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Exploring the Relationship Between Fishing Actors and Network Prominence in information-sharing Networks in Jamaican small-scale Fisheries

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Abstract
Information-sharing social networks support the adaptive capacity of small-scale fishers in the face of social and environmental change by allowing them to increase access to unique knowledge critical to their fishing success. The facilitation of information exchange may be supported and influenced by persons in key positions. Within these networks, centralized actors often control the flow and access to information. We take a descriptive approach to explore the relationship between fishing role and actor prominence within information-sharing networks in Jamaica. We hypothesized that fishing captains – given their perceived legitimacy and formal and informal authority – would be more prominent in information-sharing networks, and the information they shared would be perceived as more trustworthy and influential than that of non-captains. We collected personal social networks of fishers (n = 353) on 20 fishing beaches across four parishes in Jamaica using structured questionnaires. We found low centralization and density scores across the parishes, suggesting an even distribution of actor centrality. Our results show that non-captains play a more prominent role in information sharing than fishing captains in one parish suggesting that captains and non-captains play similar roles in facilitating information, and that differences lie in whether fishers perceive the shared information as trustworthy and influential in their fishing decisions and not the prominence of the actor. These findings contribute to understanding the various adaptive strategies fishers develop to meet growing social-ecological changes in small-scale fisheries. Identifying key informants in prominent positions can also support the development of more effective strategies to communicate and share information across communities.

Keywords Social networks · Actor prominence · Small-scale fisheries · Tie attributes · Information exchange · Trust · Decision-making · Fishing role · Jamaica

Introduction

Social networks play a pivotal role in fostering information sharing in fisheries governance (Alexander et al., 2018a; Barnes et al., 2019; Bodin & Crona, 2009). These networks are essential in small-scale fisheries where fishers typically use their networks to inform their fishing strategies and adapt to change (Barnes et al., 2016, 2020; Bodin & Prell, 2011). Within small-scale fishing crews, prominent actors play critical roles in facilitating and accessing vital information, connecting actors across sub-groups, and contributing to the ability of groups to respond to social and ecological changes (Turner et al., 2014). Exploring network and actor attributes that facilitate information exchange can facilitate

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understanding of how fishers leverage these social dynamics in their decision-making.

The importance of information sharing in small-scale fisheries networks has been widely acknowledged as key to fishers' ability to adapt to change (e.g., Obregón et al., 2020; Phillips et al., 2004; Rong et al., 2016). For example, fishers utilize their networks to reduce economic risks, gather knowledge on resource dynamics, and navigate institutional regulations (Salas & Gaertner, 2004). In addition, fishers collate information from diverse sources within their networks in developing fishing strategies on where, when, and how to fish. The success of these information exchanges may be influenced by the characteristics of the actor who shares the information and the broader network configuration. For example, studies have shown that actors linked by kinship share information more freely than those linked by friendship (Bodin & Crona, 2008; Rong et al., 2016). This pattern is similar for actors in the same community, those sharing the same ethnicity, or using similar fishing gear (Alexander et al., 2018b; Barnes et al., 2016).

The facilitation of information exchange is based on levels of trust and influence in the information shared but may also be affected by the messenger (Crona & Bodin, 2006; Obregón et al., 2020). In network theory, ties represent the relationship between two actors, while attributes describing the tie provide further insights into how decisions may occur. For example, the level of trust and influence in information shared by actors can be described as tie attributes. These attributes also contribute to actors' ability to be in key network positions. Actor attributes can be described as the characteristics an actor possesses, such as their experience fishing, their fishing role as a captain or crew member, time in the community, or other demographic attributes. The actor attributes can similarly influence and contribute to whether the information they share is perceived as trustworthy and influential. Analyzing actor and tie attributes allows for a greater understanding of the potential drivers behind fishers' influence within a network and insight into how fishers make decisions.

