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Social networks and transitions to co-management in Jamaican marine reserves and small-scale fisheries

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ABSTRACT

How social networks support or constrain the transition to co-management of small-scale fisheries and marine reserves is poorly understood. In this paper, we undertake a comparative analysis of the social network structures associated with the transition to co-management in three Jamaican marine reserves. Data from quantitative social relational surveys ($n = 380$) are integrated with data from semi-structured interviews ($n = 63$) and focus groups ($n = 10$) to assess how patterns of relational ties and interactions between and among fishermen and other local level actors (e.g., managers, wardens, NGO staff) support and constrain the transition to co-management. Our research suggests that the transitions to co-management were supported by a combination of three network structure and relational attributes: (i) the presence and position of institutional entrepreneurs; (ii) a dense central core of network actors; and (iii) the prevalence of horizontal ties and vertical linkages held by the community-based organizations formally responsible for the management of the marine reserves. Our findings also show that overall low network cohesion in the three reserves and limited social influence among the wardens may be problematic for sustained collective action that extends beyond the core set of network actors. These findings suggest the importance of strategies to enhance collective action, specifically through attention to the attributes of the corresponding social networks, as a means to contribute to successful transitions to co-management of marine reserves and small-scale fisheries. Our results provide more precise guidance, through social network analysis, on where in the respective networks social capital and leadership may require support or enhancement, and thus on how to target interventions for greatest effect.

1. Introduction

Co-management arrangements for the conservation of natural resources have been discussed for decades (e.g., Charles, 1988; Pinkerton, 1989) and are increasingly adopted in coastal-marine environments (Evans et al., 2011; Gutierrez et al., 2011). The establishment and adoption of co-management approaches for marine protected areas (MPAs) – including marine reserves – have followed a similar trend (Johannes, 2002; Alcala and Russ, 2006; Govan, 2009). These newly established co-management arrangements often involve the devolution of responsibilities associated with day-to-day management of natural resources, and in some instances a transfer of power and authority from national government agencies to communities and sub-national governments (Pomeroy et al., 2004; Carlsson and Berkes, 2005). In addition, co-management can involve the participation of local community groups or resource users in decision-making, implementation, and enforcement (Jentoft et al., 1998; Berkes, 2010). When MPAs are contemplated for coastal areas, there are typically strong interactions with small-scale fisheries, which can create significant governance issues, in terms of interactions between resource users and conservationists (Garcia et al., 2014), and for governance of MPAs themselves (Jones, 2014).

In such cases, when MPAs and small-scale fisheries interact, it is crucial to consider the corresponding 'human dimensions' (e.g., social, cultural, economic, and political aspects) (Charles and Wilson, 2009). Considerable progress has been made in understanding how these human dimensions influence transitions to co-

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management of MPAs and small-scale fisheries (Chuenpagdee and Jentoft, 2007; Cinner et al., 2012; Ayers and Kittinger, 2014). A key ingredient is the existence of formal and informal social networks to enable effective multi-actor management and governance arrangements (e.g., co-managed MPAs) (Carlsson and Sandström, 2008; Bodin et al., 2011). Social networks – and associated aspects of leadership, social capital, and appropriate institutions – have been suggested to play a critical role in effective transitions to co-management of small-scale fisheries (Crona and Bodin, 2010; Cinner et al., 2012; Gutierrez et al., 2011; Pomeroy and Andrew, 2011). Social networks are considered to contribute to increased collaboration (Armitage et al., 2009; Berkes, 2009), collective action (Ostrom, 1990; Pretty, 2003), and the adoption of new norms (Friedkin, 1998; Frank, 2011; Nunan et al., 2015).

However, not all networks are structurally equal. Different patterns of social relations (i.e. network structures) contribute to different management and governance outcomes (Bodin and Crona, 2009; Bodin and Prell, 2011). Accordingly, two major questions arise. First, how do social networks support and inhibit the transition to co-management, particularly in the context of weak state support (e.g., financial, institutional)? And second, what characteristics of the networks play the most significant role in this regard? We address these questions in the context of marine reserves and small-scale fisheries in Jamaica. Specifically, a comparative analysis is provided of the social networks associated with three *Special Fishery Conservation Areas* (SFCAs)—i.e. marine no-take areas.

We use a social relational network perspective as a conceptual model and associated suite of analytical methods to frame our analysis (see Alexander and Armitage, 2015). A social relational network perspective is informed by relational sociology (e.g., Emirbayer, 1997; Mische, 2011) and social network analysis (e.g., Wasserman and Faust, 1994), and emphasizes: (i) relations among individuals rather than personal attributes; (ii) networks rather than groups; and (iii) specific relations or patterns of relations relative to their broader relational context (Marin and Wellman, 2011; Alexander and Armitage, 2015). Taken together, these three points provide the underpinnings of a network perspective to examine the social dimensions of MPAs.

Empirical work to date concerning the role of social networks for natural resource management has largely focused on single case studies (e.g., Crona and Bodin, 2010). This study contributes to the limited number of comparative case studies that empirically examine the social relational dimensions in a natural resource management setting (Sandström and Rova, 2010a, 2010b). As Sandström and Rova (2010b) posit, comparative case studies enable the testing of hypotheses relating to network structure and function, and in turn provide the potential for "inductively identifying the design principles of successful systems [(i.e. governance arrangements)]" (p. 546). The differing co-management arrangements and actors associated with the three selected *Special Fishery Conservation Areas* we examine here provide a unique comparative opportunity (see Section 3.1).

The paper is organized as follows. First, we outline the theoretical foundation of our approach. An overview of the case study context and background is then provided along with a detailed account of the research methods we use. Next, we analyze specific structural features and characteristics of the three social networks against those theorized to influence key social processes. We then discuss the potential of the social networks to support and inhibit transitions to co-management of small-scale fisheries and MPAs. Accordingly, this paper presents a formative analysis (i.e. focusing on process) rather than a summative analysis (outcome-based). Furthermore, we consider the extent to which particular structural features, network ties, and key actors help to explain previous experiences, as well as their implications for future and sustained collective action.

2. Social networks and co-management of small-scale fisheries

Much has been written about the co-management of small-scale fisheries (Berkes et al., 2001; Pomeroy and Andrew, 2011) and participatory approaches in implementing MPAs (e.g., White et al., 2002; Pomeroy et al., 2007; Charles and Wilson, 2009). There has also been considerable study of the interactions between MPAs and fisheries in terms of both biological/ecological (Hilborn et al., 2004) and social, economic, and governance aspects (e.g., Christie and White, 2007; Charles, 2010; Jones, 2014). What is relatively new to small-scale fisheries and MPA analysis, however, is the social relational network perspective (e.g., Ramirez-Sanchez and Pinkerton, 2009; Crona and Bodin, 2010). Here we focus on applying that perspective to identify the factors influencing transitions to co-management of small-scale fisheries and MPAs from centralized government-based management.

