Contribution of bridging organizations to marine/coastal governance – a social network analysis of working groups

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Marine Affairs

University of Washington
2013

Committee:
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Program Authorized to Offer Degree:
School of Marine and Environmental Affairs

University of Washington

Abstract

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The linkage of diverse sets of actors at different management levels and across institutional and organizational boundaries is at the core of adaptive governance regimes but often poses one of the greatest challenges in managing our natural resources. Bridging organizations can form these important linkages and facilitate interactions among actors in governance regimes by lowering the transaction costs of collaboration. The Center for Ocean Solutions (COS) is an example of a bridging organization that is focused on linking actors within the ocean sciences and governance arena, in part, through the use of working groups. This research examines how network connections between group members affect working group functionality and, more specifically, whether cohesive network structures allow groups to more effectively achieve their goals and objectives. A mixed-methods approach, incorporating both qualitative and quantitative data collection and analysis methods, is employed to understand the structural characteristics of COS working groups. The study finds that cohesive network structures are not associated with increased working group functionality. Strong, centralized leadership is a better predictor of working group success in achieving goals and objectives.

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Chapter 1. INTRODUCTION

A paradigm shift is occurring within the environmental sciences that recognizes that the use of natural resources, such as fisheries, forests, and fresh water, are part of complex social-ecological systems (SESs) embedded in specific social, economic, and political settings (Ostrom 2009). The governance and management of SESs to promote socioeconomic and ecological sustainability are, therefore, increasingly requiring the cooperation and collaboration of numerous and diverse groups of actors. Actors within a given SES may include resource users, policymakers, scientists, advocacy groups, and the general public.

This understanding has led to the emergence of adaptive co-management and governance frameworks. Regimes within such frameworks are thought to be capable of addressing the vast social and ecological complexity and uncertainty associated with SESs due to their ability to integrate different knowledge systems and flexibility to respond to dynamic natural and anthropogenic pressures (Folke et al. 2005;Olsson et al. 2007). As Olsson et al. (2004: 75-76) note, "Adaptive comanagement relies on the collaboration of a diverse set of stakeholders operating at different levels, often in networks, from local users, to municipalities, to regional and national organizations, and also to international bodies."

The linkage of diverse sets of actors at different management levels and across institutional and organizational boundaries is at the core of adaptive governance regimes but often poses one of the greatest challenges in managing our natural resources. Bridging organizations, as termed in academic literature, are organizations that can form these critically important linkages and facilitate interactions among actors in governance regimes by lowering the transaction costs of collaboration through the co-production of knowledge, coordination of tasks (i.e. framing, building vision and goals, information and resource assessment), trust building, and social learning (Folke et al. 2005;Olsson et al. 2007;Berkes 2009;Crona and Parker 2012). Bridging organizations, thus, play a central role in creating, maintaining, and enhancing governance networks within the natural resource management arena.

The Center for Ocean Solutions (COS), a non-profit organization led by Stanford University, is an example of a bridging organization that is focused on linking actors within the ocean sciences and governance arena at the local, regional, and global scales, in part, through the use of working groups. Working groups within and convened by COS aim to engage various actors across scales and disciplines to solve specific marine-related environmental and socioeconomic problems and, thus, can be seen as one specific mechanism by which COS uses to facilitate interaction among its partners.

Given that bridging organizations, like COS, as well as individual participants invest a substantial amount of resources into designing, implementing, and hosting working groups, research concerning the functionality or effectiveness of working groups and similar bridging mechanisms is required to see if such initiatives are worth the organizational and individual investment. This study uses social network analysis (SNA) to examine how network connections between group members affect working group functionality and, more specifically, the success of each working group in achieving its stated goals and objectives. A mixed-methods approach, incorporating both qualitative and quantitative data collection and analysis methods, is employed to understand the structural characteristics of COS working groups.

This study is organized into five chapters. The next chapter, chapter two, provides an overview of COS and the four working groups that were analyzed as well as the theoretical context for this study. Chapter three describes the study's methodology, including the sample design, survey design, dependent and independent measures, and qualitative and quantitative analysis. Chapter four presents the findings of the research. The final chapter discusses the relevance of this study's results and proposes specific recommendations on how to strengthen COS's working group social networks and, more broadly, general conclusions about the applicability of social network analysis in understanding the structural variability of governance networks.

Chapter 2. BACKGROUND

2.1 Theoretical Context

2.2.1 Bridging organizations as integral components of governance networks

The exact role and function of governance networks within natural resource management and, more specifically, the adaptive co-management (ACM) and social-ecological systems (SES) paradigms is just beginning to be explored. It is widely recognized though that traditional top-down, command-and-control management systems are unable to address the increasingly complex environmental problems we are facing around the globe (Folke et al. 2005; Ostrom 2005; Armitage et al. 2007). Because environmental problems span social, economic, political, ecological, spatial, and temporal boundaries, governance structures that aim to effectively manage these problems must promote cross-scale and cross-level interactions among a diverse set of actors (Berkes 2001; Hirschi 2010). As Folk et al. (2005: 442) summarizes, "Human activities have become globally interconnected and intensified through new technology, capital markets, and systems of governance, with decisions in one place influencing people elsewhere."

Governance networks, as defined by Koliba et al. (2011: 46), are those networks that "facilitate the coordination of actions and exchange of resources between actors within the network." Koliba et al. (2011) characterizes governance networks by their multiscalable properties, incorporating individuals, groups of individuals, and organizations. According to their typology, governance networks can fulfill seven policy functions. These include problem definition, policy design and planning, policy coordination, policy implementation (regulatory), policy implementation (service delivery), policy alignment, and policy monitoring/evaluation. Sandstrom and Carlsson (2008) similarly classify governance networks as having four organizing functions: problem definition, prioritization, resource mobilization, and evaluation.

Another key aspect of governance networks is that they are often self-organizing and non-hierarchical in a formal sense but still contain leaders, whether individuals or organizations (Sandstrom and Carlsson 2008; Hartley 2010; Hirschi 2010). At a very basic level, governance networks can be thought of as webs of interactions between multiple actors across different institutional boundaries that form for the purpose of collective action (Newig et al. 2010; Sandstrom and Rova 2010).

Bridging organizations can play a crucial role in improving these policy functions. They can provide specific resources, as is described in the next section, to promote collective action outcomes that individual actors could not achieve independently (Provan and Kenis 2007). This is especially the case when trying to manage complex SESs since understanding the full scale and complexity of ecosystems is beyond the ability of any one individual (Olsson et al. 2004). Network-wide operating functions, as described by Koliba et al. (2011: 118-119) include coordinating action, mobilizing and exchanging resources, diffusing and sharing information, building capacity, and learning and transferring knowledge. In a management context, these function increase adaptability and collective action by reducing the transaction costs associated with cross-boundary interactions (Schneider et al. 2003; Newig et al. 2010). Governance networks, thus, are well suited to span horizontal, political, expertise, and ideological boundaries if institutions like bridging organizations are in place to facilitate interactions among the actors. (Folke et al. 2005; Carlsson and Sandstrom 2008).

