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Research, part of a Special Feature on Social Network Analysis in Natural Resource Governance

Adaptive Co-management Networks: a Comparative Analysis of Two Fishery Conservation Areas in Sweden

Annica Sandström [1,2] *and Carl Rova* [1,2]

ABSTRACT. Co-management constitutes a certain type of institutional arrangement that has gained increased attention among both policy makers and researchers involved in the field of natural resource management. Yet the concept of co-management is broad, and our knowledge about how different kinds of management structures affect the ability to deal with challenges pertinent to the commons is limited. One of these challenges is to foster an adaptive management process, i.e., a process in which rules are continuously revised and changed according to what is known about the ecological system. We aim to address the relationship between different kinds of co-management structures and adaptive management. To this end, we conducted a comparative case study of two Fishery Conservation Areas in Sweden. The concept of networks and the formal method of social network analysis are applied as theoretical and methodological devices. Building on previous research, we propose that adaptive management processes occur in co-management networks consisting of a heterogeneous set of actors that are centrally and densely integrated. Networks of this kind are believed to promote a management process in which actors with disparate perspectives and resources formulate a common view regarding the condition of the ecosystem, the basic problem to be solved, and what measures to adopt. The empirical findings support the existence of such a relationship. Nonetheless, the restricted empirical material, an inability to control for hidden variables, and a lack of success in determining causality among variables are all factors that call for more research.

Key Words: *adaptive management, co-management, governance, natural resource management, social networks, social network analysis, SNA*

INTRODUCTION

The impact of different institutional arrangements and management systems on the state and sustainability of natural resources is a central theme in current environmental research. Because natural resources are affected by various and shifting social and ecological variables, one of the challenges stems from the fact that sustainable management systems must relate and adjust to a complex and ever-changing environment. The concept of adaptive management addresses this desirable quality (Walters 1986, 1997, Folke et al. 2002, Olson et al. 2004, Smajgl and Larson 2006, Janssen et al. 2007). Adaptive management is "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of trial and error" (Folke et al. 2002:20). Thus, in adaptive management systems, management rules are continuously reconsidered and adjusted in accordance with what is known about the socioecological environment. We define adaptability as the potential to respond adaptively, and it is empirically captured by verifying the existence of a framework of rules, recognition of ecological complexity, and the integration of such ecological knowledge into the rule-making process. Indeed, it is an important, as well as challenging, task for policy makers and practitioners at all levels of governance to foster the preconditions for such adaptive processes to evolve. Moreover, it is the role of research to generate more knowledge about how different kinds of management systems might affect the realization of adaptive management.

[1]Division of Social Science/Political Science Unit, Lule&aring, [2]University of Technology, Sweden

Empirical studies suggest that collaborative arrangements involving a multitude of actors from various sectors and user groups in management are more likely to establish adaptive processes than other types of systems (Pinkerton 1989, Ostrom 1990, Bromley 1992, Rova 2004, Sabatier et al. 2005, Baland and Platteau 2006). Structures of this kind are often refereed to as co-management structures in the literature, implying a division of authority and management tasks among various stakeholders, public as well as private (Olsson et al. 2004, Plummer and FitzGibbon 2004, Carlsson and Berkes 2005, Njaya 2007, Plummer and Armitage 2007). The theoretical argument is that co-management promotes the access to, and exchange of, both material and immaterial resources, such as money, technology, scientific knowledge, local experiences, and legitimacy. Furthermore, co-management is assumed to foster the rise of functional conflict-resolution processes as co-management structures constitute arenas for problem solving among involved stakeholders (Carlsson and Berkes 2005). Nonetheless, the concept of co-management is very broad and it covers a wide range of specific ways to organize management, which is why our knowledge about how these structures operate and affect performance is still limited. In particular, enhanced knowledge about how different kinds of co-management structures relate to adaptability is needed. In particular, we ask whether some kinds of co-management structures are more likely to be adaptive than others.

We address this question with a network approach. The adopted approach has several theoretical and methodological implications. First, co-management systems are perceived as social networks of actors, as co-management networks, or governance networks, because to their role in forming the rules of the game regulating resource use. The methodological bottom-up perspective acknowledges that other actors than those with formal authority, holding formal positions, might be involved in management (Sabatier 1986, Carlsson 1996). Thus, the real co-management networks might not correspond to formal co-management structures. Second, the network perspective implies that not only the characteristics of the involved actors but also the patterns of their interactions, i.e. the network structure (Friedkin 1981), determine the quality of the process and its outcome. Thus, we assume that some kinds of co-management networks are more adaptive than others because certain structural network properties enhance, for example, the process of resource exchange and the legitimacy of rules. Recently, the particular advantage of applying social network analysis (SNA) in the empirical study of co-management of natural resources has been proposed by several scholars (see, for example, Crona and Bodin 2006, Dougill et al. 2006, Janssen et al. 2006, Frank et al. 2007, Prell et al. 2007, Carlsson and Sandström 2008). With the use of SNA, the structural properties of co-management networks can be empirically analyzed and the question of how these properties relate to adaptability can be explored.

Aim

Our aim is to elucidate the relationship between certain types of co-management networks and the potential for adaptability. Does a relationship exist between structural network qualities and adaptability? For this purpose, we compare case studies of local fishery co-management networks within two Fishery Conservation Areas (FCAs) in Sweden. The two variables network structure and adaptability are studied by combining the quantitative SNA with qualitative and interpretive techniques.