An important starting point in this exploration is the recognition that there is no ideal network structure for the diverse social processes necessary in natural resource governance contexts (Newman and Dale, 2005; Bodin and Crona, 2009). For example, a tension exists in regards to the right combination of bonding ties (i.e. "strong" ties that result from a combination of frequency of interaction, reciprocity, and emotional investment) and bridging ties (i.e. ties that connect two networks or sub-groups that would not otherwise be connected). While bonding ties develop local level trust, they can also lead to increased homophily (i.e. the process by which a network becomes composed of actors more similar with regards to socio-demographic, intrapersonal, and behavioral characteristics and thus less diverse), which has been shown to discourage experimentation and lead to the imposition of strict social norms (Newman and Dale, 2005). Similarly, bridging ties serve to introduce new information, yet tacit knowledge of complex systems requires repeated interactions associated with bonding ties (Bodin and Crona, 2009).

Insights from social network analysis imply that there are inevitable tradeoffs associated with favoring particular network characteristics and governance processes (Bodin and Prell, 2011; Henry and Vollan, 2014). There is, as a result, no ideal network structure. One network will not necessarily serve all requisite social processes equally well. Different 'ideal' network structures may exist for different purposes. A high probability of tradeoffs associated with differing network structures requires an examination of multiple features, attributes, and processes. We focus here on social influence, network cohesion, as well as horizontal ties and vertical (i.e. multi-level) linkages to examine the role of social networks in fostering transitions to co-management of small-scale fisheries and MPAs.

Social influence serves as an entry point to consider the potential to establish new norms within a community of resource users (e.g., fishermen), such as shifting from open access to the implementation of no-take MPAs within a broader fishing ground. As Marsden and Friedkin (1993) suggested, relational ties "provide a basis for the alternation of an attitude or behavior by one network actor in response to another" (p. 127). Frank (2011) has further suggested that to better understand the role of social networks with regards to sustainable behaviors and practices, or the establishment of new norms, it is useful to identify relational ties that represent the flow of influence among a community of resource users such as fishermen. Central to the examination of social influence is the identification and examination of key actors.

Certain actors embedded within social networks can play a critical role with regards to introducing new norms and behaviors (Crona and Bodin, 2010; Crona et al., 2011; Frank et al., 2011). Such

roles and individuals have been referred to by different terms, including opinion leaders (Crona and Bodin, 2010) and institutional entrepreneurs (Maguire et al., 2004; Garud et al., 2007). We follow Crona et al. (2011) and adopt the concept of institutional entrepreneurs for natural resource governance contexts, focusing here on community actors whom may be in a position to guide the Jamaican SFCAs. Institutional entrepreneurs are defined here as those actors who "have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones" (Maguire et al., 2004, p. 657). Moreover, they are actors who often possess a particular combination of structural and relational characteristics (e.g., high degree centrality) and personal attributes (e.g., capability to envision an alternative future) (Crona et al., 2011; Moore and Westley, 2011).

Network cohesion – used here as a proxy for social cohesion – has been identified as a key attribute for the successful co-management of fisheries (Gutierrez et al., 2011; Pomeroy et al., 2011) and MPAs (Rudd et al., 2003). Network cohesion is crucial in the promotion of common norms and values (Pretty, 2003; Crona and Bodin, 2011). Repeated interactions between individuals lead to development of trust and contribute to the establishment of mutual understanding about the status and conditions of natural resources (Ostrom, 1990, 2005; Ostrom and Walker, 2003). Strong relational ties further contribute to the development of shared views, perceptions, behaviors, and norms (Prell et al., 2010). The importance of network cohesion and the promotion of common norms is particularly acute in the context of co-management arrangements where there is weak state support as it reduces transaction costs and contributes to self-monitoring (Pretty, 2003; Berkes, 2010; Nunan et al., 2015).

Horizontal ties and vertical (i.e. multi-level) linkages are critical for successful conservation and natural resource management outcomes (Cash et al., 2006; Cash et al., 2006). Horizontal ties – also referred to as bridging ties – connect specific individuals and organizations with other community-based organizations and resource management initiatives (e.g., other marine reserves). Horizontal ties also facilitate knowledge exchange and the diffusion of innovative practices (Ramirez-Sanchez and Pinkerton, 2009; Ramirez-Sanchez, 2011; Marin et al., 2012). Vertical network ties to higher levels of organization (e.g., jurisdictional, political) are also an important mechanism to access and leverage resources, ideas, and information/knowledge needed for successful co-management (Bodin and Crona, 2009; Marin et al., 2012).

3. Research methods

3.1. Case study context

Coastal-marine systems in Small Island Developing States (SIDS) of the Caribbean are highly vulnerable to both current and future environmental change, including climate change (CARSEA, 2007; IPCC, 2014). Increased storm intensity, sea level rise, coastal erosion, coral bleaching, ocean acidification, and declining marine fisheries threaten the region (Pulwarty et al., 2010; Nicholls and Cazenave, 2010). Additionally, marine resource exploitation combines with other drivers of change (e.g., urbanization, tourism development) to produce cumulative effects that are complex, emergent, and cross-scale (CARSEA, 2007).

Jamaica is no exception to the general trends of the region. Coral reefs in Jamaica are vulnerable to the impacts of climate change and are similarly faced with multiple issues, including sedimentation, pollution, and overfishing (Burke and Kushner, 2011). A recent global assessment of coral reefs found that Jamaica is highly dependent upon coral reefs that rank globally among the most vulnerable to environmental change (Burke et al., 2011). As with other Caribbean islands, Jamaica is highly dependent on tourism. In 2013, travel and tourism contributed to one quarter of the country's gross domestic product (GDP) (World Travel & Tourism Council, 2014). In addition, reef-dependent fisheries contribute to