2.2.2 The role and function of bridging organizations and working groups

Bridging organizations can ultimately improve network function and performance by connecting actors at different government levels and across sectors. According to Crona and Parker (2012: 33), “Bridging organizations are organizations that link diverse actors or groups through some form of a strategic bridging process. They are organizations in their own right and are relatively distinct in terms of resources and personnel from the parties they seek to integrate." Berkes (2009) defines bridging organizations as organizations that function as an arena for knowledge co-production, trust building, sense making, learning, vertical and horizontal collaboration, and conflict resolution. While such organizations vary in size, scope, formalization, and diversity of stakeholders, bridging organizations primarily facilitate interactions between actors, both individuals and groups, that might otherwise not communicate (Crona and Parker 2012; Rathwell and Peterson 2012).

Bridging organization studies draw largely from boundary object theory. Boundary objects, as defined by Guston (2001: 440), are those objects that "sit between two different social worlds, such as science and nonscience, and they can be used by individuals within each for specific purposes without losing their own identity." Boundary objects, for example, can be organizations, technical mechanism, or decision-making models. Although bridging organizations are sometimes synonymous with boundary organizations, Crona and Parker (2012) make a distinction between the two. They state that boundary organization studies are more narrowly focused on the science-policy interface and have clearly defined organizational structures for accountability. Guston (2001: 400-401) describes boundary organizations as having three primary characteristics: 1) provide the opportunity and incentive for the creation and use of boundary objects; 2) involve actors from both sides of the boundary; and 3) exist has the intersection of policy and science. Importantly, the actors on either side of the boundary determine the functionality or effectiveness of the boundary objects: "successful boundary organization will thus succeed in pleasing two sets of principals and remain stable to external forces astride the internal instability at the actual boundary" (Guston 2001: 401). Given this context, bridging organizations share many of the same characteristics as formally defined boundary organizations but can be viewed to serve a much broader role within governance networks.

Non-governmental organizations (NGOs) often act as bridging organizations within the natural resource governance arena. Considerable technical, financial, and personnel resources enable NGOs to effectively link actors across institutional and spatial boundaries (Mitchell 2009). Working groups within a bridging organization can facilitate such efforts by providing a specific mechanisms and structure by which actors can interact. The working group structure employed by COS is based on the National Center of Ecological Analysis and Synthesis (NCEAS) working group model. Since 1995, NCEAS has aimed to engage a range of scientific collaborators in "deep analysis and synthesis of theory, methods, and data" (Hampton and Parker 2011: 901) primarily through the use of interdisciplinary working groups, which are typically composed of 8 – 15 members. As Hackett et al. (2006: 6) state, "When communication difficulties are resolved [between potential collaborators], the mixture of ideas, data, and expertise may generate unusual ideas." Such a collaborative environment is believed to yield high degrees of trust, limit conflict, and facilitate creativity (Hampton and Parker 2011).

Hampton and Parker (2011), conducted extensive research on the productivity of NCEAS working groups through ethnographic observations, in-depth interviews, attitudinal surveys, and social network analysis. They collected longitudinal data on 200 working groups between 1995 and 2009. Working group productivity, the dependent variable, is measured through peer-reviewed journal publications. Independent variables analyzed include time (e.g. start date, total number of group meetings), group size (e.g. average group meeting size), and group composition (e.g. percentage non-US members). Hampton and Parker (2011) find that the number of group meetings most influences working group productivity and scientific impact.

Bridging organizations as well as specific mechanisms that they utilize to connect actors can clearly fulfill many roles and functions. In turn, working groups are affected by a variety of individual, institutional, and network variables. The next section describes some key aspects of network science that this study is structured around and how they are applicable to examining social relations within working group networks.

2.2.3 Understanding social relations within networks

Although social relations undoubtedly influence collaborative processes in natural resource management, researchers have only limited empirical studies of how social relations affect the functionality of bridging organizations and governance networks (Bodin and Prell 2011; Crona and Park 2012). The use of social network analysis (SNA) has the potential to offer valuable and unique insights into this emerging research area. SNA seeks to understand the structural variables of social relations, infer relationships between structural characteristics and various outcomes, examine connections (structure) among the elements (actors), and locate areas of networks that can be improved to enhance organizational outputs, outcomes, and impacts (Freeman 2004; Prell et al. 2009; Bodin and Prell 2011). By exploring the relational linkages between actors, SNA can quantitatively and qualitatively analyze the social connections between individuals, subgroups, and larger social systems (Scott 2000).

Critical to network science is the collection and analysis of relational data. Unlike social attribute data (e.g. age, sex, and occupation), relational data "cannot be reduced to the properties of the individual agents themselves" (Scott 2000: 3). Relational data describes the type and quality of relationship between two or more actors. This can include the frequency, intensity, and direction of interaction. Scott (2000) notes that network structures are then built from these relations as individual actors are connected to a larger relational system. Prell et al. (2010: 2) classify social networks as a type of informal social structure because “the patterns of interdependence among individuals and their actions” are not explicitly defined by an organizational context or institutionalized practice.

There are numerous types of relational structures that social scientists endeavor to examine. Wassermann and Faust (1994: 37) describe seven common types of relations: individual evaluations (e.g. liking); transfers of material resources (e.g. buying/selling); transfer of non-material resources (e.g. sending/receiving information); interactions (e.g. talking); movement between places or statuses (e.g. migration); formal roles (e.g. authority); and kinship (e.g. marriage). This study examines individual evaluations, transfer of non-material resources, and interactions. Regardless of what type of relation is being examined though, individual actors within a network are most commonly the unit of observation or the level at which measures are taken. Actors within a network can be people, subgroups, organizations, communities, and nations. Subgroups consist of groups of people, organizations consist of subgroups of people, communities and nations contain multiple subgroups and organizations. The unit of analysis or modeling unit can also vary within network analysis. Unit of analyses can include the actor, dyad, triad, subgroup, and network (Wasserman and Faust 1994). Within a working group structure, individual members would be considered the unit of observation, whereas the unit of analysis may vary depending the specific research objectives.