Some limitations should be mentioned. The study examines the connection between the variables of network structure and adaptability at a given point in time. This means that the issue of causality will not be addressed, and that the possible influence from other hidden variables can not be ruled out. Additionally, the study is based on a small empirical sample, which is why the ambition is restricted to the possibility to falsify, rather than verify, the hypothesized relationship. Even so, we believe the study will contribute to contemporary research. As previous research has been dominated by single case study designs, the present study offers a good opportunity to address the correlation between specific types of structural network measures and adaptive management using a comparative approach.

NETWORKS AND ADAPTABILITY IN THEORY

The current study draws primarily on recent work by Carlsson and Sandström (2008) and Sandström and Rova (2010). Whereas the former approached the topic of social networks and performance in co-

management settings theoretically, the latter examined the relationship empirically. The theoretical argument for why networks are decisive for the outcomes of co-management was formulated by combining notions from policy network theory, institutional theory, and social capital theory (Carlsson and Sandström 2008, Sandström and Carlsson 2008). The founding idea is that networks, and their structural properties, affect the qualities of collaboration processes and, therefore, should be perceived as important variables in the search for explanations about success and failure.

Networks are formed by purposive actors in need of various types of resources, both material and immaterial (Scharpf 1978, Coleman 1990, Lin 2001). These resources are exchanged through interactions that form webs of social relations (Rhodes and Marsh 1992, Elmore 1993, Thatcher 1998). Proponents for a network approach consider these webs or networks as decisive because they affect actors' behavior. Thus, the purpose, interest, and resources of the participating actors are likely to affect performance. At the same time, the specific features of the relational webs also matter for the turnout (Friedkin 1981, Knoke 1990, Powell 1990). These webs of interactions, or networks, both reflect and are affected by the institutional context, i.e, the framework of rules, into which they are embedded (North 1990, Carlsson 2000, Ostrom 2005). However, they also affect the rules of the game and, accordingly, are institutional entities (Granovetter 1985, 1992). Thus, a dialectical and ongoing relationship between network and agency, between network and context, and between network and outcome, is assumed (Marsh and Smith 2000). The founding theoretical framework acknowledges both agency and structure. However, we focus exclusively on the variables of network structure and, more specifically, on particular aspects of network structure and outcomes in terms of adaptability.

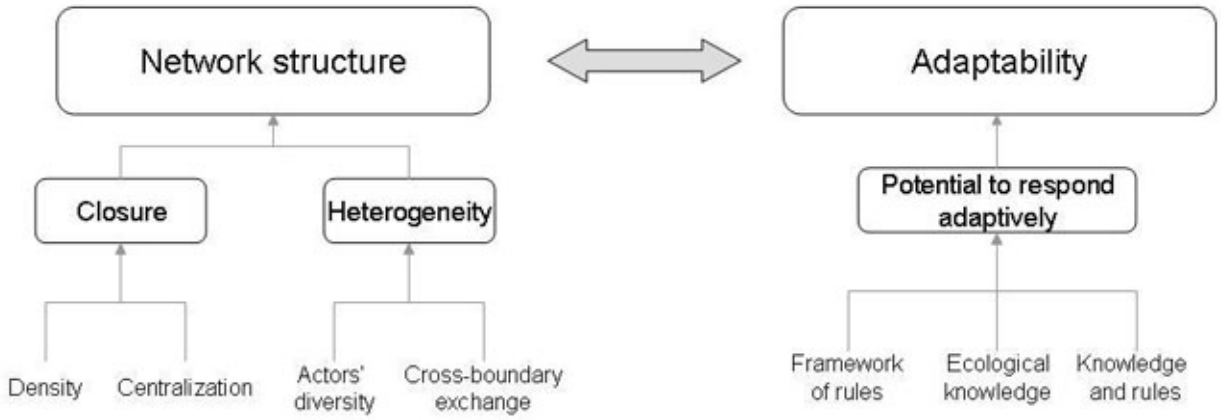
Figure 1 presents the analytical design of the study. The theoretical concepts of closure and heterogeneity are applied to determine the structural properties of the co-management networks. To capture these properties empirically, we investigate network measures such as density, centralization, actors' diversity, and cross-boundary exchange. For the sake of determining adaptability, we analyze the management processes in relation to existing management rules, prevailing ecological knowledge, and the link between knowledge and rule-making. The adoption of these concepts and measures is described below.

Closure and Heterogeneity

The reasoning specifying the tentative relationship between structure and adaptability is primarily adopted from Burt (2000), who suggests that two structural features affect co-management performance, namely, "network closure" and "structural holes." The concept of network closure refers to structures that are well-integrated, either directly through many connections, or indirectly through coordinating actors (Burt 2000). A closed structure promotes collaboration and facilitates the creation of a common priority process. This idea is closely associated with Coleman's (1990) notion of effective norm-generation and trust-building within closed structures, or Lin's (2001) proposition regarding the strengths of strong ties for expressive action. For our purposes, closure is assumed to increase the capacity of a co-management network to establish, uphold, and maintain the rules of the game.