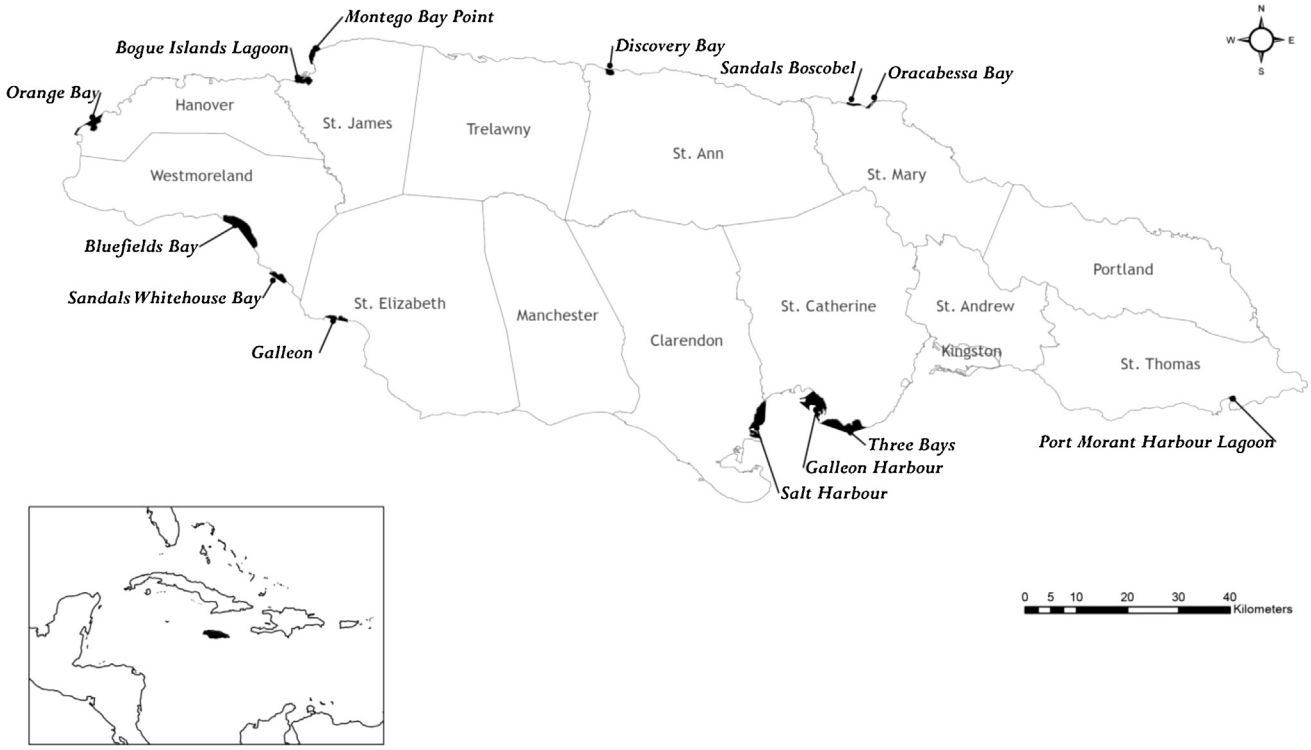

Fig. 1. Jamaica has established fourteen *Special Fishery Conservation Areas* to date with varying co-management arrangements. Not shown here is the South West Cay *SFCA* located at Pedro Bank, approximately 80 km south of Jamaica (Map: D. Campbell).

the livelihoods of nearly five percent of the island's population and upwards of seventy-five percent of households' in some communities (Burke and Kushner, 2011; Burke et al., 2011). Moreover, near shore artisanal fisheries provide close to ten percent of protein consumed by Jamaicans making the health of coral reefs a matter of food security, especially for rural fishing communities (Waite et al., 2011).

To address the potential impacts of climate change, loss of biodiversity, and marine resource exploitation, eight Caribbean nations, including Jamaica, launched the *Caribbean Challenge* in 2008. In signing the Challenge, nations committed to protecting approximately 20% of their near shore marine area by 2020. Accordingly, the Jamaican government established twelve *Special Fishery Conservation Areas* (SFCAs) between 2009 and 2012, with more under consideration (Fig. 1). SFCAs are marine no-take zones, and recent efforts to expand the SFCAs build upon formerly established no-take areas. The identification of potential sites for SFCAs is based on a number of social and ecological criteria established by an advisory committee (see Aiken et al., 2011). One of the key criteria is the presence and involvement of "at least one functioning Non-Government Organization that will operate the sanctuary and enforce the regulations protecting it" (Aiken et al., 2011, p. 162). To date, thirteen of the fourteen SFCAs are under active co-management, though with varying levels of monitoring and enforcement, ranging from a few patrols a week to near twenty-four hour coverage.

The Jamaican government has established co-management arrangements that devolve roles and responsibilities (e.g., monitoring) associated with the day-to-day management of marine reserves to local non-governmental organizations and/or fishermen co-operatives. The co-management roles and responsibilities are supported by formal Memorandums of Agreement. The Government of Jamaica (i.e. Fisheries Division) maintains the power and responsibility to gazette the boundaries of the SFCAs as well as to establish and amend relevant regulations and fines. The local non-governmental organizations and/or fishermen co-operatives are responsible for hiring and training wardens, maintaining regular patrols of the SFCAs, enforcing fishery regulations, conducting ongoing monitoring, and providing regular reports.

The three SFCAs included in this study (Table 1) range in size from approximately 1 km^2 to 13.5 km^2, and all three are in proximity to several small coastal communities. In these communities – as with the majority of coastal communities around the island – the fishery is predominately small-scale and artisanal (Aiken and Kong, 2000). The fishery is best characterized as mixed gear (e.g., fish traps, gill nets, handlines, spearguns) and multi-species (e.g., reef fish, spiny lobster, conch, small coastal pelagic finfish, large offshore pelagic finfish) with the majority of capture occurring near shore. While each of the SFCAs has a formal co-management arrangement with the government (i.e. Fisheries Division), these take different forms. In Orange Bay, the arrangement is between a local environmental NGO and the government. In Bluefields Bay, the arrangement is between a local fisherman's society and the government. In Oracabessa Bay, the arrangement is between a local fisherman's cooperative, a local private community foundation, and the government. All three SFCAs have been under active co-management for 5–5$^1/_2$ years (see Table 1).

The three SFCAs in this study have several key similarities and differences. For example, the characteristics of the near-shore fishery and length of time under active co-management were similar across all three sites. However, they differed based on their overall size, number of fishermen, and the type of co-management arrangement – including the types of organizations involved. Furthermore, the establishment of two of the SFCAs – Bluefields Bay and Oracabessa Bay – were largely driven by local fishermen groups, while the third – Orange Bay – was sited within an established marine park.

3.2. Data collection

This study employed a mixed methods approach (Creswell, 2009; Hay, 2010; Hollstein, 2014), including questionnaires, focus groups, semi-structured interviews, document review (e.g., management plans, legal material), and participant observation. Data were collected over five months of fieldwork between November 2012 and February 2014, with the majority of data collection taking place from August 2013 through November 2013.

Social network data were collected via questionnaires administered through personal interviews with fishermen ($n = 380$). The distribution of the questionnaires across the three cases is as follows: Bluefields Bay ($n = 130$); Oracabessa Bay ($n = 147$); and Orange Bay ($n = 103$). The target population was defined as all fishers based at landing sites located within the boundaries of the SFCA in addition to those landing sites directly adjacent to the boundary. To capture as complete a network data set of fishermen as possible, lists of registered fishers provided by the Fisheries Division were coupled with lists of fishers produced by local community partners. Respondents from the list were also asked to suggest other fishers at each landing site. In addition, multiple visits to each landing site at varying times of day over the course of two weeks were made. This modified snowball sampling method was carried out until network closure had been reached—i.e. the addition and mention of new names is minimal, akin to saturation (Hanneman and Riddle, 2005). Network data collected was based on information-sharing ties. Questions capturing information-sharing ties employed a *name generator* with free-recall which asked respondents to list individuals with various relational ties (e.g., knowledge exchange) (Marsden, 2011). Chua et al. (2011) note this technique is well suited to capture strong ties. Data related to personal attributes and fishing activities of each respondent were also collected through the questionnaires (e.g., gender, age, gear type, landing site).

Additional social network data were collected via a sociometric survey administered through personal interviews ($n = 18$) with organizations and agencies affiliated with the governance of the national network of SFCAs. This data captures the collaboration and knowledge exchange ties among actors – at the organizational level – across the island including managers, NGOs, academic institutions, and government agencies. Participants were provided a roster with different organizations and agencies and asked to identify the presence or absence of relational ties to each (e.g.,

Table 1
Summary of Special Fishery Conservation Area Attributes.

SFCA	Size (km^2)	Declared	CBO with management mandate	Number of wardens	Fishermen's cooperative	Number of landing sites targeted
Bluefields Bay	13.59	July, 2009	Fishermen's friendly society	8	Yes	7
Oracabessa Bay	0.84	February, 2010	Community foundation + fishermen's cooperative	12	Yes	5
Orange Bay	5.36	July, 2009	Environmental NGO	2	No	5

collaboration, knowledge exchange). *Name interpreter* questions were used to elicit responses on the nature of the ties (e.g., frequency). Participants were also given the opportunity to add organizations and agencies not included with whom they had relevant ties with.