In many common pool resources, the development of fishing strategies must be adaptable to the uncertainties and opportunities within the system. Developing fishing strategies such as when, where, and what to catch is a combination of opportunistic and deliberate decision making. For example, fishers must contend with ecological dynamics and weather uncertainty, and chasing catch they often cannot see (Acheson, 1981). To develop strategies to maximize their success, fishers weigh many factors, including knowledge, skills, and the desires of crew members. The development of these strategies is thus a product of experience with the resource and fishing experience. However, as many small-scale fishers work in groups, the success of fishing strategies is linked to the group's shared knowledge and skills. This information may come from members on the same fishing boat, and from connections crew members have with fishers on other boats or within the community. This connectivity across fishing crews is a key source of knowledge gathering by fishers and helps to reduce risk (Haskell et al., 2019).

During decision-making, key actors facilitate and mediate the flow of information across networks (Arlidge et al., 2021; Gould & Fernandez, 1989). These actors are often in advantageous central positions that allow them to influence knowledge creation, transfer, and access (Bodin & Crona, 2009; Borgatti, 2005; Burt, 1992, 2000). In network theory, these key positions are referred to as centrality positions, which can take a variety of forms. For example, degree centrality refers to the number of connections an actor holds (Burt, 1992). A high degree centrality provides the actor access to different sources of information and influence.

Within fishing crews, fishing captains and crew members may differ in their contribution to the flow and access to the information across the networks (Barnes et al., 2016; Borgatti & Foster, 2003). In some cases, given their years of experience and perceived legitimacy, fishing captains may be assumed to be centralized actors within the networks. Bodin and Crona (2008) found that occupying central positions within a network may be influenced by formal and informal power sources. For example, in controlling access to fishing resources in Kenya, actors in a central position were recognized as a formal source of power (Bodin & Crona, 2009; King, 2000). Combined, their centralized position and formal power contribute to the ability of actors to influence how decisions are made and resources are governed (Cohen et al., 2012). In fishing crews, we may expect fishing captains to hold these positions because of both formal (e.g., decision-making authority while at sea) and informal (e.g., years of fishing experience, access to resources) power attributed to their positions. These sources of power may contribute to greater trust and influence in the information they share compared to other fishing actors. At the same time, some non-captains may similarly hold informal sources of power, which can contribute to how the information they share is perceived. This potential differential access to information may contribute to the fishers' prominence within their networks and their contribution to how decisions are made within the fishing crew.

In addition to centrality at the node level, centrality can also be calculated at the network level. A network with low centralization has lower variability among actor centrality scores (Freeman, 1978; Wasserman & Faust, 1994). Accordingly, a network with high centralization typically has a few actors with high centrality scores and most other actors with low scores. The centralization of a network quantifies the distribution of power and influence within the network. For

example, networks with high centralization can show skewness in the distribution of power or influence and how these networks make decisions (Freeman, 1978).

The centralization of a network contributes to its ability to adequately respond to socio-ecological changes and achieve collective action (Carlsson & Sandström, 2007; Coleman, 1994; Crona & Bodin, 2006). In supporting collective action, networks with high centralization can reduce the costs of making decisions and rely on access to a diversity of knowledge sources (Carlsson & Sandström, 2007). For example, a highly centralized network may be less receptive to changes in current fisheries regulations, but the cohesion within the network tends to support a longer-term stakeholder engagement in fisheries management (Bodin & Prell, 2011; Reed et al., 2009). Highly centralized networks can more efficiently respond to changes because of their ability to easily organize and coordinate (Leavitt, 1951; Walker et al., 2004). However, networks with high centralization are more prone to be disrupted if a key actor leaves, exposing the network to fragmentation (Folke et al., 2005).

A network with high centralization will have a few individuals with high decision-making powers, limiting the spread of information across the network (Cáceres et al., 2022). Within centralized networks, there are also important trade-offs in density and heterogeneity. Although a heterogeneous network may bring access to many knowledge sources, it may lead to greater conflicts because of potentially competing interests. In contrast, a highly dense network with low levels of heterogeneity can quickly solve problems and conflicts, but access to unique sources of information is reduced. In small-scale fisheries, network configuration and who holds prominent positions will influence overall ability to adapt and respond to available information.