On the other hand, the structural holes argument emphasizes the importance of bridges between otherwise unconnected actors, or sets of actors, for the sake of mobilizing diversified resources and increasing performance (Burt 2000). Similar ideas have been proposed by, for example, Granovetter (1973) and Reagans and McEvily (2003). Carlsson and Sandström (2008) used the concept of network heterogeneity (Reagans and Zuckerman 2001), which refers to networks that consist of a rich diversity of different types of actors involved in extensive cross-border collaboration to capture this structural feature empirically. We also use heterogeneity as a proxy for bridges over structural holes, because the methodological approach fails to capture these links. The reason for this stems from the theoretical notion of co-management networks as institutional entities. Institutions are the rules of the game (North 1990), or the prescriptions that organize repetitive and structured interactions among stakeholders (Ostrom 2005). Accordingly, institutional structures are assumed to be composed of more stable connections, as stability and regularity are prerequisites for institutional processes to evolve. At the same time, bridging ties are essentially weaker (Granovetter 1973, Friedkin 1980). Thus, the empirical unit of analysis, as it is

Fig. 1. Analytical design.



understood here, i.e., the co-management network forming the rules of the game, does not include these bridging ties. To deal with this problem, it is assumed that co-management networks that involve a rich diversity of actors, representing various sectors of society, will accordingly also include many bridging ties, although these are not measured explicitly using the research design applied here (see Sandström 2008).

We approach network heterogeneity as enhancing the acquisition of relevant resources in co-management, for example, ecological knowledge. Thus, both closure and heterogeneity are tentatively positively correlated with the important organizing functions of problem definition, prioritization, and resource mobilization in the management process (Sandström and Carlsson 2008). The conceptual reasoning regarding closure and heterogeneity is comparable with the discussion on bonding and bridging ties in social capital theory (Woolcook and Narayan 2000, Crona and Bodin 2008).

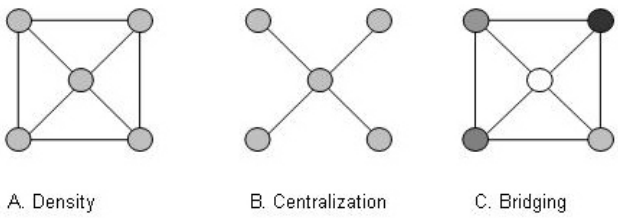
If adaptive management is defined as an active process in which rules are revised and changed based on a continuous inflow of ecological knowledge, the achievement of such a process can easily be related to the two network features discussed above. The general hypothesis is that although network heterogeneity facilitates access to different types of ecological knowledge, network closure promotes the ability to set, maintain, and monitor common management rules. Sandström and Rova (2010) studied this hypothesis in a single case study of a fishery co-management network. The empirical findings concurred with the theory, in the sense that the hypothesis could not be falsified. Yet, the limitations of a single case-study design called for more research. With the point of departure in the theoretical framework described above, this study sets out to continue our search for more knowledge about the relationship between closure, heterogeneity, and adaptability in natural resource management. Thus, the research question we posed earlier can be reformulated and further specified: do network closure and heterogeneity relate to adaptability and, if so, in what respect?

Empirical Measures

Network closure

Two measures, namely, density and centralization, are used as empirical indicators of network closure. These measures reflect how well connected a network is. Density is calculated by dividing the number of present connections with the maximum number of possible connections (Scott 2000). Structures like Network A (Fig. 2), in which all actors are completely connected, have a density of 1.

Fig. 2. Different network structures.



Networks might also be well connected and characterized by closure through a coordinating actor, and this structural aspect is measured by network centralization. Different notions of centralization exist (Bonacich 1987, Freeman 1978–1979,Freeman et al. 1979–1980, Friedkin 1991, Wasserman and Faust 1994). For our purposes, we use the concept of "degree centralization." Centralization can be explained as a calculation in several steps that starts at the individual level. First, the centrality of each individual actor is examined by counting the number of direct links connecting an actor, ascribing the most connected actor the highest centrality value. Second, the variation in centrality values is determined by summarizing the differences among the most central actor and every other actor in the network. This sum is then divided by a theoretical value reflecting the maximum possible sum of differences (Wasserman and Faust 1994, Scott 2000). Thus, network centralization reflects to what extent one actor is central for the management activities, or how "star-like" the structure is. Network B (Fig. 2) illustrates a network with the highest centralization level possible, i.e., 100%. High density and centralization levels are considered as empirical measures of network closure.

Network heterogeneity

Network heterogeneity is captured here by two measures: actors' diversity and cross-boundary exchange (Sandström and Carlsson 2008). A similar approach was used by Reagans and Zuckerman (2001). Actors' diversity is calculated by counting the number of organizations represented in the network. The cross-boundary character of the network is examined by calculating the percentage of network ties connecting actors from different organizations. The number of ties connecting actors with different affiliations is divided by the total number of connections in the network. Together, these two measures reflect the diversity of resources available and how these are exchanged. Thus, a network with many links among different types of actors, or actors representing different types of organizations, is perceived as heterogeneous. See, for example, Network C in Fig 2., where different shades of grey reflect different organizations. Closure is a compound measure, determined through density and decentralization. Likewise, heterogeneity is a compound measure, determined by one structural measure, that is, cross-boundary exchange, and one non-structural measure, that is, actors' diversity.

Adaptability

The adaptability of management is determined here by analyzing how the respondents describe the rule-making processes (Appendix 1). The following topics and questions guide the interpretation: (1) Framework of rules: are there rules that regulate access to and appropriation of the resource? If so, are these rules known, used, accepted, and followed by the users? These questions are determined by analyzing the actors' responses to questions 8–9, 15–19, and 25–28 in Appendix 1. (2) Ecological knowledge: do actors involved in the rule-making process consider the resource system to be complex, non-linear, and characterized by uncertainty? Are observations, experiments, and learning important parts of the rule-making process? These questions are determined by analyzing the actors' responses to questions 10–14 in Appendix 1. (3) Knowledge

and the formulation of rules: are rules continuously changed in reaction to existing ecological knowledge? Do the conditions of the ecosystem constitute criteria for when and how rules are altered? These questions are determined by analyzing the actors' responses to questions 23–24 in Appendix 1. Affirmative answers to the thematic questions above indicate that the management process is adaptive.