Focus groups ($n = 10$) were conducted with fishermen at landing sites within or directly adjacent to the three *Special Fishery Conservation Areas.* The number of participants at each focus group session ranged from 4 to 12. The focus groups lasted on average between sixty and ninety minutes in length covering four main topics: (i) rules governing the use of the SFCA; (ii) alternatives to the current rules, regulations, and boundaries of the SFCA; (iii) participation with regards to the planning and management of the SFCA; and (iv) relational ties and patterns of interactions between fishermen (and other persons) with respect to the management of the SFCA.

Semi-structured interviews ($n = 63$) were conducted with local community organizations, fisherman cooperatives, non-governmental agencies (e.g., local, national, international) and government agencies (e.g., national) involved with the SFCAs—including wardens. Interviews lasted thirty to ninety minutes in length and were usually undertaken at the respondents' office. Respondents were selected using a snowball sampling technique in which each respondent was asked to provide contact information for other potential respondents (Hay, 2010). To reduce bias in the sample, multiple snowballs were initiated. SFCA managers – or community-based organization board representatives – served as initial respondents. Interviews continued until the majority of relevant governance organizations had been sampled. This was determined as the point when individuals from new organizations (e.g., agencies, divisions, departments, NGOs) were no longer being suggested as possible respondents (i.e. network closure had been reached) (Hanneman and Riddle, 2005). In addition to capturing relevant background information and insights concerning the establishment of the *Special Fishery Conservation Areas,* the interview guide contained open-ended questions designed to cover three dimensions of governance with regards to the SFCAs: (i) co-management arrangements; (ii) institutions and fit; and (iii) actor networks. Interviews were digitally recorded and transcribed verbatim. They were then analyzed using qualitative content analysis in NVivo 10 (QSR International).

3.3. Social network analysis

Social network analysis (SNA) was used here to examine network components within each SFCA including actors and linkages (e.g., information flows), along with network structure (e.g., density) to reveal both formal and informal relational ties (Wasserman and Faust, 1994). Social network analysis results were further combined with qualitative content analysis of data derived from interviews, focus groups, and observations. Integrating the data types provides significant benefits for the interpretation of network data—e.g., contextual background, the content and meaning of individual ties (Cross et al., 2009; Bodin and Prell, 2011; Prell, 2012; Hollstein 2014). UCINet (Borgatti et al., 2002) and Gephi were used for social network analysis while Gephi, an open source platform for network analysis, was used to generate visuals.

Network cohesion was examined by looking at fragmentation. Fragmentation reflects the proportion of pairs of actors within the network that cannot reach each other (Borgatti et al., 2002). Further analysis to identify cohesive subgroups was done through the examination of modularity. Modularity captures subgroups, or community structure, through the partitioning of the network to reflect groups of nodes that have a higher density of ties within the group as compared to ties between the groups (Blondel et al., 2008). The modularity function in Gephi was used for this analysis, which adopts the algorithm developed in Blondel et al. (2008). Specifically, the modularity function was used to identify the largest cohesive subgroup rather than to capture a network wide 'index'.

Social Influence was examined by focusing upon the wardens via the measure of K-reach, calculating the percentage of the network reached within two steps of the wardens. Specifically, K-reach was calculated through a three-step process. First, the total number of actors within two network ties was calculated for each SFCA warden—i.e. one relational tie removed from the warden. Overlap of actors and ties to other wardens were then subtracted from the total sum. For example, this ensured that "Fishermen 1" is only counted once even though the fishermen may be connected to both SFCA "Warden A" and "Warden B." The final number of actors within two steps of the wardens is then calculated as a percentage of the total number of actors found within the network.

Horizontal ties and vertical (i.e. multi-level) linkages were examined by calculating the degree centrality of the community-based organizations formally responsible for the management of the three SFCAs (i.e. counting the direct horizontal and vertical ties held by each). Horizontal and vertical refer here to jurisdictional level. For example, horizontal ties include those ties to other community-based organizations locally as well as other SFCAs around the island, while vertical ties would include connections to actors such as national NGOs and government agencies.

4. Results

The collective responses from the questionnaires resulted in three respective social networks: Bluefields Bay (188 actors, 221 ties), see Fig. 2; Oracabessa Bay (191 actors, 167 ties), see Fig. 3; and Orange Bay (126 actors, 118 ties), see Fig. 4 (see Supplementary material A for rationale concerning non-response and missing data). Figs. 2–4 include all actors identified by respondents and all isolates (i.e. respondents with no connections). The network ties in Figs. 2–4 represent undirected information sharing ties between two given actors in the network (i.e. A says s/he communicates about fishing with B and/or B says s/he communicates about fishing with A). The National Environment and Planning Agency of Jamaica was removed from the network in Orange Bay to ensure the social network analysis best reflected the information-sharing network among individual resource users.

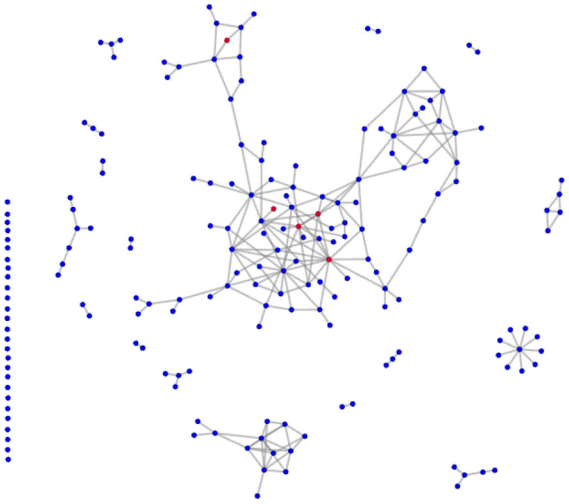

Fig. 2. Graphical visualization of the information-sharing network among fishers in the vicinity of the Bluefields Bay Special Fishery Conservation Area. Red nodes indicate wardens.

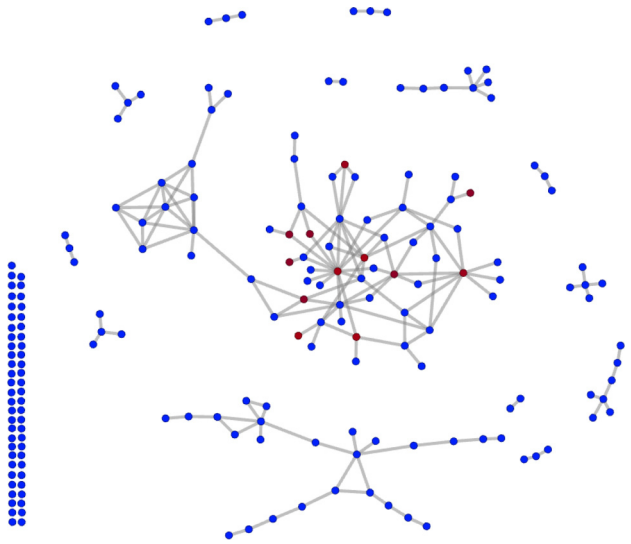

Fig. 3. Graphical visualization of the information-sharing network among fishers in the vicinity of the Oracabessa Bay Special Fishery Conservation Area. Red nodes indicate wardens.