Table 1 Total fisher population by the parish in Jamaica (National Fisheries Authority of Jamaica, 2021). *Italicized and bolded parishes are sample sites covered in this study*

	Parish Name	Total Fishers	Vessels
1	*Clarendon*	*2390*	*707*
2	Hanover	747	207
3	Kingston/St. Andrew	3602	1124
4	Manchester	523	183
5	Offshore Banks	977	377
6	***Portland***	***1699***	***535***
7	St. Ann	1373	395
8	***St. Catherine***	***3858***	***1211***
9	***St. Elizabeth***	***1361***	***367***
10	St. James	1203	313
11	St. Mary	1264	259
12	St. Thomas	1583	488
13	Trelawny	695	227
14	Westmoreland	2835	731
XX	Unknown	281	15
	Total	**24,391**	**7139**

A social network analysis of information sharing in small-scale fisheries (SSF) identifies key players in knowledge transfer and defines the structural properties of communication that may be leveraged to facilitate the development or modification of fishing strategies. We have a joint objective to look at both the relationship between fishing roles and actor prominence and the relationship between perceived trust and influence in the information received and fishing roles. First, we hypothesize that fishing captains will tend to occupy more central positions within networks to influence the flow of information compared to non-captains. Second, we hypothesize that greater trust and influence will be placed in the information shared by fishing captains than by non-captains. This hypothesized relationship of the centrality of fishing captains is driven by their perceived legitimacy and authority. Our case study explores these relationships in small-scale fishing communities in Jamaica.

Methods and Analysis

Study Site

Jamaica is in the Greater Antilles in the northwestern Caribbean Sea, with an estimated marine territory of approximately 235,000 km^2 or at least 21 times the mainland area. The fishing industry is primarily artisanal and small-scale, with over 23,000 registered fishers across the country and some 7,000 registered fishing vessels (Table 1) operating from approximately 187 fishing beaches (National Fisheries Authority of Jamaica, 2021). As in many artisanal and small-scale fisheries, many unregistered fishers also join fishing crews or fish opportunistically. The fisheries sector contributes to the livelihood of 80% of households in some communities and approximately 6% of the island's entire population (Aiken & Kong, 2000). In addition, more than 10% of the protein consumed by Jamaicans is estimated to come from seafood, with up to 85% in some communities (Kushner et al., 2011). The typical fishing vessel is an open glass-fiber reinforced plastic canoe ranging from 4 to 18 m. Fishers use a combination of gear, including fish traps (pots), gillnets, hand lines, spearfishing, and "tank" diving. The number of fishing crew varies between 3 and 15, depending on the type of gear and fishing grounds. Vessels traveling to Pedro Bank typically have a crew of between 3 and 15, while vessels fishing near shore carry from 3 to 4 (Marschke et al., 2020). The main fishing areas are on the island shelf where coral reef fishes and spiny lobster (*Panulirus argus)* constitute the main catch. Recent estimates from the National Fisheries Authority highlight that of the marine fish production between April and December 2022, 93.09% was from finfish (artisanal), 3.59% Queen Conch

(industrial), 3.24% spiny lobster (industrial), and 0.07% sea cucumber (artisanal)(National Fisheries Authority of Jamaica, 2023). Fisheries products are sold primarily to a middleman (or fishmonger), with other modes of distribution including direct to consumer, sale to a distributor, or supply to hotels. It is estimated that approximately 3.7% of Jamaica's fishery product is exported to regional and international markets, mostly spiny lobster and queen conch (Caribbean Regional Fisheries Mechanism, 2021).

Jamaica manages its fisheries sector under an open-access system. As a result, fishers compete for a resource base that is gradually declining due to social and ecological drivers (Aiken & Haughton, 1987; Kushner et al., 2011). Socially, high levels of unemployment, an informal economy, populated coastal areas, and easy access to fishing grounds have contributed to overfishing. Ecologically, the habitat and associated species are threatened by hurricanes and warming waters, leading to widespread coral bleaching events and mass die-off of sea urchins and other herbivores. To mitigate these impending ecological changes, in 2009 Jamaica began to establish Special Fishery Conservation Areas (SFCAs) in areas selected for their ecological importance and social acceptability (Aiken et al., 1999) where extractive activities are not allowed. There are currently 17 SFCAs around the country.