METHOD AND DATA COLLECTION

Fishing rights in the inland and coastal waters of Sweden are connected to properties and belong to various types of actors: private persons, companies, municipalities, the church, or the state. Often, several property owners have fishing rights in the same waters. To handle these sometimes very complicated ownership patterns, and to enhance the possibility to commonly manage the waters, FCAs can be established (Fishery Conservation Areas Act 1981:533, Dyhre and Edlund 1982). An FCA is a state-regulated management regime that incorporates the fishing rights of all owners within a certain geographical area. The access and appropriation rules are jointly set, formally, during annual summits where fishery-rights owners are entitled to participate. Between those meetings, an elected board is responsible for the operational work (Fishery Conservation Areas Act 1981:533). Thus, in administrative terms, a FCA is a property-based co-management system (Piriz 2005).

We conducted a comparative analysis of co-management networks within two FCA situated in the middle and inland parts of Sweden. A co-management network is defined as the social network of actors involved in the rule-making process. In accordance with the methodological bottom-up perspective, the real rule-making structure might in fact involve other actors and constitute other power relations than what is depicted by the formal legal framework briefly presented above (Hull and Hjern 1987, Hjern and Porter 1997, Carlsson 2000). For example, a previous study has shown that the management process of an FCA might be characterized by deliberate elements, i.e., discussions, bargaining, and resource exchange, among both fishery-rights owners, i.e., those who are mandated to rule by law, and other interested stakeholders (Sandström and Rova 2010). To clarify, a person can be a fishery-rights owner without being an actor; likewise, a person can be an actor while lacking the formal mandate to govern. This is why the social network of actors involved in the management process, and not the elected board or the set of formal property owners, constitute the unit of analysis used here. We empirically define an involved actor as a person involved in regular discussions and communications concerning the rules of the FCA. Thus, by mapping the communication patterns among actors, the rule-making co-management network is captured.

The current study was conducted in the autumn and winter of 2007 and 2008. Data describing the two co-management networks with regard to network structure and adaptability were collected through numerous steps (see Fig. 1). To start with, a qualitative interview study was conducted to learn about the management processes and to start the identification of involved actors (Appendix 1). The respondents were selected using a "snowballing interview technique" (Miles and Huberman 1994), starting with the chairs of the boards and subsequently letting respondents nominate additional respondents. The respondents were asked to name other actors involved in management. The identified persons that were considered as important for the management process were then interviewed, and this process continued until no new actors were ascribed to any central role in management. Seven semistructured interviews were carried out in Network A, and eight interviews were conducted with people from Network B. The interview study generated two lists of names with potential actors, representing 24 individuals from each FCA.

As a second step, a survey was distributed to all 48 actors mentioned during the interview study for the purpose of mapping the patterns of relations, i.e., the network structure. The questionnaire listed all names, and asked actors who they would usually talk to about the goals, rules, and routines of the FCA. The respondents were asked to mark the actors they communicate with about this topic. Note that two sociometric questions were asked, however, only the first one is analyzed here. (See Appendix 2.) They were also given the opportunity to complement the list with new names. This technique is very much in line with the adopted bottom-up methodology.

The response rates were 92% and 91% respectively. The network data were processed in UCINET6 and Netdraw (Borgatti 2002, Borgatti et al. 2002). Given that our aim was to study co-management networks,

here perceived as institutional entities reflecting and forming the rules of the game, only the stronger and more stable network relations are included in the analysis. Institutional processes require certain stability and regularity, which is why webs of weaker connections should not be confused with structures of that kind. Reciprocity is one empirical indicator of tie strengths (Friedkin 1980), which is why only reciprocated ties are considered here. The exclusion of actors with asymmetric ties explains why the networks in the next section contain a smaller number of actors. Moreover, research has shown that the accuracy of the reported information is improved when working with stronger ties (Freeman et al. 1987, Marsden 1990, Wasserman and Faust 1994, Bell et al. 2007). The steps taken to transform the raw data set and the procedures run in the program are described in Appendix 3.

RESULTS

Comparative Analysis of Adaptability

The assessment of the co-management networks' adaptability is summarized in Table 1. Below, we discuss the similarities and dissimilarities of the two networks.

Framework of rules

Both areas are governed by an institutional framework of rules that regulates who can utilize the resource, when it can be utilized, and how it can be utilized. See the first column in Table 1 for more detail. For example, there are access rules that stipulate that fishing requires a license, and appropriation rules that regulate what kinds of actions are allowed, e.g., minimum sizes and bag limits, permitted equipment, geographical and seasonal restrictions.

In practice, the rules-in-use that actually structure behavior might differ from these rules-in-form (Ostrom 2005). The acceptance of, and compliance to, formal rules cannot be assumed. The general perception is that most users do respect the rules. According to the respondents, sport fishers and tourists are more inclined to follow regulations than some local people, and particularly those of the older generation. This situation is acknowledged by actors in both networks. Nonetheless, differences in compliance with rules are evident, and the problem is more significant in Network B than in Network A. To clarify, six out of eight actors in FCA B emphasized compliance as a problem, whereas only two respondents in FCA A identified rule-breaking behavior to be a problem.