2.2 Center for Ocean Solutions

The Center for Ocean Solutions (COS), as previously described, is a non-profit environmental research organization led by Stanford University's Woods Institute for the Environment and Hopkins Marine Station in collaboration with the Monterey Bay Aquarium and Monterey Bay Aquarium Research Institute. COS's overall mission is to solve the major problems facing the oceans and prepare leaders to confront those problems by focusing on ocean/coastal ecosystems in the natural, physical, and social sciences. COS has three focal areas – ecosystem health, climate change, land-sea interactions – that categorize the organization's six overarching goals:

- Probe for root causes of key threats to global ocean health and work in interdisciplinary teams to build enduring solutions.
- Crack open impenetrable problems and develop new ways to articulate and visualize them so they can be understood, quantified, modeled, and solved.
- Engineer solutions for real-world applications through active engagement with managers, decision-makers, and stakeholders.
- Help define and measure ocean health and develop resiliency metrics including thresholds and indicators to support ocean health.
- Link knowledge and technology to needs resulting in action by government, non-governmental organizations, foundations, and business.
- Equip decision-makers and emerging leaders with the knowledge and skills they need to make decisions that lead to long-term health of the ocean (COS 2012)

To help achieve these goals, COS has established five working groups that "synthesize the latest critical knowledge gaps and to create a path for turning that information into policy actions" (COS 2013). The workings groups include the rapid detection of marine pathogens, climate change and coral reefs, climate change and pelagic predators, coastal hypoxia, and social-ecological resilience in small-scale fisheries. Participants are from academia, federal and local government, and non-governmental organizations. Group membership ranges from twelve to over thirty participants. This research project examines four of the five COS working groups. The rapid detection of marine pathogens working group is not included in this study because the group has formally concluded its activities, and, therefore, comparable measures of social relations among group members could not be obtained. A description of the goals and objectives as well as membership composition of each of the working groups that is included in this study follows below.

Climate Change and Coral Reefs

The Climate Change and Corals Reefs (CCCR) working group recognizes coral reefs around the world face numerous threats including sea level increase, temperature rise, and ocean acidification. The goal of CCCR is to "define the state of knowledge" surrounding the affects of climate change on coral reefs. To accomplish this goal, the CCCR working group proposed three deliverable objectives: 1) a current review of the potential for corals to respond to climate change through migration, acclimation or adaptation; 2) a review of the potential impacts of climate change on the reefs of Pacific island nations; and 3) a wide ranging discussion of potential approaches to these problems at the local level (COS 2011).

Climate Change and Pelagic Predators

The Climate Change and Pelagic Predators (CCPP) working group intends to review and synthesize available information on pelagic marine predators, which are vital components of marine ecosystems, in order to provide specific recommendations for designing conservation strategies for the protection of pelagic predators in the central and eastern Pacific. The specific objective of the CCPP working group is to produce papers and reports that address the following areas: 1) explore how movement data, environmental data and behavioral diving data can be used to examine predator movements in relationship to current climate patterns; 2) predict future movement patterns based on climate change models; and 3) identify critical hot spots in the eastern and central Pacific Ocean for protection.

Coastal Hypoxia

The Coastal Hypoxia (CH) working group aims to assess and compare the patterns, drivers and consequences of coastal hypoxia in the California Current Large Marine Ecosystems with the understanding that hypoxia is increasingly threatening coastal environments. The CH has seven objectives, with the recognition that all are unlikely to be accomplished within the course of the group's working period: 1) produce a synthesis paper; 2) organize, integrate and analyze existing databases; 3) conduct literature review and meta-analyses; 4) synthesize existing information to produce conceptual models and predictions; 5) develop a research program to investigate the drivers and consequences of coastal hypoxia; 6) devise approaches for incorporating hypoxia in coastal management and integrated ecosystem assessments; and 7) create a network of researchers to promote collaboration. Objectives #1 and #2 are stated to be most feasible within the working group period.

Social-ecological Resilience in Small-scale Fisheries

The social-ecological resilience in small-scale fisheries (SSF) working group is the most recently established COS working group. The SSF working group aims to understand the biophysical, social, cognitive and governance dimensions of small-scale fisheries SESs with the overall goal of producing conceptual and operational frameworks to promote sustainable development and social-ecological well-being. The group has outlined four major activities that it will undertake: 1) design and conduct field research; 2) develop and test conceptual and quantitative models; 3) support and evaluation local conservation and adaptation initiatives; and developing and support learning networks through courses, workshops and fellowships.

Chapter 3. METHODS

This study uses a mixed-methods approach, incorporating both qualitative and quantitative social network analysis methods to test the primary hypothesis as stated below.

H_1: Working group functionality is positively associated with cohesive network structures.

3.1 Measures

3.1.1 Functionality (dependent variable)

Measuring the performance of networks is inherently difficult since networks are composed of diverse actors, all whom may have different goals and objectives (Koliba et al. 2011). As Provan and Kenis (2007) note, a basic and important question remains when analyzing network effectiveness, effectiveness for whom? They define network effectiveness very broadly, as the "attainment of positive network level outcomes that could not normally be achieved by individual organizational participants acting independently" (Provan and Kenis 2007: 230). Arganoff (2007: 173) similarly states that networks facilitate collaboration among actors that leads directly or indirectly to problem solutions. He notes that actors within the network determine the problem and, therefore, must ultimately measure the performance: "In the final analysis, the actors themselves have to determine the benefits derived along with considering the costs" (Arganoff 2007: 30). Sandstrom and Carlsson (2008) more specifically define network effectiveness as consisting of two components: efficiency and innovativeness. Efficiency refers to the cost (e.g. time) of establishing new organizational arrangements, while innovativeness depends on the overall fulfillment of management goals, if previously established. In this study, functionality is defined according to the achievement of specific goals and objectives of each COS working group as stated in working group proposals, thereby leading to network level outcomes, otherwise unachievable by individual members. The achievement of specific goals and objectives of each COS working group is qualitatively measured from open-ended survey responses and quantitatively measured from closed-ended survey responses by working group members.

3.1.2 Network structure (independent variable)

Network structure is defined as the relational patterns that emerge from social interaction between two or more actors (Scott 2000; Freeman 2004). Relational patterns are measured in terms of frequency, intensity, and direction of interactions between working group members through a web-based questionnaire. The primary network concepts used in this study to measure structural cohesion are density and centralization. This study uses Moody and White's (2003: 107) definition of cohesion: "A group is structurally cohesive to the extent that multiple independent relational paths among all pairs of members hold it together." These network concepts are examined across three time domains in the survey instrument: prior (i.e. before the working group began); current (i.e. when the survey was administered); and future (i.e. after the working group ends).

Density measures generally describe the degree to which a network is connected. Density, one of the most common network-level measures in SNA, is the proportion of ties or connections that are present in given network. Specifically, it is the ratio of the number of present ties to the maximum number of possible ties in a network (Wasserman and Faust 1994). A network density value of 1 indicates that all actors are directly connected, whereas a density network value of 0 indicates that no connections exist between actors. Density measures, although widely used, present a few of problems. Most importantly, density is largely dependent on the size of the network (Scott 2000). Large networks will inherently have smaller density values “because the potential number of ties is so large, thus making it difficult, if not impossible, for actors to create and maintain a large number of ties” (Prell 2011: 40).

Centralization is another measured used to examine network-level structure. Scott (2000) notes that centralization measures reflect the overall integration of a network. Larger centralization values indicate that a single actor is more central in the network than the other actors and, thus, prominent structural positions (i.e. power), as described below, are unequally distributed (Wassermann and Faust 1994). Centralization measures are derived from centrality.