Fig. 4. Graphical visualization of the information-sharing network.

As noted above, Figs. 2–4 include all isolates (i.e. respondents with no connections). Orange Bay had the fewest isolates – 19 of 126 – while Oracabessa Bay had the most isolates – 55 of 191. Bluefields Bay fell in the middle with 27 isolates of 188 total actors in the network. In all three cases, the large majority of these individuals appearing as isolates responded that they do not share or receive information from others, nor were they identified by fellow respondents (Orange Bay 94.7%; Oracabessa Bay 89.1%; Bluefields Bay 77.8%; see Supplementary material A).

4.1. Social influence

The establishment of the *Special Fishery Conservation Areas* resulted in a shift from open access to closed access (i.e. no-take areas). Accordingly, it requires establishing new norms and behaviors within the community of resource users (i.e. fishermen) with regards to how they interact with the near shore marine environment. This challenge is particularly acute considering the persistent problems with compliance and conflict revealed through personal observations, interviews, and focus groups. Problems range from illegal fishing in the SFCAs to conflicts over the boundaries resulting in the repeated cutting of marker buoys and general displeasure resulting in threats to the wardens—and in some instances even altercations.

4.1.1. Network measures

Results related to social influence (Table 2) focus on one particular network measure in relation to the wardens. The K-Reach (2) for Bluefields Bay included 29.3% of the network (Fig. 5), while the same calculation for Oracabessa Bay included 20.9% of the network (Fig. 6). Oracabessa Bay has more wardens embedded in the network (i.e. 50% more) than Bluefields Bay. However, their K-reach is smaller. Orange Bay has two wardens. However, neither was identified during the administration of the questionnaire to the fishermen. Accordingly, they were not included in the network.

4.1.2. Institutional entrepreneurs

Identifying key actors and the role of social influence serve as important entry points to understand the potential for the introduction and adoption of new norms. Some of the wardens (i.e., approximately two to three respectively) in Bluefields Bay and Oracabessa Bay have played a critical role as early adopters of new norms (e.g., establishing marine no-take areas) and as institutional entrepreneurs (*sensu* Crona et al., 2011; Maguire et al., 2004). They are current and former fishermen whom have realized that new

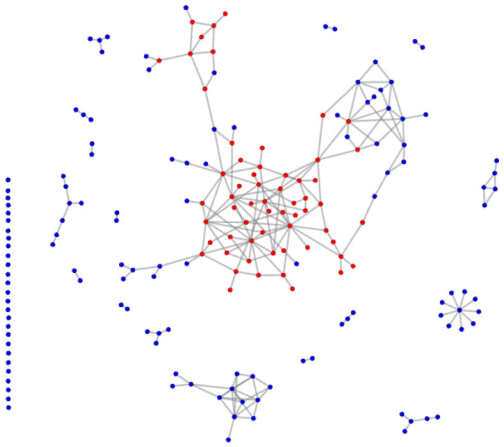

Fig. 5. Bluefields Bay Special Fishery Conservation Area—K-Reach (2), 29.3% coverage. Red nodes = those nodes actors that are 2 steps or less from the wardens.

Table 2
Summary of comparative social network analysis.

SFCA	Network cohesion	Social influence (wardens)	Horizontal and vertical linkages (organization)	
	Fragmentation	K-Reach (2) %	Horizontal	Vertical
Bluefields Bay	0.746	29.3	5	13
Oracabessa Bay	0.868	20.9	5	11
Orange Bay	0.642	0	1	5

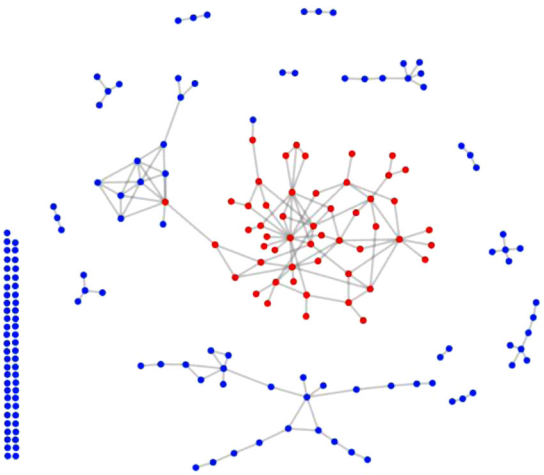

Fig. 6. Oracabessa Bay Special Fishery Conservation Area—K-Reach (2), 20.9% coverage. Red nodes = those nodes actors that are 2 steps or less from the wardens.

norms are necessary for a better future. These select individuals are currently involved with monitoring, enforcement, and outreach, and they have contributed since 'step zero' (i.e. pre-implementation) before their formal warden position was established. These individuals have influenced other network actors through community meetings, fisherman cooperative meetings, and visits to neighboring landing sites.

There are several commonalities among these institutional entrepreneurs in both Bluefields Bay and Oracabessa Bay. They are well positioned with high degree centrality to introduce new ideas and norms into their community. Moreover, the actor with the highest degree centrality in both Bluefields Bay ($n = 13$) and Oracabessa Bay ($n = 15$) were wardens. These two wardens with the highest degree centrality are also the respective presidents of the local fishermen's cooperatives in Bluefields Bay and Oracabessa Bay, which likely contributes to their high degree centrality. In addition to being well positioned with a high degree centrality, however, interviews and personal observation revealed that these same individuals often had established personal ties through repeated interactions with other community organizations, NGOs, and government agencies often exposing them to new ideas, information, and training.

A third common trait among these individuals is that they can envision an alternative future and believe strongly that it is possible to redefine their trajectory (i.e. overcome path dependency). As one warden noted:

> *"So all we need, all of us just come together and just make it work. And it will work . . . .It's going to work. Throughout the island this is one of the best. Most improved . . . .So I want to, maybe the next ten years when I sit back I just, maybe can just come at the beach and just watch fishes . . . and just sit down and say yeah, that's what I started. Somebody have to carry it on." – Respondent 10*

In conjunction with this vision for an alternative future was a historical perspective that these individuals had, a perspective that includes observation of changes to the local marine environment and fish populations over time.

Finally, the wardens whom are playing the role of institutional entrepreneurs are so committed to the vision and new norms that they have often made sacrifices. They have patrolled without pay, used their own boats and purchased their own fuel, and have divided salaries to support more wardens when they did get paid. As one warden explained:

> *"So now we are seeing the effects – we are not going to sit back – whether we are getting paid or not, and let nobody destroy it. So that is why I'm here working the past two months without a dollar and I'm not complaining because I see what I want to see – I see the fishes coming back and that's what I need to see for my grandchildren, not even for me. Because, I used to see them – I know there was a time they were there – lots and lots of fish, and then I see them dwindle away, so they're coming back now. I love that – I am happy for that." – Respondent 18*

Moreover, they have continued to make such sacrifices in the face of repeated threats (i.e. verbal) and in some case physical altercations.

In light of this particular combination of structural position and supporting traits, some of the wardens whom were identified as institutional entrepreneurs, also had some polarizing qualities. As highlighted in informal interviews and focus groups, some of the fishermen and groups of fishermen expressed distaste for these particular individuals, and describe a situation of us vs. them.