A spirit of collaboration and a common view regarding the overall goal and direction of the FCA was reflected in the interviews with actors from Network A. The respondents promoted the growing tourism sector and expressed their support for prevailing management rules. According to the chair of this FCA, "everyone is working for what is best for the community [...] there are no groups pursuing their own agendas." The same individual emphasized the importance of sustaining a cooperative atmosphere and put a lot of effort into negotiating and anchoring ideas and strategies among different groups of users: "If radical changes are suggested, we want people to know about it, and be able to discuss it, to ensure that no one feel sidestepped." A component of this success is that the users perceive current management rules to be highly legitimate.

In Network B, on the other hand, no common view concerning the appropriateness of management rules was reflected in the interviews. On the contrary, the existence of two groups with opposite perspectives and opinions concerning the aim and future direction of the FCA became apparent. One group wanted to form regulations to promote sport fishing and tourism. The other group shared the opinion that the primary aim of the FCA should be to facilitate locals' access to the resource, e.g., by allowing fishing from boats and net fishing. These opinions are pertinent to the fundamental goal of management and, evidently, the process of deciding upon goals and means that are ridden with conflicts. The chair of FCA B states that "there are often wild discussions at our annual meetings, for example, if there are proposals for boat prohibitions or net prohibitions." To conclude, Network B struggles with substantive controversies, and the perceived legitimacy of prevailing management rules is comparatively lower in Network B than in Network A.

Ecological knowledge

The respondents indicated an understanding of the ecological system as essentially complex,

Table 1. Aspects of adaptability.

	Framework of rules	Ecological knowledge	Knowledge and rules
Network A	Rules are in place	Ecosystem perspective	Continuous rule-making process
	Strong rule-obedience is evident	Science, systematic observations, and local experiments	Ecological criteria guide the rule-making process
	Accepted management rules	Common view regarding the status of the ecological system	
Network B	Rules are in place	Ecosystem perspective	Continuous rule-making process
	Conflicting views are evident concerning the substance of rules	Science, systematic observations, and local experiences	Ecological criteria guide the rule-making process
	In general, strong rule-obedience is evident, but rule-breaking behavior among some user groups	Conflicting views concerning the reliability of ecological knowledge	
		Skepticism regarding scientific knowledge	
		Conflicting views regarding the status of the ecological system	

nonlinear, and dynamic. Knowledge about the state of the resource, and changes within, is acquired through the users' own experiences and by the input from scientific expertise. See the second column in Table 1 for more detail. Both management areas have participated in different scientific projects that have generated new information about the resource system. Expertise at the county-administrative board supports the management areas on a more regular basis.

Fishery Conservation Area A has a long history of working with scientific projects, which has brought about an understanding of the scientific community as well as an understanding of how to assimilate new ecological knowledge. A member of the board said that "there is more fish now due to the rules generated from the scientific experiments." The management of this area works actively to sustain a continuous inflow of knowledge. Fishery Conservation Area A has a well-functioning catch reporting system, and fishermen have been interviewed out in the field, to ensure access to reliable information regarding catches. These practices generate broadly accepted indicators of the status of the ecological system and, therefore, could be one explanation as to why the respondents in this network share a fairly common understanding of the ecological status of the system.

The respondents from FCA B stressed that prevailing knowledge about actual catches and the fishery resource is insufficient. Conflicting views regarding the condition of the ecological system and the reliability of ecological knowledge were evident in the answers. According to the chair of FCA B, "a lot of elderly people are skeptical towards knowledge generated from scientific experiments." Another member of the board states that "some of us adopt scientific advice but there are people who think that it is merely nonsense. Some actors expressed a notable skepticism toward scientific knowledge. The controversies among different groups, i.e., traditional fishing for locals or sport

fishing and tourism, became evident. An advocate for more traditional fishing, and in this case also a member of the board, expressed the view that "the academic representatives have their focus on fly fishing." Thus, researchers are perceived as agents for the tourism industry. To summarize, Network B struggles with conflicting views regarding the usefulness of scientific knowledge and the actors have disparate views regarding the state of the resource system. One of the university actors concluded that "the fish stock has decreased during the past years, probably because of overfishing. But I don't think that the management has realized that."

Knowledge and rules

Most respondents in both areas expressed a clear ambition to establish an adaptive management process, and gave several examples of how ecological criteria have guided the formulation of new rules. See the last column in Table 1 for more detail. A member of the board of FCA B is quoted as saying: "Nowadays, the statistics presented from the county administrative board affect the rules." A member of the board of FCA A stated that "the rules about bag limits and fishing prohibition within certain geographical areas are direct results of the research project." Thus, rules have changed as new ecological information has been generated in both FCAs. According to the chair of FCA A, fisheries management is a never-ending learning process: "We will never find one strategy for how to manage our area. Instead, we need to be active and test new methods." With rules holding high legitimacy, and cooperation with the university community being well developed, the critical prerequisites for adaptive management to evolve are in place in this FCA. One important condition for adaptive management is that rules are accepted and followed. This latter condition has not been fully attained in FCA B, as rule-breaking behavior among certain user groups was identified as a problem by the actors interviewed. Thus, a comparatively lower level of legitimacy for rules was detected within Network B. This problematic situation is probably related to the lack of a common goal and common perception of the state of the resource system. Thus, even though management rules are changed in response to ecological criteria, the rules are contested and not always accepted and followed. To summarize, the link between ecological knowledge and rules is weaker in Network B than in Network A.