Unlike density and centralization, centrality is an actor-level measure, focusing on the structural characteristics of ties between nodes or individual actors (Bodin and Crona 2009). Centrality generally describes the most important, powerful, and/or prominent actors located within a network (Scott 2000; Borgatti et al. 2009). Actors with high centrality values “are those that are extensively involved in relationships with other actors” (Wasserman and Faust 1994: 173). There are five main types of centrality measures: degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, and beta centrality (Wasserman and Faust 1994; Scott 2000). As is discussed in the Section 3.3, this study only analyzes degree centrality and degree centralization. Degree centrality, the most basic of all the centrality measures, is the number of ties an actor has in a network. Degree centrality can take into account the direction (i.e. incoming and outgoing) and value (i.e. intensity/strength of relationship) of ties between actors. In-degree centrality reflects how many incoming ties an actor receives, while out-degree centrality refers to how many outgoing ties an actor gives Prell (2011: 345).

Therefore, when using density, centralization, centrality together to examine structural cohesion, it is argued that a network with high density and low centralization is more cohesive than a network with high density level and high centralizations given that actors in the first network have many ties to other group members while not as reliant on central or prominent actors to connect them (i.e. there are more direct ties between actors) (Prell 2011). This follows the Moody and White's (2003: 107) discussion of network cohesion, in which they state that the "The strongest cohesive groups are those in which every person is directly connected to every other person [. . .]." Cohesive networks should theoretically foster more collaboration if the majority of group members are in direct contact with each other and, thus, can more easily share information and knowledge.

3.2 Data Collection

Quantitative and qualitative data was collected via web-based surveys from December 2012 to February 2013.

3.2.1 Sample Design

This study analyzed four separate working group networks at the Center for Ocean Solutions (COS). From this point forward, working groups will only be referred to by an alphabetical letter (A, B, C, and D) for confidentiality purposes. The network boundaries for each working group were initially defined according membership lists that were complied when each group was established. For confidentiality reasons, the specific institutions to which members belong to within each network are not presented in this study. Working groups have between 16 to 35 members. Key informant interviews were focused on the program leaders of each working group or other prominent group members.

A request to participate in the study (i.e. have your name listed in the survey instrument) was sent via email to all working group members. However, after preliminary interviews with key informants at COS, an examination of attendance lists for working group meetings, and unsolicited feedback from participants, the initial sample was refined to enhance the validity of the survey results. For the purpose of this study, individuals were considered to be a member of a working group if they attended at least one of the working group meetings. All working groups have formally met between two to four times at the time the survey was administered. Given this criterion, the number of members for each working group are as follows: A, n=18; B, n=11; C, n=22; and D, n=17.

Of these working group members, not all responded to the initial request to participate in the study. Those individuals that did not respond could not have their name listed in the survey instrument, so no data was collected from or about them. The response rate for the initial request (i.e. the percentage of working group members included in the survey) each working group is as follows: A, 72%; B, 73%; C, 64%; D, 94%. The response rate for those individuals that completed the survey was expectedly lower: A, 56%; B, 64%; C, 59%; D, 67%. Through initial participant feedback, it is known that names of key members of each of the four working groups are not included in the survey. However, as a discussed in the analysis section (3.3), specific analysis methods were used to reliably interpret data sets with low response rates.

3.2.2 Survey and Interview Design

A web-based survey was administered that consisted of twenty-seven open-ended and closed-ended questions. The opened-ended question were intended to elicit qualitative information about the perceived functionality and effectiveness of the specific working group that each respondent belonged to. For example, respondents were asked to discuss aspects of their respective working group that had most facilitated communication and collaboration between members. Closed-ended questions were designed to collect quantitative relational or sociometric data. Respondents were asked to rate the quality, intensity, and frequency of certain types of relationships with every other participant in the survey based on a likert scale system. For example, respondents were asked to rate the strength of their relationship with group members across three time domains based on a four-point scale. Respondents were specifically asked how closely they worked with group members prior to joining the working group, how closely they now work with group members, and how closely they believe they will work with group members in the future once the working group concludes: 0 = do not know; 1 = not closely (e.g. casual interactions at professional meetings); 2 = somewhat closely (e.g. blue ribbon panel); 3 = very closely (e.g. coauthorship). Thus, both directional and valued data was collected for each working group network. Additional sociometric questions about peer advice and frequency of communication with group members were also asked but not analyzed.

Attributed data about each respondent was also collected. This included demographic data (e.g. age, sex, affiliation, length of membership), the respondent's perception of working group functionality, and the respondent's rating of certain individual qualities of other group members, such as leadership ability and quality of contribution to the group. Each survey participants was asked to rate every other participant in the various categories as well as their own contribution and involvement in the group on a scale of scale of 1 to 4, with 1 being the lowest rating and 4 being the highest rating.

Interviews were focused on key-informants, namely the official program leaders of each working group or other prominent members in the group. Key-informants were asked questions about the functionality of their respective working groups. Questions included how many group goals/objectives have been accomplished and progress towards/challenges of achieving a strong collaborative group environment. Key-informants were also asked to provide feedback on initial structural patterns found during preliminary network analysis in order to partially validate the quantitative analysis. They were presented with a brief description of the structural network characteristics of their working group (e.g. the X working group was loosely connected prior to the start) and asked how such structures were affecting group functionality.

3.3 Analysis

3.3.1 Qualitative Analysis

Qualitative data collected from the questionnaires and key-informant interviews is analyzed using a constant comparison method, where collected responses are compared against each other throughout the research process to identify key themes relating to group functionality and network structure (Corbin and Strauss 2008). All responses from both the interviews and open-ended survey questions were read multiple times. Notes were taken during the first reading and then subsequently refined through previous readings until clear themes were defined. Interviews could only be conducted for two of the four working groups, C and D. Thus, in the absence of key-information interviews for the remaining two working groups, A and B qualitative analysis of the dependent variable will rely solely upon open-ended survey responses.

3.3.2 Quantitative Analysis

Quantitative network data collected from the survey is analyzed using a social network software package, UCINET version 6.459 (Borgatti et al. 2002). The same data transformation and analysis procedures described below was conducted for each network. After the data was imported and transformed, density, centralization, and degree centrality measures were calculated using UCINET functions. Given a low survey response rate – A, 56%; B, 64%; C, 59%, and D, 67% - for a study that aims to map and analyze complete working group networks, data collected on nonrespondents is used in the final analysis. When nonrespondents are included in the data set, 72%, 73%, 64%, and 94% of Working Groups A, B, C, and D respectively are included in the analysis. Although, as discussed by Borgatti and Molina (2003: 339), eliminating nonrespondents from analysis is an easy solution, "this leads to networks maps and metrics that may be highly misleading, wrecking the quality of the data." Since, through unsolicited participation feedback and preliminary analysis, it is known that key working group members in each network did not respond, it was decided to include all nonrespondents so to not lose a substantial and significant amount of network data. Nonetheless, missing data generally has a negative effect on network analyses and, therefore, the quantitative network findings of this study are supplemented with qualitative information.

