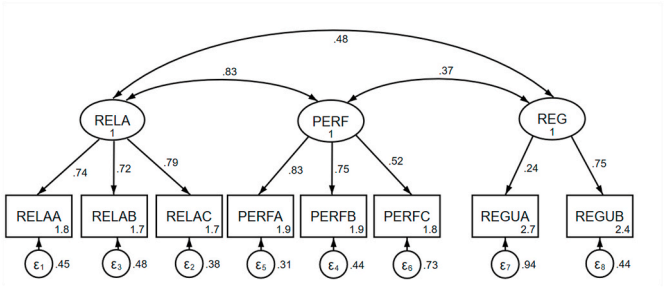


Fig. 4. Structural equation model showing standardized parameter estimates for the risk scale.

still validated by the CFI model as being different enough to warrant their separate inclusion in further analyses. The specification of the model returned reasonably acceptable goodness of fit values (CFI = 0.933, RMSEA = 0.100, TLI = 0.889), suggesting that the model is appropriate but there is scope to strengthen the fit between the model and the observed data in future iterations. Finally, Cronbach alpha values of 0.788 for relational risk, 0.726 for performance risk, and 0.302 for regulatory risk indicate that the internal consistency of the regulatory risk subscale may be enhanced by further refining the items in the scale.

The model resulting from our CFA of the control mechanisms scale is presented in Fig. 5. Before arriving at this final model specification, we had to re-specify the model to limit correlation between the underlying constructs. For each one of the latent types of control mechanisms (behavioral, output, social) one of the observed dichotomous items needed to be removed. The staffing and training item (ST) was removed as an indicator of behaviour control and the planning and budgeting (PB) item was removed as indicator of output control because these concepts were highly correlated. Participatory decision-making (PDM) was removed as an indicator of social control since it was highly correlated with other control mechanisms. The final CFA output shows that the six observed variables loaded significantly ($p < .05$) onto their three theoretically proposed latent constructs with acceptable levels of covariance between the latent dimension of control (Fig. 5). This final model returns good goodness of fit values (CFI = 1.000, TLI = 1.003). Cronbach alpha values of 0.72 for behavioral control, 0.57 for output control, and 0.48 for social control indicate that the internal consistency of the social control subscale can be strengthened in future research.

In summary, the measurement models presented above validate that the central concepts from our proposed architecture framework can be simultaneously operationalized in accordance with their separate dimensions using a single survey designed to collect data on multiple inter-organizational relations. Although the scales that we constructed can still be improved, particularly the internal consistency of some subscales, our approach nonetheless shows that it is possible to validly differentiate between the different dimensions of trust, risk perception, and control operating within inter-organizational NRM networks that

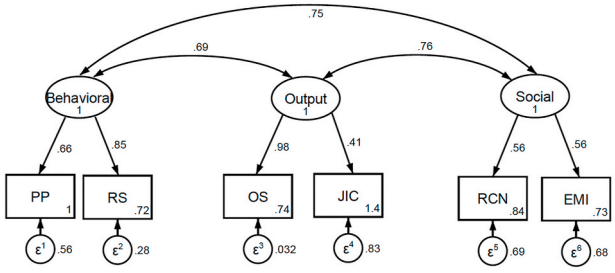


Fig. 5. Structural equation model showing standardized parameter estimates for the control mechanisms scale.

we conceptualized as being distinct from each other. For future work, there are opportunities to empirically test the propositions presented in Section 2, and to investigate the specific relationships between the different types of multi-dimensional trust, risk perception, and control within different NRM network settings. Our novel operationalization and measurement of control mechanisms enables future studies to empirically expand upon previous work that has mainly focused on trust alone (see Song et al., 2019) or solely on risk (see Zhang and Li, 2015; Zhang and Qian, 2017). Being able to test how the presence of different control mechanisms affects the development of inter-organizational trust, and how perceived risk is mitigated by control mechanisms opens exciting opportunities to better understand how NRM networks should be designed (its architecture) to enhance performance and collaborative success.

4. Conclusion

Adopting a focus on control and trust as the orchestrators of collaborative performance within inter-organizational NRM networks, where both serve to mitigate perceived risks in different, yet potentially complementary ways, leads to an architecture of collaboration summarizing the key social mechanisms that shape and are shaped by NRM network collaboration. This is a helpful orientation, particularly as network managers seek to develop strategies that build and maintain inter-organizational collaboration, drawing on both formal and informal mechanisms of control. Moreover, through our overview of the definitions of multi-dimensional trust, perceived risk, and control, and in the discussion of the proposed relationships between these constructs, this paper provides additional conceptual clarity for researchers aiming to assess their complex relations in practice. To further facilitate future empirical assessment of these relations, we trialed a series of survey measures designed to operationalize the constructs presented in Fig. 1 and validated these measures for use in empirical analyses using data collected in the Salish Sea fishery context. There is now a need for a cumulative body of work to be developed based on reliable and valid instruments that can facilitate cross-level and cross-context comparisons (McEvily and Tortoriello, 2011). Further empirical research is needed to test the propositions presented in Section 2 in different inter-organizational NRM contexts. This will not only contribute to refining and enhancing their precision, but also the overall utility of the proposed architecture of collaboration to NRM network management. More specifically, there is a need to examine and analyze the various formal institutional arrangements like MOUs, treaties, legislation, and inter-group agreements operating in different NRM networks using case study research to qualify their effects on dimensions of collaborative trust and risk perception. Further analysis of the informal institutional arrangements, social control mechanisms, and inter-organizational risk perceptions specific to different resource systems would also be valuable to identify their effects on collaborative antecedents, like trust. Closer study of the interrelation between formal and informal control mechanisms within the proposed architecture would also be valuable.

By adopting a complexity perspective, we recognize that different dimensions of trust, perceived risk and control will evolve recursively among collaborating organizations, with shifts in the levels of trust and risk perceptions based on the current and past experiences of participants (Nielsen, 2004; Serva et al., 2005; Schweitzer et al., 2006; de Vries et al., 2015a), thereby challenging interpretation. Qualitative longitudinal case studies that map how trust and perceptions of risk evolve over time in relation to the various (formal/informal) control mechanism being used, would complement our quantitative approach, and provide much needed insights how the proposed architecture shapes and is shaped by collaborative performance in different settings. There is also an opportunity for more ethnographic-type research focusing on the ways in which various control mechanisms are produced, reproduced, and changed through the preferences and actions of individuals within organizations. Such research has the potential to help attenuate the

problems that prevent organizations from working collaboratively and coproducing knowledge (e.g., epistemological incongruities, different types of perceived relational risk), and may enhance the evaluation of NRM networks operating under high uncertainty. Efforts to link the impacts of specific control types to different dimensions of trust and perceived risk in relationship over time, by tracing their interactions and effectiveness, could highlight opportunities for practitioners to utilize complementary management strategies to enhance the collaborative performance of transboundary NRM networks.

Credit author statement

Conceptualization, G.M.H., R.V., J.R.D.V. and O.T.; Methodology, G.M.H., E.R., D.K., R.V. and O.T.; Formal analysis, E.R., D.K. and O.T.; Writing – Original Draft, G.M.H., E.R. R.V., A.S., J.R.D.V. and O.T.; Writing – Review & Editing, G.M.H., E.R., R.V., J.R.D.V., D.K., A.S. and O.T.; Funding Acquisition, G.M.H., J.R.D.V., D.K., and O.T.

Declaration of competing interest

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

Data availability

The authors do not have permission to share data.

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