No institutional entrepreneurs were identified in Orange Bay. Furthermore, neither of the two wardens in Orange Bay were identified during the administration of the questionnaire and thus do not show up in the network. The fact that the wardens were neither former fishermen nor from the community likely explains why they were not identified. In addition, the local environmental NGO with the mandate to manage the Orange Bay SFCA is based in a different community. This lack of daily physical presence coupled with the less frequent patrols greatly reduces the frequency of interactions the wardens have with many of the fishermen as compared to the Bluefields Bay and Oracabessa Bay SFCAs. However, the wardens are building rapport with the fishermen and recognize the importance of spending time with them to build those important relational ties.

4.2. Network cohesion

Network cohesion plays an important role in the promotion of common norms and values (Crona and Bodin 2011), and we focus here on network measures, analyzing subgroup cohesion, and the establishment and adoption of new norms.

4.2.1. Network measures

Results related to network cohesion (Table 2) varied across the three SFCAs. Fragmentation, which reflects the proportion of pairs of actors within the network that cannot reach each other, is lowest in Orange Bay (0.642) and highest in Oracabessa Bay (0.868), with Bluefields Bay (0.746) in the middle. This latter measure of fragmentation suggests low cohesion overall as sixty-four to approximately eighty-seven percent of actors within the respective networks are not able to reach each other.

4.2.2. Cohesive subgroups

Analysis of the main network component in both Bluefield Bay and Oracabessa Bay – based on relational ties – identified cohesive subgroups. In both cases a single more dominant subgroup stands out due to: (a) number of total actors; (b) number of ties; and (c) density of ties. The composition of these two dominant subgroups is worth noting as well. In Bluefields Bay, approximately 47% of the fishermen were from a single landing site while in Oracabessa Bay approximately 75% of the fishermen were from a single landing site. In both instances, the landing sites are also the location of management offices for the respective SFCAs. The second compositional characteristic of these two dominant subgroups concerns membership in the local fishermen's cooperative. In Bluefields Bay, approximately 26% of the fishermen were members of the fishermen's friendly society while in Oracabessa Bay approximately 34% of the fishermen that make up the cohesive subgroup are members of the local fishermen's cooperative.

4.2.3. Establishing and adopting new norms

These dominant subgroups are not only where the institutional entrepreneurs are embedded, they are also characterized by a group of actors whom often share a similar landing site and/or membership in the local fishermen's cooperative indicating opportunities for repeated interactions and the development of new norms.

The adoption of new norms associated with the establishment of the Special Fishery Conservation Areas in Bluefields Bay and Oracabessa Bay is starting to emerge and gain traction. This is evident in the perceived compliance. As one warden from Bluefields Bay noted:

> *"The majority of them know – the majority of them know – as a matter of fact, you hardly find anyone from this beach fishing in the sanctuary. You kind of can tell that we actually have a hundred percent compliance from this beach" – Respondent 18*

Another example is the emergence of a community alert 'network' in Bluefields Bay and Oracabessa Bay whereby not only fellow fishermen but also community members whom live on the coast will call the wardens when they see individuals fishing in the SFCA. For example, as one warden from Bluefields Bay explained:

> Respondent 10: "*People do, when I would say help then, if a person see somebody down there . . . they will alert us . . . They call us sometimes and say somebody is fishing."*
>
> Interviewer: *"Are you seeing more people calling you now and reaching out to you?"*
>
> Respondent 10: *"Yes, yes yes yes. And that's one of the things, that's one of the things now that help us to be more vigilant in what we are doing. And the people now, the fishers now understand, because they are saying now, they are in the far end of the corner, how did we see them . . . I would say, we got a call saying that you're here . . . So is not only we alone watching you. We're all watching you."*

In addition, there are other fishermen whom noted that while they might not call, they would confront the individual themselves. In both cases it reflects the adoption of these new norms and development of shared values.

4.3. Horizontal ties and vertical (i.e. multi-level) linkages

4.3.1. Network measures

Results for multilevel linkages (Table 2) reflect the degree centrality of the community-based organizations formally responsible for the management of the three SFCAs. The degree centrality for Bluefields Bay was highest at 18, which included five horizontal ties and 13 vertical ties. The degree centrality for Oracabessa Bay was similar at 16, which included five horizontal ties and 11 vertical ties. The degree centrality for Orange Bay was significantly lower at six, which included one horizontal tie and five vertical ties.

4.3.2. Leveraging resources and information

The horizontal and vertical linkages identified in Bluefields Bay ($n = 18$) and Oracabessa Bay ($n = 16$) included relational ties to other community-based organizations locally, other SFCAs around the island, national NGOs, and government agencies. These horizontal and vertical ties proved vital, particularly in the early stages of establishing the marine reserves. Through these ties, the CBOs with a mandate to manage the marine reserves were able to leverage resources, ideas, and information critical for community-based natural resource management efforts. For example, in one case, the organization didn't wait for the government to support their efforts. Rather, they approached another local group for initial funding for gas. This support continued for a year until the government started providing necessary funding. In another case, several organizations – particularly specific individuals within those organizations – were identified as regular 'touchstones,' serving as sources of ideas, information, and advice. Other benefits and outcomes from these horizontal and vertical linkages included contributions to capacity building, annual monitoring (e.g., dive surveys), coral restoration projects, habitat mapping, and gear (e.g., mesh exchange).

While the environmental NGO in Orange Bay ($n = 6$) had significantly fewer multilevel linkages, they have nonetheless played an important role. Similar to the other cases noted above, the relational ties included another active CBO in the community along with national government agencies and departments. Through these ties, the CBO responsible for the Orange Bay SFCA were able to leverage needed resources. For example, when their boat had been out of commission they were able to go out on joint patrols with the Marine Police. As the data show, it is not just about the number of horizontal and vertical ties. The quality, depth, and strength of those linkages is critical as well.

5. Discussion

Our findings across the three cases provide several insights about collective action and transitions to co-management of small-scale fisheries and marine reserves in the study sites. These insights, arising through a social relational network perspective, add to a growing recognition of the need to develop new norms for co-management transitions and processes both for fisheries and for MPAs—and in many cases, for the two together (e.g., Castrejón and Charles, 2013). The results suggest that a combination of three structural and relational conditions may help to explain the previous experiences with the transition to co-management in Bluefields Bay and Oracabessa Bay. This includes the role and position of institutional entrepreneurs, a dense central core, and a prevalence of horizontal and vertical linkages. While Orange Bay lacked this same combination, structural and relational conditions did emerge that may have contributed to their transition to co-management.

5.1. Social influence

Transitions to co-management of small-scale fisheries and MPAs are often accompanied with new institutions (i.e. rules, rights, and norms) that govern how resource users interact with the near shore environment (Pomeroy and Berkes, 1997; Nielsen et al., 2004; Nunan et al., 2015). In the case of the SFCAs examined here there has been a shift from open access in adjacent coastal waters to access restrictions (e.g., establishment of no-take areas in the SFCAs). This change in access has required establishing new norms and behaviors within the community of resource users (i.e. fishermen). In situations of weak state support, the establishment of new local institutions can take upwards of 10 to 15 years as was documented in Turkey (Berkes, 1986). At the same time, newly established institutions can quickly erode when there is inadequate state support, as was the case in the Gulf of California, Mexico (Cudney-Bueno and Basurto, 2009).