To increase the validity of the network analysis given the incorporation of nonrespondent data, only in-degree measures for centralization and centrality are calculated. In-degree ties specifically describe the prestige or prominence of an actor within a network by measuring the degree to which an actor receives ties from other actors in the network (Hanneman and Riddle 2005). According to a study conducted by Constenbader and Valente (2003) examining the stability of 11 network centrality measures across 59 networks, in-degree centrality, which in-degree centralization is then calculated from, is a more stable centrality measure than most others when respondents do not respond. They specifically conclude, "Even at low sampling rates, in-degree had higher correlations between the actual and the sample network measures than all of the other centrality measures with the exception of simple eigenvector centrality." (Constenbader and Valente 2003: 291).

While missing out-going data on nonrespondents can be reconstructed by substituting the value of the in-coming tie, such an approach is only valid if out-going and in-coming ties between actors usually match or thought to be reciprocal (Huisman and Steglich 2008). Substituting missing out-going ties for in-coming ties between actors in this study is inappropriate. Analysis of the percentage of symmetric pairs, calculated through UCINET, finds that, aside from Working Group B the percentage of symmetric pairs for the majority of the relational data collected is well below 50 percent. Therefore, only in-coming or in-degree ties are analyzed.

This approach is chosen over the more common method of using binary data to produce a network density value as a percentage since all other relational measures in our study also use valued data. Because valued data is used, the density values presented in this study cannot be compared to density values reported in other network studies.

Due to the small sample size of networks (n = 4) examined in this study, statistical methods to examine the correlation between the dependent variable, working group functionality, and the independent variable, network structures, are not useful. Therefore, quantitative analysis focused on descriptive statistics calculated in IMB SPSS Statistics, version 21. Network maps, or sociographs, created through NetDraw (Borgatti et al. 2002), provide visualizations of the network structures.

Chapter 4. RESULTS

4.1. Functionality

The two primary open-ended questions that pertain to working group functionality in the survey are: "What aspects of the working group help efficiency and overall functionality?" and "What aspects of the working group are not helping efficiency and overall functionality?" Respondents were also able to provide additional comments on all of the closed-ended survey questions. In addition to identifying key variables that affect functionality that may have been unaccounted for in this study, these questions are also intended to examine the degree to which group members agree about the functionality of their respective groups. Below are the most common themes in order of frequency.

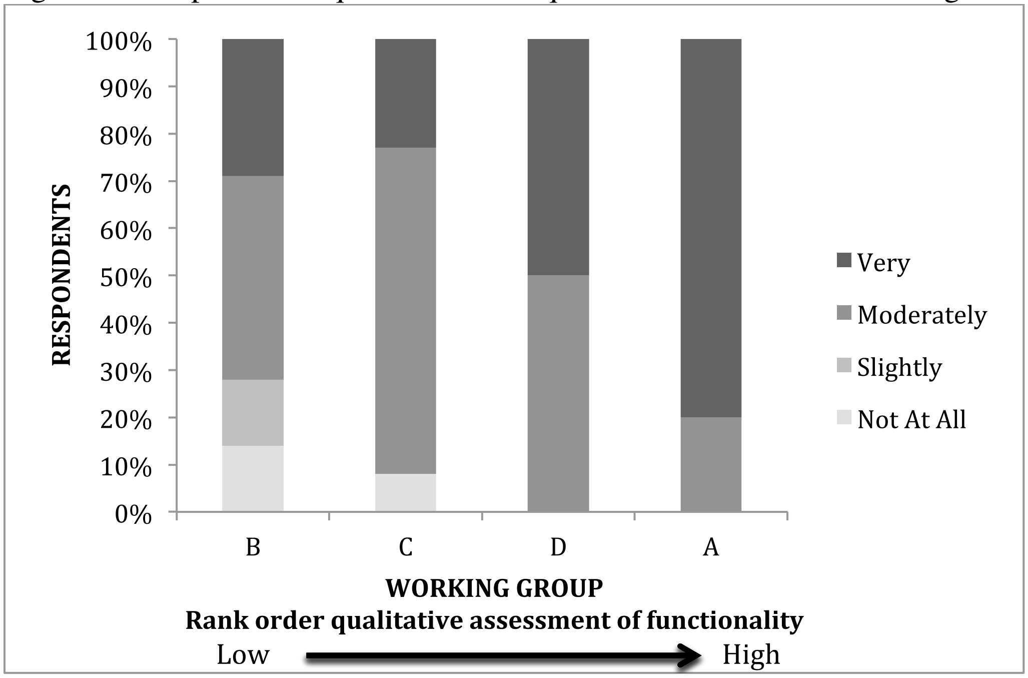
1. Functionality regarding leadership
    - Strong leadership essential for group productivity
        - Keeps group focused on specific goals and objectives
    - Lack of leadership or communication with leader(s) hinders the group's ability to move forward on projects
2. Functionality regarding face-to-face interactions
    - Critical for building and maintaining working relationships
    - Geographically dispersed memberships makes regular face-to-face meetings difficult
3. Functionality regarding communication/interaction
    - Productivity hindered by long time spans between communications
        - Group looses momentum and focus

    - Members are too busy
        - Over-extended with other responsibilities
        - Low-meeting attendance
4. Functionality regarding institutional support
    - Reduces administrative burden on group members
        - Members do not need to focus effort on meeting logistics

Working Group A members are most positive in comparison to other groups about their group's progress on achieving their goals and objectives and the general functionality of the group. Respondents overwhelming attribute the perceived success of the working group to strong leadership. Working Group D members exhibit a high degree group consensus on the goals and objectives as well as the primary problems the group is encountering, notably a geographically dispersed membership and, thus, difficulty in organizing frequent face-to-face meetings. Working Group C members are less positive about the group's productivity and functionality due to a noted lack of communication between members, but still feel that the group is achieving its goals and objectives. Finally, Working Group B members disagree the most about the functionality of their group and, specifically, what the goals and objectives of the group are. Respondents often refer to a lack of coordination and unclear member roles as a central problem.

Meeting goals, the first component of working group functionality, was also measured quantitatively. Survey respondents were asked to rate the degree to which they feel their respective working group was meeting its goals and objectives, on a scale of 1 to 4, where 1 = not at all, 2 = slightly, 3 = moderately, and 4 = very (Figure 1).

Figure 1: Comparison of quantitative and qualitative measures of Working Group Functionality



The Working Group A has the highest percentage of respondents (80%) who believe the their working group is very much achieving its goals and objectives, while the B and C working groups have the lowest percentage of respondents – 29% and 23% respectively – who feel their working group is very much achieving its goals and objectives.