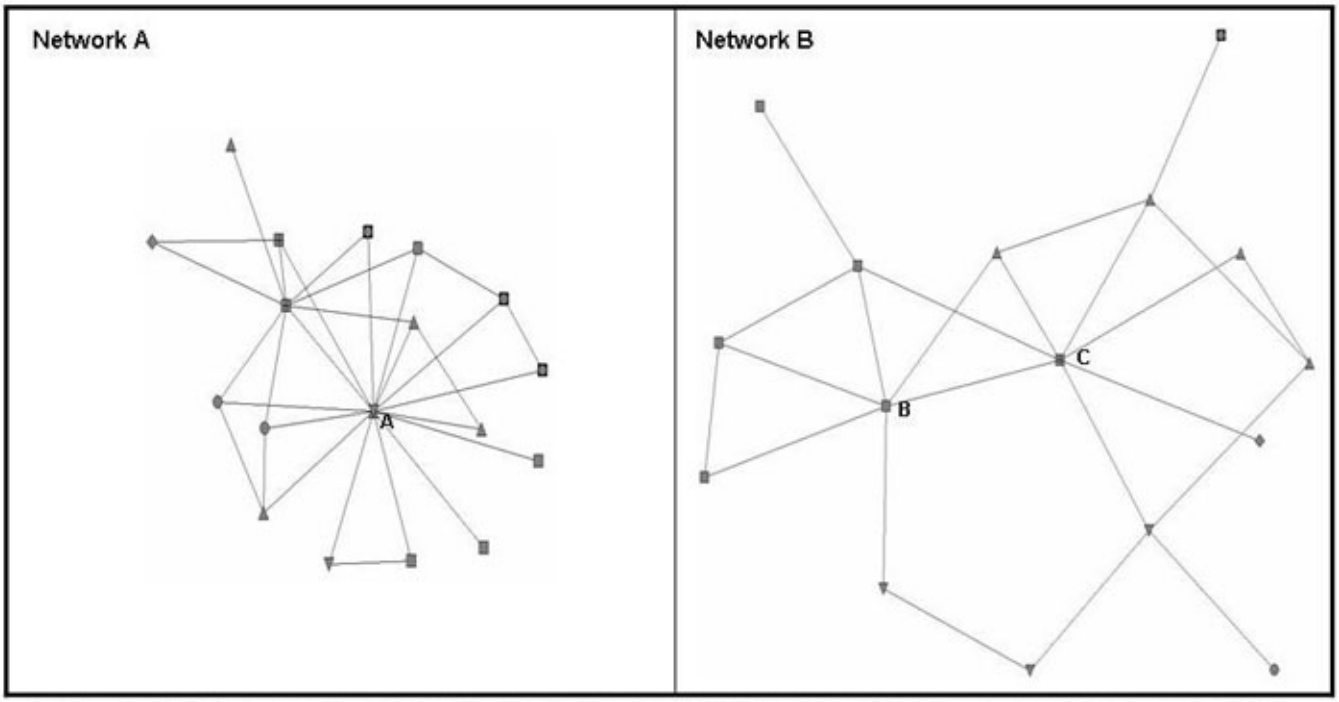
Comparative Social Network Analysis

Figure 3 shows the two fishery co-management networks. It should be noted that two actors from Network A were excluded from the figure, and from the analysis that follows, as they became unconnected from the main network when the data set was transformed, excluding the asymmetric links. According to the adopted definition of co-management networks, as composed of strong links only, these individuals are not considered as actors in the rule-making process. All nodes are shaped according to the actors' affiliations. Figure 3 shows two diversified networks of similar sizes, although seemingly structurally different. Network A is considerably more tightly connected around one actor than Network B is. Node A in Network A is easily detected as the central actor coordinating the rule-making process. This actor has double affiliations, being both a commercial actor and the chair of the board. It is also clear from the figure that this central actor connects diverse actors who would otherwise be disconnected, and bridges numerous organizational borders. Thus, the coordinating role of the chair in FCA A that was so clearly reflected in the interviews corresponds well to the structural position of this actor.

Network B is significantly less centralized and, here, the most central actor is a person who belongs to both the academic community and the county administration board, the state authority on the regional level (Node C in Network B). The chair of FCA B is represented by Node B in Network B. When analyzing how actors with different affiliations are linked in this figure, it seems that there are two groups of actors in the network. There is one group, to the right in the figure, that consists of public administrative actors (represented by the up triangles) and scientific actors (represented by the diamonds and the box), and one group to the left comprising the board of the FCA (represented by squares). Based on the figure, the communication pattern within Network B is more intra-organizational than in Network A.

Table 2 presents the social network data describing the network characteristics of the two co-management networks. Network A is slightly larger and has a marginally higher density value compared with Network B. The density measure is dependent on network size. A small network needs a higher density value than a large network, to reflect the same level of cohesion (Friedkin 1981). In this case,

Fig. 3. Rule-making network.



Network A is slightly larger with two more actors. At the same time, Network A also has a slightly larger density value than Network B. Thus, no notable difference occurs when comparing the two density measures. However, by analyzing the network centralization measures, structural differences become evident. The numbers in Table 2 verify the assumption that Network A is much more star-like than Network B.

Both networks involve actors from a variety of organizations that represent different sectors of society. However, the process in Network A is of a much more cross-boundary character than the process in Network B. Thus, the initial notion of structural differences regarding both centralization and cross-boundary exchange that was based on the representations in Fig. 3 is verified by the information in Table 2. Consequently, the social network analysis indicates the existence of structural differences between the two co-management networks. Network A is considerably more centralized and cross-boundary than Network B.