Certain actors embedded within social networks can play a critical role in transitions to new institutional arrangements (Crona and Bodin, 2010; Crona et al., 2011; Frank et al., 2011). For example, a study of a mixed gear artisanal fishery in a rural Kenyan village suggests that the informal opinion leaders – who were characterized by their structural position, diverse knowledge, and potential influence – may have served as barriers to collective action and new institutional arrangements despite continued declines in the condition of marine resources (Crona and Bodin, 2010). Here, however, we find that key actors whom we have identified as institutional entrepreneurs – i.e. particular park wardens – have

played an important role with regards to the transition to co-management in two of the SFCAs (Bluefields Bay and Oracabessa Bay).

The identified institutional entrepreneurs served as early adopters and introduced the new norms and behaviors to other fishermen in the community through outreach – e.g., community meetings, fisherman cooperative meetings, and visits to neighboring landing sites – before the SFCAs were established. The combination of structural characteristics and personal attributes that these institutional entrepreneurs had in common is particularly notable. In addition to being well positioned with a high degree centrality among the network of fishermen, these same individuals often had established personal ties that extended beyond that immediate community of resource users (e.g., other community organizations, NGOs and government agencies). The latter, external ties are what some refer to as bridging and linking social capital (e.g., Marin et al., 2012). While the external ties served as an important mechanism for exposing them to new ideas and information, their high centrality served as a conduit for introducing those new ideas and associated norms (i.e. the marine reserve) to their community of fellow fishermen. At the same time, these individuals possessed an important if not unique combination of personal attributes, which included: (i) a historical perspective; (ii) a vision of an alternative future; and (iii) a commitment to that vision including a willingness to make sacrifices.

The common characteristics and conditions found among these key individuals highlighted above draw attention to the dual role of agency and structure – through the social networks with which they are embedded – reflecting what Garud et al. (2007) refer to as embedded agency. As Garud et al. (2007) note, the structural conditions not only have the potential to constrain agency but also to foster agency by "provid[ing] a platform for the unfolding of entrepreneurial activities" (p. 9). The structural conditions, therefore, open up the opportunity for transformation and change

5.2. Network cohesion

The second structural and relational condition likely contributing to a transition to co-management in Bluefields Bay and Oracabessa Bay relates to the level of network cohesion. While collective action and collaboration at the community level is imperative (Ostrom, 1990; Ghimire and Pimbert, 1997; Brown, 2002), communities are not homogenous – i.e. there is no single group of stakeholders. Rather, communities are defined by complex patterns of relational ties between actors – and groups of actors – with differing values, perceptions, resource uses, and influence (Carlsson and Berkes, 2005). This reality can have a significant impact on the establishment of MPAs in fishing communities (White et al., 2002; Christie 2004; Mills et al., 2013).

Despite the overall level of fragmentation of the social networks in Bluefields Bay and Oracabessa Bay that reflects some of the heterogeneity (e.g., gear type, landing sites), both sites possessed an identifiable cohesive subgroup. Not only are the institutional entrepreneurs found within these subgroups, they are characterized by a group of actors who often share a similar landing site or membership in the local fishermen's cooperative. As noted elsewhere, such strong multiplex ties have been shown to contribute to the development of shared views, perceptions, behaviors, and norms (Prell et al., 2010). Establishing and adopting new norms and behaviors is especially crucial for the transition to co-management of small-scale fisheries and MPAs, which requires a shift to new institutional arrangements (Nielsen et al., 2004; Gelcich et al., 2010; Nunan et al., 2015). Furthermore, such community cohesion has been shown to serve as a buffer against changes (e.g., institutional, economic, environmental) (Ostrom, 1990). However, while the cohesive sub-group may have played an important role in the transition to co-management the resulting co-management arrangement may not be equally beneficial to all members of the community. For example, those members outside of the sub-group could be marginalized or experience fewer benefits if decisions are not made in their favor.

5.3. Horizontal and vertical linkages: leveraging resources and information for action

The third structural and relational condition likely contributing to collective action and transitions to co-management of small-scale fisheries and MPAs concerns the prevalence of horizontal and vertical linkages in Bluefields Bay and Oracabessa Bay. These horizontal and vertical ties have been repeatedly identified as playing an important role for successful conservation and natural resource management outcomes (Cash et al., 2006; Armitage et al., 2012) as they facilitate knowledge exchange and the diffusion of innovative practices, and provide an important mechanism for accessing and leveraging necessary resources (Bodin and Crona, 2009; Ramirez-Sanchez and Pinkerton, 2009; Marin et al., 2012). Moreover, such linkages can provide opportunities to make local changes (Adger et al., 2005). Our findings are consistent with Marin et al. (2012) who examined a coastal benthic co-management system in Chile and found that higher performing fisher organizations had more horizontal and vertical linkages. Indeed, in a fishery context, this reflects the classic recognition that in co-management, it takes "two to tango"—i.e. that fishers and governments need to act together, typically across levels (Pomeroy and Berkes, 1997).

In the Jamaican context, these horizontal and vertical linkages were invaluable but the nature of these relational ties was often tenuous. Respondents repeatedly noted that while ties existed between different organizations and agencies, they were often associated with particular individuals. When organizations and leadership change, those strong relational ties could quickly disappear—and in some instances they already have. For example, the head of the NGO managing the Orange Bay SFCA resigned within the last year, which may help to explain the lower number of horizontal and vertical linkages the organization had (see Section 4.3.1). This highlights one of the challenges where high turnover among staff in CBOs and NGOs is common, such as in Jamaica. In addition, it suggests the important role of bridging organizations to foster and cultivate horizontal and vertical linkages (Berkes, 2009), especially in instances where capacity is limited and turnover high.

5.4. Challenges and barriers to co-management

Our findings on network cohesion are consistent with recent assessments that find community cohesion and high social capital to be important attributes contributing to the successful co-management of fisheries (e.g., Gutierrez et al., 2011; Pomeroy et al., 2011) and MPAs (e.g., Rudd et al., 2003). However, structural and relational conditions were also identified that may pose a challenge to network cohesion and successful co-management outcomes in the long-term (i.e. social and ecological). The overall low network cohesion – reflected particularly through the fragmented nature of the networks – and limited social influence may be problematic for sustained collective action that extends beyond the core set of actors. This is evident in some of the continued problems with compliance and conflict that have persisted in each of the three sites. Key problems include illegal fishing in the SFCAs, conflicts over the boundaries that have resulted in the repeated cutting of marker buoys, and general

displeasure resulting in threats to the wardens—and in some instances even altercations.

Four possible barriers that may inhibit an increase in network cohesion and social influence also emerged. The first concerns the polarizing qualities associated with some of the institutional entrepreneurs. While these individuals have been able to leverage their social networks and mobilize the dense central core, others noted their distaste for particular individuals and groups painting a picture of 'us vs. them'.