The qualitative and quantitative analysis reveals that Working Group A is the most functional working group, having the greatest degree of positive consensus about the groups progress towards achieving its goals and objectives. Working Group B appears to be the least functional, with the lowest proportion of members that believe the group is very to moderately achieving its goals and objectives and many members unclear about what the goals and objectives are. The functionality of working groups C and D is not as clearly identified. Although respondents are much more positive about group progress than Working Group B members, there are many noted problems related to the functionality of these groups, including a lack of communication between members. However, it is likely inconclusive to judge the SSF working group in this regards since it was only recently established and, thus, members have not had the same amount of time together as other working groups.

4.2 Network Structure

Figure 2 shows how that the density of the workings groups, except for Working Group B, increases across all three time domains. Working Group B has the highest current density value (2.74), while Working Group A has the lowest current density value (1.58). As previously noted, the high density values for Working Group B may be a result of small network size (n=11). The positive changes in the majority of density values indicates that working group networks are becoming more connected through time and stronger working relations are becoming formed.

Figure 2: Working group density over time

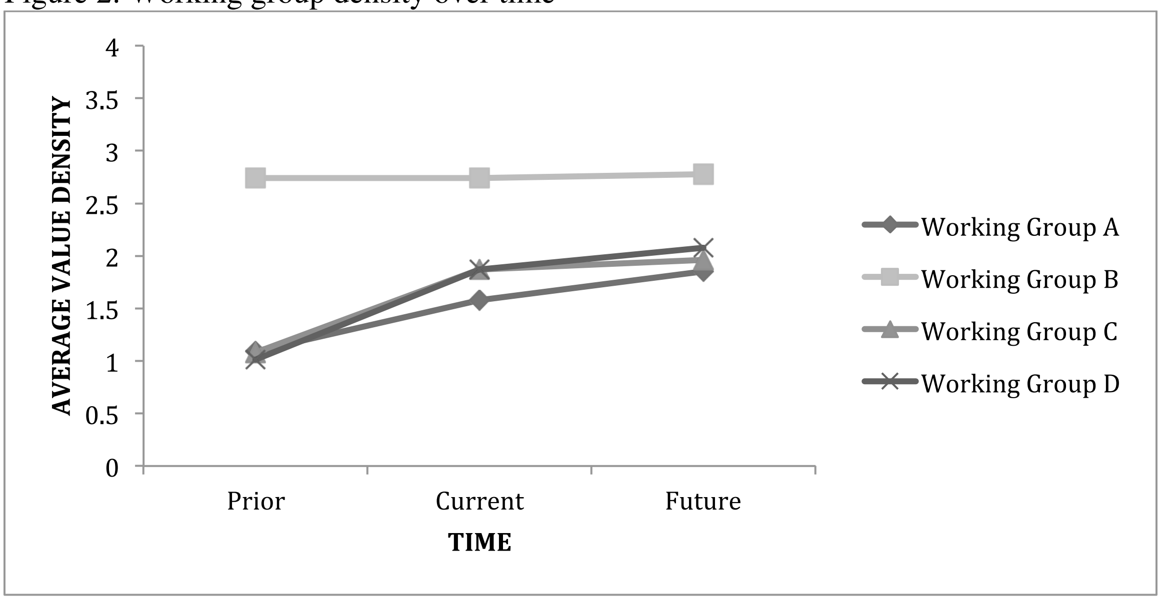


Figure 3 shows that the working groups, except for Working Group B, which has no change, become less centralized from when the working groups were established to now (i.e. from the prior to current time domains). This indicates that the networks are becoming more integrated, by not relying as much on prominent members in the group to connect group members. Working Group B has the lowest current centralization value (7.94%), while the

Working Group A has the highest current centralization value (27.53%). Interestingly, aside from Working Group A, centralization values actually increase from the current to future time domains. This signifies that there are certain individuals, who are known to be prominent within the working group due to higher in-degree centrality values, that members would rather be connected to and work with in the future. Thus, future connections become unequally distributed within the networks. Attributed data indicates that most of these members are older males who are more prominent in their field or are directly associated with COS and its partners. Prestige or prominence outside of the working group setting seems to be associated with high future in-degree centrality values.