The central authority responsible for managing the country's fisheries is the National Fisheries Authority (hereafter referred to as "Authority"). However, insufficient financial and human resources limit the Authority's capacity to manage the vast marine area. To assist in managing the resources, the Authority has established Memoranda of Agreement for co-management arrangements with local NGOs that are responsible for the day-to-day management of the SFCAs, including enforcement, community engagement, and biological and social monitoring. Fishing cooperatives also play an important role in fisheries management. These are member-only organizations providing fishers with social and economic benefits, including opportunities for purchasing fishing equipment and other goods and services. Senior fishers often lead the cooperatives, including captains and boat owners who play a central role in the decision-making processes of the cooperatives, coordinating with the government and NGOs to aid in the social and environmental protection of the fishery.

Data Collection

Our study to observe potential similarities and differences in actor prominence and network configuration based on the contextual similarities they hold in common was conducted in coastal fishing communities in four parishes[1] from February 2021 to May 2021 by 12 local research assistants. The parishes we selected were St. Elizabeth, Portland, St. Catherine, and Clarendon. We combined St. Catherine and Clarendon parishes as a single study site because fishers often straddle beaches across both parishes, and fishing crews are often comprised of fishers from both parishes. In addition, these parishes were selected because of similar fishing dynamics employed by fishers, including similar gear types, target species, and fishing trip durations.

A structured questionnaire was administered in Patois (an English-based creole language with West African influences) to collect network data and associated social attributes (Table 2). The structured questionnaire also captured information on fishers' livelihood, catch dynamics, and fishing dependence. During the administration of the questionnaire, participants were also encouraged to provide a narrative for their responses to assist in interpretation of quantitative data. Our sample of 353 fishers was collected at fishing beaches in the four parishes: Portland n = 8, St. Elizabeth n = 6, and St. Catherine/Clarendon n = 6. (Fig. 1). The fishing beaches were conveniently sampled from a master list of fishing beaches in the parishes. The research assistants then purposively selected different periods when fishers would most likely be at the fishing beaches throughout the data collection days. These times included early mornings and mid-afternoon to evenings. This approach was used to sample the personal social networks of fishers within the same parishes. We limited the boundary of personal networks to include only those fishers within the same parishes. The data collection did not follow up on named fishers outside the parishes although they were included in the analysis. The goal of this approach was not to collect the whole network, which would seek to capture all ties an actor has within the parish boundary. Inference in this technique is therefore limited to individuals at the data collection sites and may not represent populations that do not attend these locations. The questionnaire did not ask whether fishers were registered by the National Fisheries Authority, therefore fishers in our study may include both registered and unregistered fishers. Accordingly, some unregistered fishers may be crew for registered fishers or may fish with an independent boat and crew. This research was approved by the Oregon State University Institutional Review Board (IRB-2020-0861). All participants gave verbal consent before participating in the study. As the study occurred during the COVID-19 global pandemic, all research assistants adhered to local authorities' health and safety guidelines.

The network data were collected via the name generator and name interpreter approach. For the name generator,

[1] Socio-political units of local government.