DISCUSSION

Our purpose was to elucidate the relationship between certain types of co-management networks and the potential for adaptability. Table 3 summarizes the empirical data. What findings can be generated from a comparative analysis, and how do these findings correspond to the theoretical hypothesis and previous research? Do network closure and heterogeneity relate to adaptability, and, if so, in what respect?

In Table 3, we can conclude that Network A is a closed and heterogeneous network, whereas Network B is characterized by relatively lower levels of both closure and heterogeneity. The

Table 2. Rule-making networks.

	Size (Nr)	Density (D)	Degree Centralization (%)	Actors' diversity (Nr)	Cross-boundary exchange (%)
Network A	18	0.20	70	7	71
Network B	16	0.19	31	6	39

comparative analysis suggests that both co-management networks are adaptive in the sense that rules are continuously changed based on prevailing ecological knowledge. See the last column in Table 1 for more detail. Thus, the idea of a direct relationship between a high level of closure and an active rule-making process, as suggested by Sandström and Rova (2010), is not fully supported by our data. Nor is a direct relationship clearly evident between heterogeneity and the existence of ecological knowledge in management, also proposed by Sandström and Rova (2010). To clarify the argument, even though significant differences in closure exist, both networks revise and change rules on a regular basis. Despite notable differences in heterogeneity, both processes encompass an ecosystem perspective and make use of science and systematic observations. As such, should the idea of closure and heterogeneity as decisive variables relating to adaptability be rejected? The answer to this question is no.

Comparing the networks, some clear differences regarding specific aspects of adaptability emerge. These differences are italicized in Table 3. To start with, Network B struggles with conflicting views regarding the substance of rules, and suffers from lower rule-compliance than Network A. For a management process to be interpreted as truly adaptive, rules have to be implemented and followed, which is not the case in Network B. This downside of management could tentatively be related to the lower level of closure within this network, even though causality cannot be inferred. The basic argument is that the disintegrated structure relates to the absence of a common problem definition and prioritizing process, hindering effective rule-making. Within Network B, different perceptions, goals, and interests are competing, and the formal management rules suffer from legitimacy deficits. Network A, being a well-connected structure with high closure, does not share these problems.

Other notable differences relate to how the ecological system is understood and the perceptions of how knowledge about these systems can be acquired. Contrary to the situation in Network A, the actors in Network B have disparate views concerning the condition of the resource, e.g., the size of fish stocks, as well as about how to utilize the resource, whether to promote tourism or not, and what management rules are the most appropriate. They also express divergent viewpoints regarding the usefulness and reliability of scientific information. The absence of a common knowledge base and a common understanding of the ecological system to work from could influence the disintegrated structure previously discussed and the relatively lower level of heterogeneity within Network B. Heterogeneity is likely to promote learning across borders, for example, between scientists and users. In Network B, this process has not been successfully achieved within the rule-making network.

Thus, although the relationship among closure, heterogeneity, and adaptability might not be as straightforward as suggested by previous studies, the findings generated by our work concur with current theory. To specify, the idea that network closure and heterogeneity promote the establishment of a common process in which actors with disparate perspectives and resources formulate a common view regarding the condition of the ecosystem and decide on necessary action to enhance the resource, is still a valid hypothesis.

Table 3. Network structure and adaptability.

	Network structure:		Adaptability:		
	Closure	Heterogeneity	Framework of rules	Ecological knowledge	Knowledge and rules
Network A	High	High	Rules are in place *High rule-compliance* *Accepted management rules*	Ecosystem perspective Science, systematic observations, and local experiences *Common view regarding the status of the ecological system*	Rules are continuously changed based on ecological criteria
Network B	Low	Low	Rules are in place *Conflicting views concerning the substance of rules* Generally high obedience, *thus, rule-breaking among locals*	Ecosystem perspective Science, systematic observations, and local experiences *Conflicting views regarding the reliability of ecological knowledge* *Skepticism toward scientific knowledge* *Conflicting views regarding the status of the ecological system*	Rules are continuously changed based on ecological criteria

Note: Italics indicate evident differences regarding aspects of adaptability.

CONCLUSION

The search for appropriate management systems governing the commons is a necessary and demanding task for present-day and future policy makers. The shift from government to governance, and from political administrative hierarchy to various types of collaborative structures (see, for example, Kickert et al. 1997, Koppenjan and Klijn 2004) suggests a shift in perspective concerning how these systems should be designed. In this vein, the specific advantages of co-management have been suggested. Certainly, we need more knowledge about how these types of systems operate and deal with the challenges related to the commons. The main theoretical argument proposed herein is that some kinds of co-management networks are better performing and more adaptive than others. Further, the importance of refining the concept of co-management to comprehend the vast structural variety of different types of collaborative structures is emphasized. Finally, the application of a network approach and social network analysis has proven valuable and promising, as the methodological tools can generate a greater depth of knowledge about the full complexity of co-management of natural resources. Such knowledge is crucial when designing management systems for the future.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/volXX/issYY/artZZ/responses/

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APPENDIX 1

Background

1. Name

2. Age

3. Do you live within the geographical area of the Fishery Conservation Area (FCA)? Have you immigrated into this area?

4. Have you participated in similar management processes previously? Do you have previous experiences working with non-profit associations (movements, political parties, etc.)?

5. In what way do you use the resource?

6. What kinds of expectations do you have concerning the results of your engagement in the FCA in both short- and long-term perspectives? Do you think that your future possibilities to use the resource will be affected by your involvement in the process in either the short or long term?

7. Are you representing someone other than yourself in the management process (i.e., do you represent any special organization or any special interests)?