Figure 3: Working group centralization over time

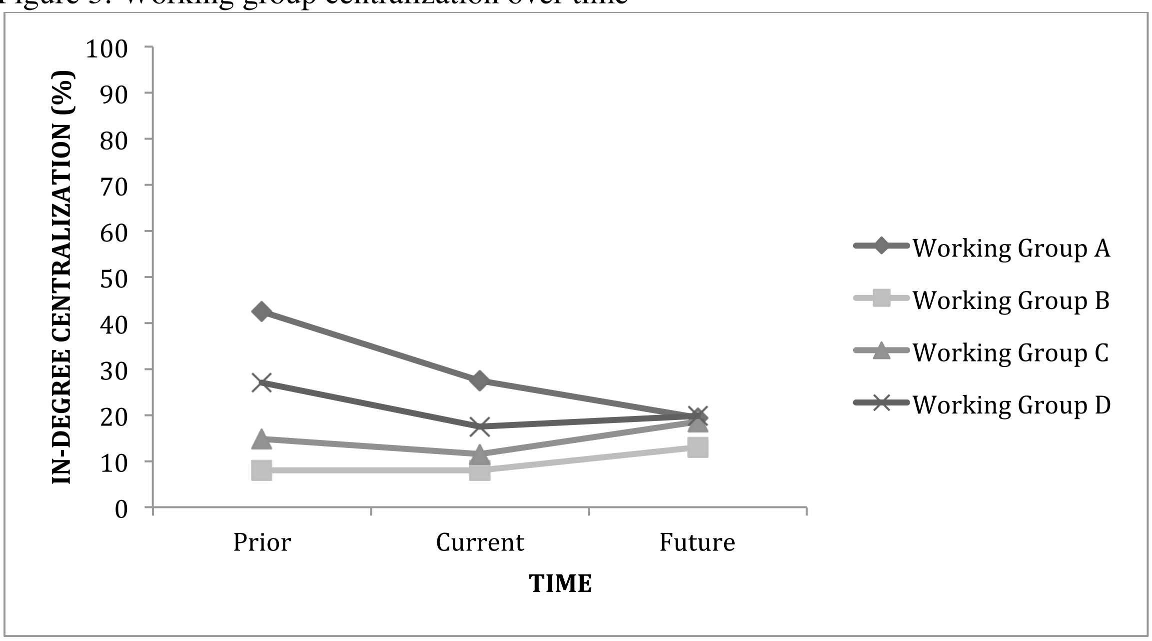


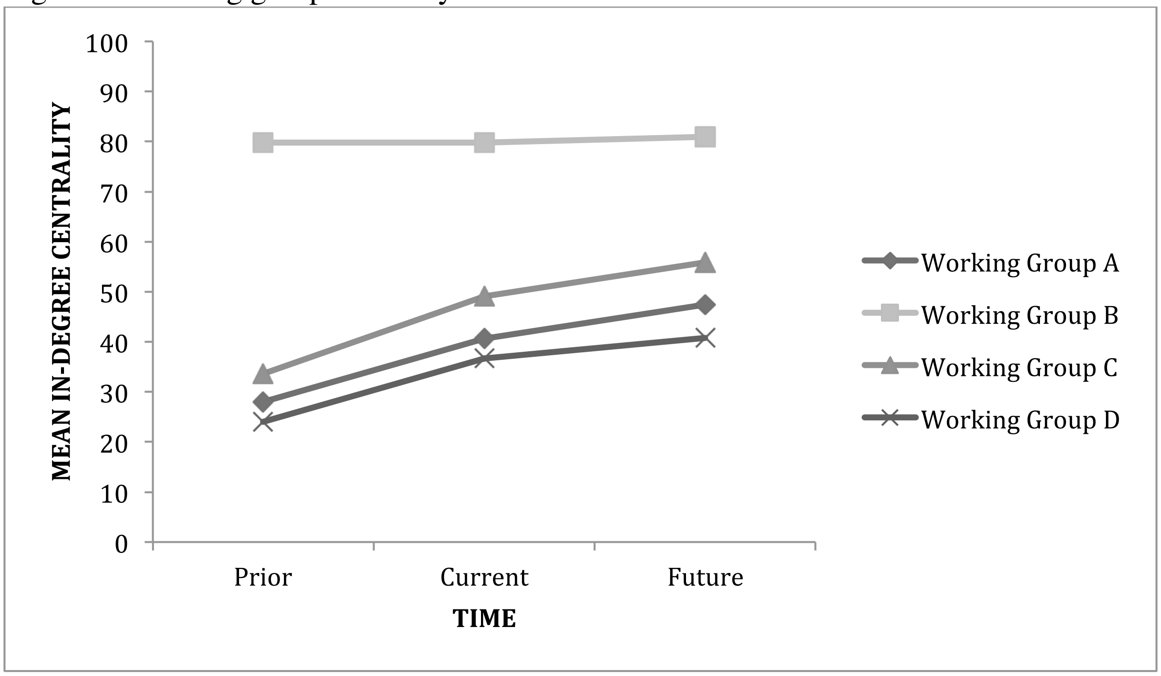
Table 1 shows the cohesiveness of all four working groups. Working Group A is the most cohesive, while Working B is the least cohesive. Working Groups C and D are determined to be moderately cohesive, as they both have density and centralizations values that fall between those values of Working Groups A and B.

Table 1: Working Group Current Cohesion (relative to each working group network)

	Density	Centralization	Cohesion
Working Group A	Low	High	Low
Working Group B	High	Low	High
Working Group C	Moderate	Low	Moderate
Working Group D	Moderate	Moderate	Moderate

Figure 4 shows the mean in-degree centrality of the four working group. The mean in-degree centrality for the workings increases across all three times domains, with the exception of Working Group B. This indicates that on average individual group members have formed stronger, working relations with relations with one another and, based on the this working group experience, would like to more closely work with each other in the future on other collaborative endeavors. Working Group B only shows a slight increase from the current to future time domains and no change from the prior to future time domains. This relative lack of structural network change is most likely because group members knew each other relatively well prior to joining the group. The working group activities, therefore, have not had a significant role in fostering new relationship unlike Working Groups A, C, and D.

Figure 4: Working group centrality over time



Chapter 5. DISCUSSION

The primary hypothesis – working group functionality is positively associated with cohesive network structures – is not supported (Table 2). Working Group A, although being the most functional group, is the least cohesive network. In contrast, Working Group B is the most cohesive network but the least functional. Working Groups C and D fall in between Working Groups A and B in terms of both functionality and cohesiveness. These results, however, must be interpreted with caution given the fact that each working group network was only partially sampled. Based on the qualitative analysis of survey responses and quantitative network analysis, centralization or group leadership is a better predictor of functionality than cohesion. This is supported by other network studies that show that leadership helps coordinate collective action and maximize group benefits (Bodin and Crona 2006; Bodin and Crona 2008).

Table 2: Comparison of working group functionality and cohesion.

	Functionality	**Cohesion**
Working Group A	High	Low
Working Group B	Low	High
Working Group C	Moderate	Moderate
Working Group D	Moderate	Moderate

Figures 5 and 6 show the current network structures of Working Groups A and B respectively. It is important to recognize that with a highly functionality network structure, Working Group A (Figure 5), there is a clearly defined leadership structure. Although a few working group members are on the periphery of the network, most notably Nodes 11 and 23, one member in particular, Node 42, occupies a very prominent position in the network. This centralized leadership structure allows for more effective communication about working group tasks and activities, as respondents indicate in the survey. In contrast, Working Group B (Figure 6), while well-connected, does not have a clear leadership structure. Most of the working groups members occupy equally prominent positions within the network. Survey respondents indicate that this has led to poorly delegated member tasks and an overall uncertainty surrounding working group goals and objectives.

Figure 5: Working Group A – Nodes represent individual working group members. Node size represents the member's in-degree centrality. A larger node indicates a higher in-degree centrality value for that member and, thus, more prominence within the network.