A second barrier to network cohesion and adoption of this new institutional arrangement (i.e. marine reserves) is the pervasiveness of the negative connotations associated with being considered an 'informant'. As one recent headline read: "Time to rid country of 'informer fi dead'[1] culture – Mayor Harris" (Jamaica Observer, 2014). While the Mayor's comments were targeted at more traditional issues of crime (e.g., robbery, vandalism, violence) it is equally applicable to issues concerning illegal fishing. In some cases fishermen do fear for their lives. For example, one warden noted that despite building good rapport with the fishermen, "[t]hey don't really talk a lot of what is going on out there" as there is "always the fear for [their] health and safety" (Respondent 42). While fearing for one's life isn't necessarily of concern for more minor instances, the predominating view among fishers is that 'informers' are considered the lowest class with little if any respect.

A third possible barrier that may inhibit an increase in network cohesion and social influence is related to the number of isolates found in all three cases. The number of isolates contributes to both overall low network cohesion and social influence with upwards of 29% of network actors being isolates—as is the case in Oracabessa Bay. The pervasiveness of isolates reflects a culture of independence and autonomy that is common among rural Jamaican communities, and especially predominates among those who fish (see Espeut, 1993), thereby limiting social cohesion in fisheries and fishery-related activities.

A fourth challenge to network cohesion and social influence is the limited membership in the local fishermen's cooperative and/or the complete lack of a cooperative. This finding, related to the third point above, reflects the historical lack of self-organization and limited presence of active fishermen's cooperatives in Jamaica (see Espeut, 1993). Participation in local organizations can play an important role with regard to sustainable fishing practices and behavior (e.g., compliance) (Viteri and Chávez, 2007). Not only does this participation contribute to increased legitimacy (Jentoft et al., 1998), it serves as a forum and opportunity to strengthen social ties and to open up the possibility to increase network cohesion and social influence, which have also been shown to contribute to improved compliance (Viteri and Chávez, 2007). While the lack of self-organization and involvement may limit the success of co-management arrangements, if the latter can be made to succeed, this may in itself help to overcome the lack of self-organization, by providing the necessary incentive for more active engagement and increased membership in cooperatives.

Network cohesion and the development of strong relational ties founded upon trust lubricate cooperation, result in reduced transaction costs and the promotion of self-monitoring, and are a critical component to successful outcomes (Ostrom, 1990, 2005; Ostrom and Walker, 2003). The 'informer fi dead' culture in Jamaica highlights the importance of considering how particular cultural norms interact with social networks to ultimately inhibit successful transitions to co-management. At the same time, there is evidence that certain cultural norms coupled with high levels of network cohesion can contribute to collective action and successful natural resource management outcomes, such as the case of the 'harbor gangs' associated with the Maine lobster fishery (Acheson, 1988). However, it is worth noting that positive resource outcomes documented often came with significant social costs (e.g., threats, intimidation, potential for violence) (Acheson, 1988).

5.5. Network weaving for transitions to co-management

A social relational network perspective and our analysis serve as an entrée to identify specific 'network weaving' strategies and to consider the possible tradeoffs associated with different strategies that support transitions to co-management. Vance-Borland and Holley (2011) describe network weaving as the process of communicating results after assessing the structural characteristics and sharing network maps with stakeholders to encourage network change and address key gaps (e.g., collaboration, communication).

Two key attributes for successful transitions to co-management repeatedly identified in the literature are community cohesion and leadership (Gutierrez et al., 2011; Pomeroy et al., 2011; Ayers and Kittinger, 2014; Levin and Richmond, 2014). Our results reinforce these findings. However, we note that while community cohesion is important, how community is defined with regard to criteria and boundaries is just as important (e.g., landing sites, gear types, traditional use, administrative) (Carlsson and Berkes, 2005). The perspective employed here provides key insights for heterogeneous social contexts – i.e. whom is in the network and how they are connected – that can be leveraged to support new ties and/or reinforce existing ones (e.g., that extend to other landing sites and gear types) to improve transitions to co-management. Furthermore, the results provide important insights with regards to the role of social networks and social capital, which Fox et al. (2012) identified as one of the research frontiers for policy-relevant MPA science.

While leadership – via the institutional entrepreneurs – is found to play an important role in the transition to co-management, these particular actors may be problematic in the long term due to some of their polarizing qualities. Overcoming the potential drawbacks of these particular actors requires different leadership types and actors in different positions. In the three cases presented here, other key actors (e.g., SFCA managers, an executive director of a community foundation) are a critical complementary component as they fostered important vertical and horizontal organizational ties while also tempering conflicting personalities. Our findings thus support emerging evidence for the important role of multiple sources of leadership (e.g., Olsson et al., 2008; Marin et al., 2012). Furthermore, our results illustrate that it is not just leaders per se that are important, rather the broader network of linkages – i.e. how the leaders are connected, how others are connected, and where the leaders are positioned within the network – are equally important. Considering the previous insights, our findings support Evans et al. (2015) recent call for a more nuanced approach to leadership and its role in environmental management and conservation. To that end, the results illustrate the utility of a social relational network perspective to understand and examine the role of leadership.

6. Conclusions

Examining multiple network structures, attributes, and processes revealed a combination of structural and relational conditions that help to explain the previous experience with collective action that resulted in the establishment of the co-managed marine reserves in the case study communities. Specifically, our research suggests that transitions to co-management are supported by a combination of three main network structure and relational attributes: (i) the presence and position of

[1] This Jamaican Patois phrase roughly translates to "the snitch must/should die".

institutional entrepreneurs; (ii) a dense central core of network actors; and (iii) the prevalence of horizontal ties and vertical linkages held by the community-based organizations formally responsible for the management of the marine reserves. Our findings also indicate that overall low network cohesion (as in the three reserves) and limited social influence of those in positions of responsibility (as with the wardens of the marine reserves) may be problematic for sustained collective action that extends beyond the core set of network actors. These findings suggest the importance of strategies to enhance collective action, specifically through attention to the attributes of the corresponding social networks, as a means to contribute to successful transitions to co-management of MPAs and small-scale fisheries.

While our findings apply explicitly to Jamaica, they are also germane to a wide range of contexts given the global expansion of MPAs and MPA networks (see Spalding et al., 2013) where similar social relational challenges and opportunities are bound to occur (e.g., Crawford et al., 2006; Fabinyi et al., 2010). The results are also likely to apply to many fisheries, reinforcing past research showing the importance of social capital and leadership in fisheries co-management (Gutierrez et al., 2011; Pomeroy et al., 2011; Ayers and Kittinger, 2014; Levin and Richmond, 2014). More specifically, the results produced here provide more precise guidance, through social network analysis, on where in the respective networks social capital and leadership may require support or enhancement, and thus on how to target interventions for greatest effect. Understanding these network conditions and engaging in network weaving is needed as MPA and fishery systems (such as the SFCAs in Jamaica) will deal not only with fishing and conservation pressures but also with the context of warming waters, acidification, and coral bleaching associated with climate change.

There is much to be learned from formative analyses – i.e. focusing on process – of transitions to co-management as we show here. In the longer term, understanding how the different network features and components associated with the three SFCAs in Jamaica contribute to different ecological or social outcomes will require a complementary summative analysis – i.e. outcome-based – of the transitions we are documenting. Bodin et al. (2014) note that understanding the causal influence of particular network structures on different conservation outcomes (social and ecological) represents an important research frontier; this is one to which we are now turning in the context of these Jamaican cases.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.gloenvcha.2015.09.001.

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