About the Resource

8. What resource(s) are managed within the FCA? Is there a clear boundary stipulating what the scope of the management system is? Does the management system overlap any other system governing other resources or other areas?

9. Can you, within the frame of the FCA, affect the supply and quality of the resource or is the resource strongly affected by external factors beyond your control?

10. How would you describe the condition of the resource? What is the ecological state of the area? How “healthy” is the resource?

11. How do you gain knowledge about the state of the resource system (methods for measurements, systematic observations, or “just knowing” and own experiences)? Who provides this information? Do you have access to reliable information concerning the resource (quantities, health, etc.)?

12. Who has access to information regarding the state of the resource? Do all users have this information? How is the information distributed among users?

13. Is there a common view concerning the state of the resource among those participating in the management of it or do different points of view exist concerning these issues?

14. Is the resource supply fairly predictable? Do people know, on average, what catches to expect or do large variations or irregular variations exist in supply?

About the Management System

15. Are there rules stipulating who has the right to participate in the management of the FCA? What do these rules say and how do they actually work?

16. Are some people more influential than others? If so, who?

17. Do those who use the resource take part in the management of it or are there groups of users excluded from the management system?

18. What is the goal of the FCA? How has this goal been processed? Who participated in the process?

19. Is there a management plan for the FCA? How was this plan processed? Who participated in that process? Is the plan known and used? Is it continuously reviewed and reversed? If not, why not?

20. Are there rules stipulating who is entitled, and who is not entitled, to fish within the FCA?

21. How have these rules been processed? Are the rules clear? What do the rules say and how do they actually work?

22. Are there rules stipulating when and how one can fish—for example, during what periods, with what equipment, and in what quantities? What do the rules say and how do they actually work?

23. How have these rules been processed? Who participated in that process? Based on what criteria are these decisions made? Does prevailing information regarding the state of the ecological system and the resource supply influence this process?

24. Are the appropriation rules based on the heath of the resource? Are the rules changed and adapted according to changes in the resource? Provide examples. Elements of learning in this process of rule-formation? Have the experiments (the project together with the university) influenced the formation of rules or, more generally, influenced the activities within the FCA? If so, in what way? Do you think that the rules set by the FCA have affected the supply and quality of the resource?

25. Do the rules stipulate and clearly define what is to be regarded as rule-breeching behavior? Do rules exist stipulating what courses of actions are taken when someone breeches the rules? If so, what do the rules say? Do graduated sanctions exist? What do the rules say and how do they actually work?

26. How are the rules monitored? Who participates in this process? What do the rules say and how do they actually work?

27. Do you think that the rules are obeyed? Are there any differences between the formal rules and “what people actually do”? Provide examples.

28. What happens in cases when those of you participating in the process have different points of view? Provide examples. How are differences handled? Is there a certain course of action to pursue on these occasions? What do the rules say and how do they actually work?

Network

29. With whom do you, on a regular basis, discuss issues concerning the goals and routines of the FCA?

30. With whom do you, on a regular basis, discuss issues concerning the resource supply and the state of the ecological system?

Relation to other Actors

31. Does the legal framework regulating the FCA provide appropriate prerequisites for managing the resource in a good way? Does the FCA have access to necessary resources such as money, knowledge, and contacts in order to manage the area satisfactory?

32. What relationship does the FCA have to the County Administrative Board and other public administrative actors, including the municipality? What is the level of mutual understanding? Have these relations changed over time? Have the experiments affected the state of these relationships?

33. What relationship does the FCA have to the university and scientific representatives? What is the level of mutual understanding? Have these relations changed over time? Have the experiments affected the state of these relationships?

34. Are there any other important actors?

APPENDIX 2

ARE YOU A PART OF THE NETWORK RELATED TO THE FISHERY CONSERVATION AREA?

- The questionnaire, which starts on the next page, includes two questions:

  Question I asks who you usually talk to about the goals, rules, and routines of the FCA. The question is followed by a list of names. Your task is to mark the persons to whom you usually talk concerning these issues.

  Question 2 asks to whom you usually talk concerning the ecological status (i.e., the physical condition of the fish and waters of the FCA)? The question is followed by a list of names. Your task is to indicate the persons to whom you usually talk concerning these issues.

- If you have not had any repeated contacts in discussing the ecological status or the rules and routines of the FCA, leave the questionnaire blank. However, it is still important that you return your answer!

- If persons are missing from the list, add those names to the list.

Thank you for your participation!

1. Who do you usually talk to about the *goals*, *rules*, and *routines* of the Fishery Conservation Area? Indicate this by marking the square behind the person's name.

Name	**X**
Actor A	
Actor B	
Actor C	

2. Who do you usually talk to about the *ecological status* (i.e., the physical condition of the fish and waters of the FCA)? Indicate this by marking the square behind the person's name.

Name	**X**
Actor A	
Actor B	
Actor C	

APPENDIX 3

1. A data file is created from the raw data
File/ Text editor/ Create a DL-file; format = nodelist1

2. The data is imported into UCINET6
Data/ Import text file/ DL

3. In order to work with only reciprocated links and to give each relation the value of 1 the following steps were taken:
Transform/ Symmetrize/ chose “sum”
Transform/ Recode/ values 0-1 are recoded as 0, values 2 are recoded as 1
Data/ Remove/ Remove isolates

4. Calculate overall **Density** using UCINET function

5. Calculate **Centralization** indexes using UCINET function

6. In order to visualize import the files into **Netdraw** and choose the **Spring embedding** function