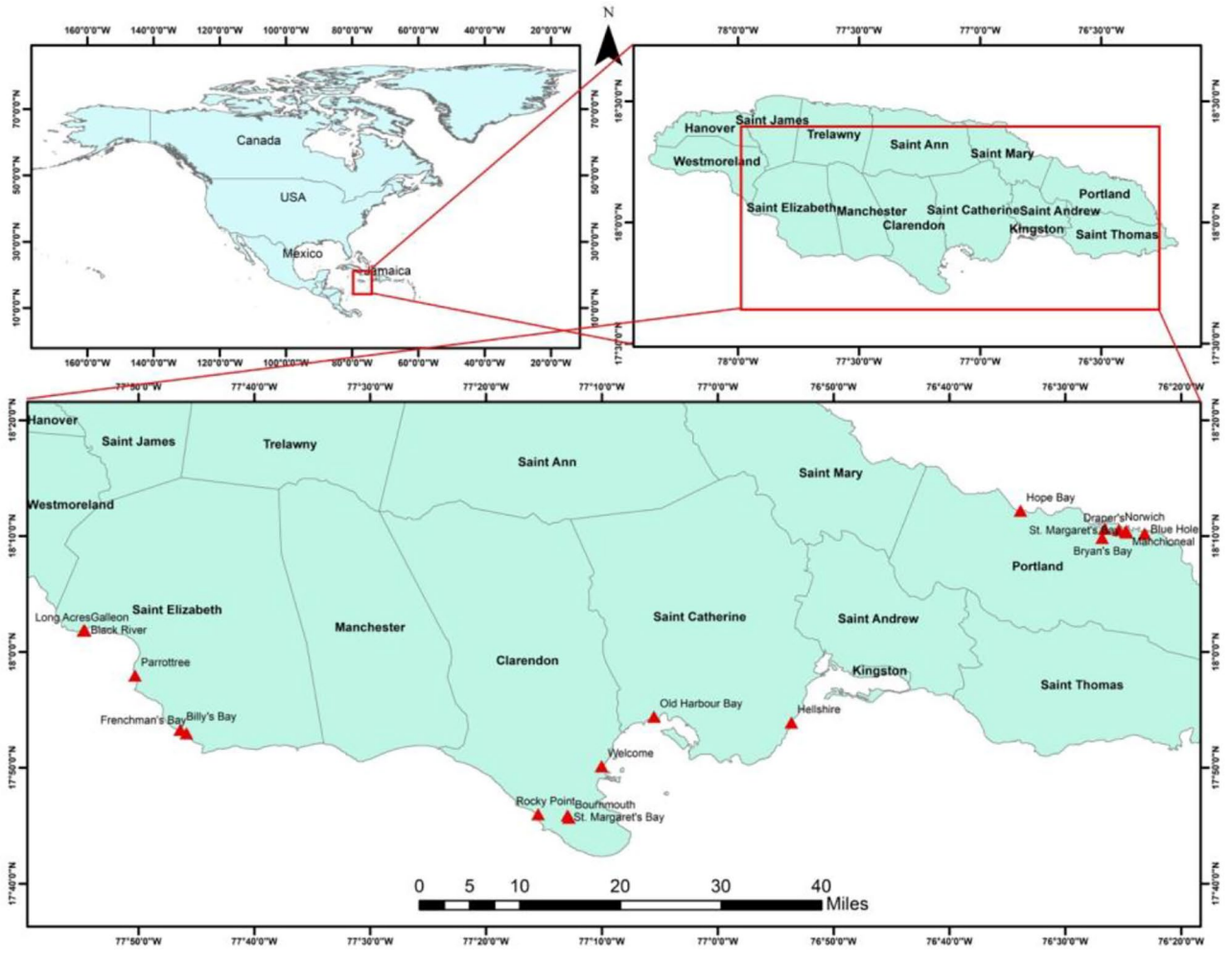

Fig. 1 Map of parishes in Jamaica, showing fishing beaches used in the study (green icons indicate communities sampled in Portland, red icons represent fishing communities sampled in Clarendon/St. Catherine and yellow icons represent fishing communities sampled in St. Elizabeth)

participants were first asked to list all persons they share information about fishing: "who do you typically share information with about fishing decisions at your fishing beach [fishing decisions can include information about fishing rules, gear use, fishing locations, or fishing frequency]?" However, during data collection, fishers indicated that their networks often extended beyond one fishing beach. To address this issue, we adjusted our question to: "who do you typically share information with about fishing decisions in your parish?" This change was made after the first few days of data collection in Portland Parish and was implemented in subsequent data collection in St. Elizabeth and Clarendon/St. Catherine. We included only results after this change was made in the protocol. After recording the names of these actors, the participant was then asked to provide relevant attributes for all actors, which included relationship type, length of time interacting with the actor, type of information shared between actors, frequency of interactions, and the level of trust and influence in the information received from the actor. We used a Likert scale to capture the perceived level of trust and influence in the information received (Table 2). Here, we refer to the level of trust and influence in the information received as tie attributes, describing the information shared and received (Groce et al., 2019; Prell et al., 2009). This differs from a trust or influence network where an actor is asked to list fishers they trust. To gather

Table 2 Description of hypothesized study variables that influence the legitimacy of information-sharing networks in Jamaica

Variables	Description
Influence	How important is this person in influencing your fishing decisions? *(on a scale of 1–5, 1: not important at all to 5: very important)*
Trust	How much do you trust the information from this person? *(on a scale of 1–5, 1: not important at all to 5: very important)*

the characteristics of each fisher, participants also completed a questionnaire.