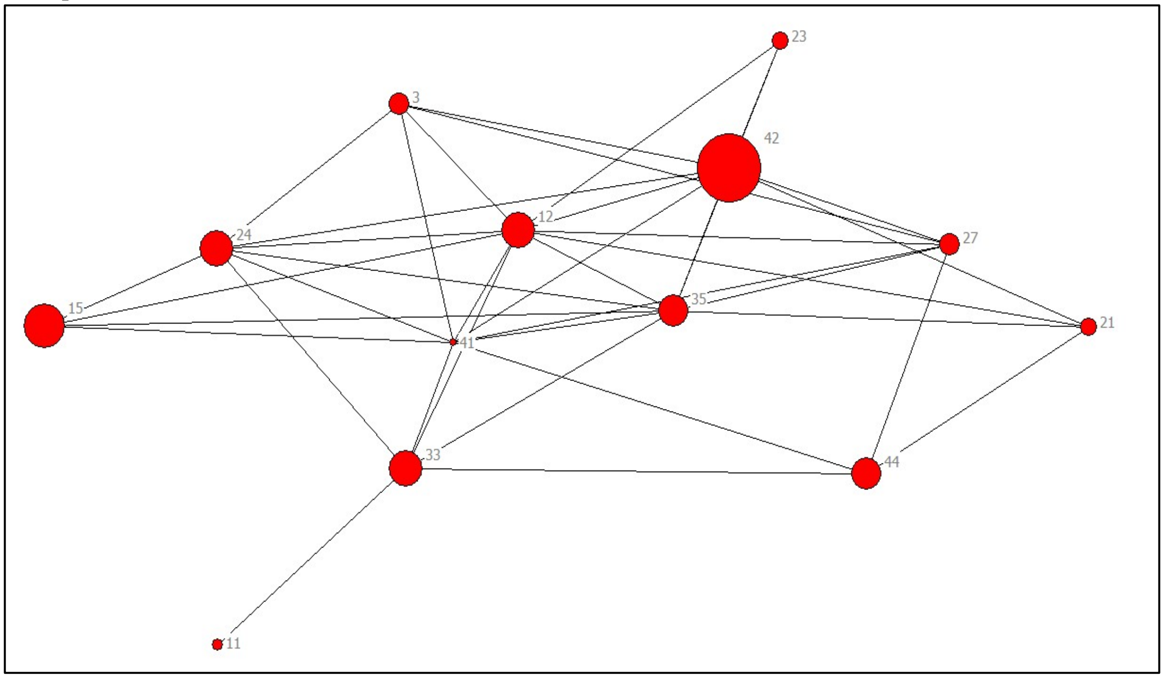
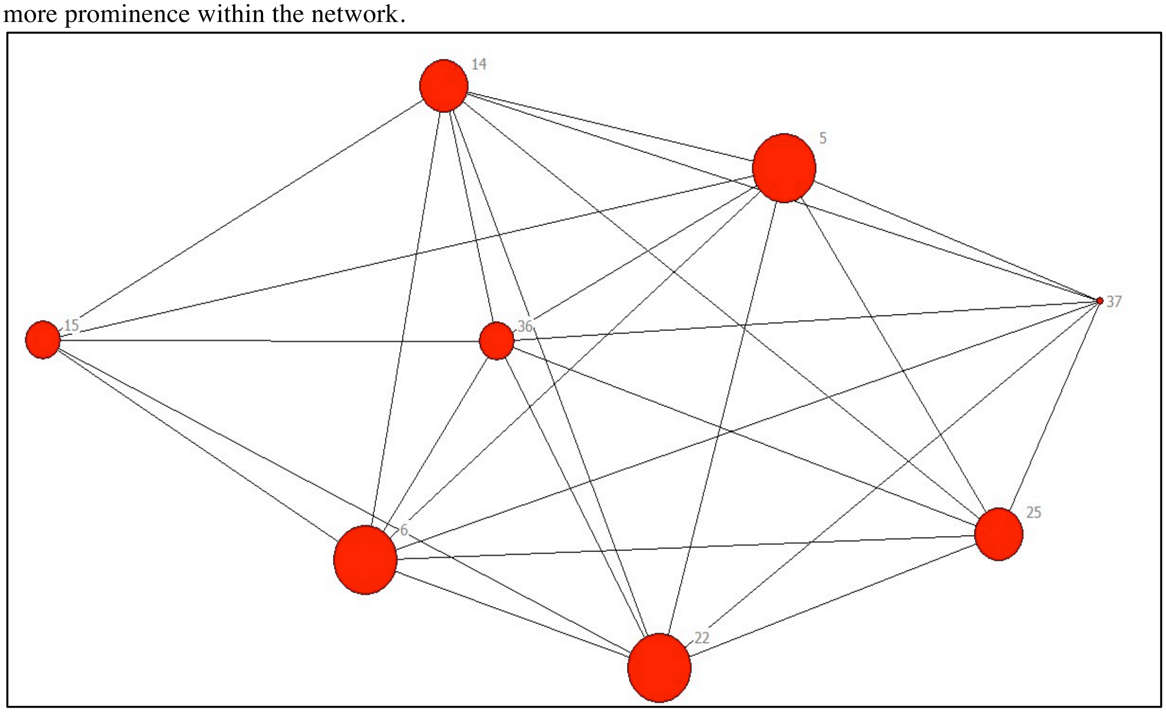


Figure 6: Working Group B – Nodes represent individual working group members. Node size represents the member's in-degree centrality. A larger node indicates a higher in-degree centrality value for that member and, thus, more prominence within the network.



Regardless of functionality, all working groups underwent structural network changes. The bridging mechanisms employed by COS, more specifically the working group process, are changing the relational patterns between actors. All networks, except for Working Group B become more cohesive through time. Density increases and centralization decreases from the prior to current time domains. Furthermore, all actor-level in-degree centrality values increase from the current to future time domains in all four networks, signifying that group members are forming closer working relationships that will presumably continue once the working groups conclude. From a bridging organization theory perspective, this indicates that the working groups are successful in facilitating interactions between individual actors. Whether or not all working groups are achieving their goals and objectives, the working group process is acting as an effective bridging mechanism. The technical, financial, and personnel resources that COS is providing to these working groups is creating network structures that allow for more interdisciplinary dialogue and, hopefully, future collaboration. This study finds that, for the most part, these structural changes lead to increased interactions and stronger collaborative relationships among working group members.

Ultimately working group functionality should be measured by not only group outcomes but also policy impacts. After all, regardless of what bridging organizations and working groups accomplish at the group level, if there are no noticeable improvements to the broader management or governance system than both organizational and individual resources are being squandered. At this stage, however, COS workings are presumably too young – the oldest of which has only been operation for two years – for group outcomes to affect policy in the specific marine/coastal governance setting in a measurable way. Furthermore, such an undertaking was beyond the initial scope of this project. Nonetheless, this study's findings are still able to improve the functionality of COS working groups and similar task-oriented, interdisciplinary teams in the environmental science fields. Below is a list of three primary recommendations to improve network functions of such groups.

1. Have a defined leadership structure, where group leaders are accessible and in regular communication with the working group. Both qualitative and quantitative analysis reveals that more centralized network structures facilitate group interactions by having clearly established short-term and long-term objectives. This leads to increased working group functionality. A centralized leadership structure, however, may decrease the cohesiveness of working groups, as found in this study. This could potentially limit the effectiveness of bridging organizations and mechanisms to foster collaboration across sectors and institutional boundaries.
2. In the absence of face-to-face group meetings, schedule regular video and/or telephone meetings so group members can discuss the progress of the group in achieving its goals and objectives, thereby maintaining focus and momentum. This will help build and maintain working relationship between members, which survey respondents believe is an important component of working group functionality. This will require institutional support from the bridging organization so to reduce the logistical burden on working group members, most of whom are already busy with other professional commitments.
3. Have defined group member roles so each member knows what he or she is working towards as well as what other members are contributing to the group.

> Defined member roles, with specific tasks and duties to accomplish, will help group products to move forward even if long time lapses remain between face-to-face meetings, as many respondents indicate is a problem. This will require a defined leadership structure to effectively delegate duties and tasks.

Future research should aim to collect longitudinal data on both the network structures of bridging organizations and mechanisms as well as the affects they have on environmental policy and natural resource management. This is a difficult goal given the complex governance systems that bridging organizations operate in. Governance networks that address any social-ecological system are fundamentally characterized by their mulitobjective approach and multiscalable properties, both of which can greatly increase the number and type of structural network variables that researchers should account for.

This study has hopefully contributed to understanding governance networks and the role bridging organizations, like COS and NCEAS, play by examining select network variables and their association to functionality as well as mapping working group network structures through time. While this project has certainly proved to be an interesting theoretical and methodological exercise in examining social networks within a natural resource management context, the study's results can also be used by COS, and potentially similar organizations, in an applied manner to improve the working group process and, ultimately, the impact working groups have on environmental policy.

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