Data Analysis

Analyses for the generation of the social network were carried out in R 4.0.2 (Core Team, 2020) using the *igraph* (Csardi & Nepusz, 2006), *statnet* (Handcock et al., 2018), and *Intergraph* (Bojanowski, 2015) packages. To analyze the social attributes, we used IBM SPSS Statistics 27. We first produced an adjacency matrix to visualize the network ties and nodes to generate the social network. All ties were dichotomous (presence or absence of a tie between two nodes) and undirected for this study. Here, we use undirected ties as our interest was only in the presence of the tie and not the directionality of the relationship. Despite collecting self-reported data on the directionality of the ties, as we collected personal social networks and not the whole networks, this approach still allows understanding of the network structure and dynamics.

To address our research hypothesis that fishing captains may hold more central positions because of their formal power in making fishing decisions while at sea, we stratified our sample into fishing captains and non-captains (crew members, boat owners, and fishmongers[2]). We combine crew members, boat owners, fishmongers because while they may contribute to decision-making, they may not always possess the same perceived authority as fishing captains. While boat owners contribute the vessels and equipment, their influence in the information sharing network may originate more from their ownership status than direct decision-making power. We included fishmongers in our stratification because they generally buy the majority of fish product.

We start by calculating the structural properties of the networks to answer our first hypothesis that fishing captains occupy prominent positions within networks and act as brokers to influence the flow and access of information. For each parish, we calculated network density and centralization measures. To calculate network degree centralization, we assessed how all the ties in a parish network were distributed among the fishers there. A network with a higher degree of centralization has a larger number of ties involving fewer fishers, while a network with a lower degree of centralization has a more even distribution of ties among its fishers.

To further address our first hypothesis, we calculated degree centrality scores at the actor level, using the *statnet* package in R. To assess the relationship between centrality scores and fishing roles, we conducted independent sample t-tests for each parish to compare differences in means and calculated effect sizes using point biserial correlations. Interpretations of the effect sizes were conducted using Cohen (1988) (small relationship = 0.20, medium relationship = 0.50, and large relationship = 0.80). Effect sizes are useful additional measures of interpretation that add further context of the relationship between groups or variables.

To respond to our second hypothesis that greater trust and influence will be placed in the information shared by fishing captains rather than non-captains, we used the independent sample t-test to assess the relationships between the fishing roles of actors and trust and influence as continuous variables (Table 2) and the fishing roles of actors. We used point-biserial correlations to assess the effect sizes for the independent sample t-tests.

Results

Network and structural properties

We collected network data for 353 fishers (nodes) across four parishes: Portland (n = 102 or 6% of the parish's registered fisher population), St. Elizabeth (n = 119 or 9% of the parish's registered fisher population), and Clarendon/St. Catherine (n = 132 or 2% of the parish's registered fisher population) (Fig. 2). The densities of the three networks were: Portland = 0.112, St. Elizabeth = 0.121, and Clarendon/St. Catherine = 0.011(Table 3). Densities reflect the proportion of observed ties over the total number of possible ties in the network. We found that despite Clarendon/St. Catherine having the largest number of nodes, it had the lowest density. The variation in centralization across the three parishes was minimal. The highest centralization was found in St. Elizabeth (0.061), followed by Portland (0.059) and Clarendon/St. Catherine (0.057).

Table 3 Structural and descriptive properties of information sharing in fishing decision networks in three parishes in Jamaica

Parish Name	Nodes	Captains	Non-captains	Edges	Density	Centralization
Portland	102	27	75	116	0.112	0.059
St. Elizabeth	119	42	77	170	0.121	0.061
Clarendon /St. Catherine	132	47	85	206	0.011	0.057

[2] Fishmongers sell fishery products, either wholesale or retail, usually at a fish market.

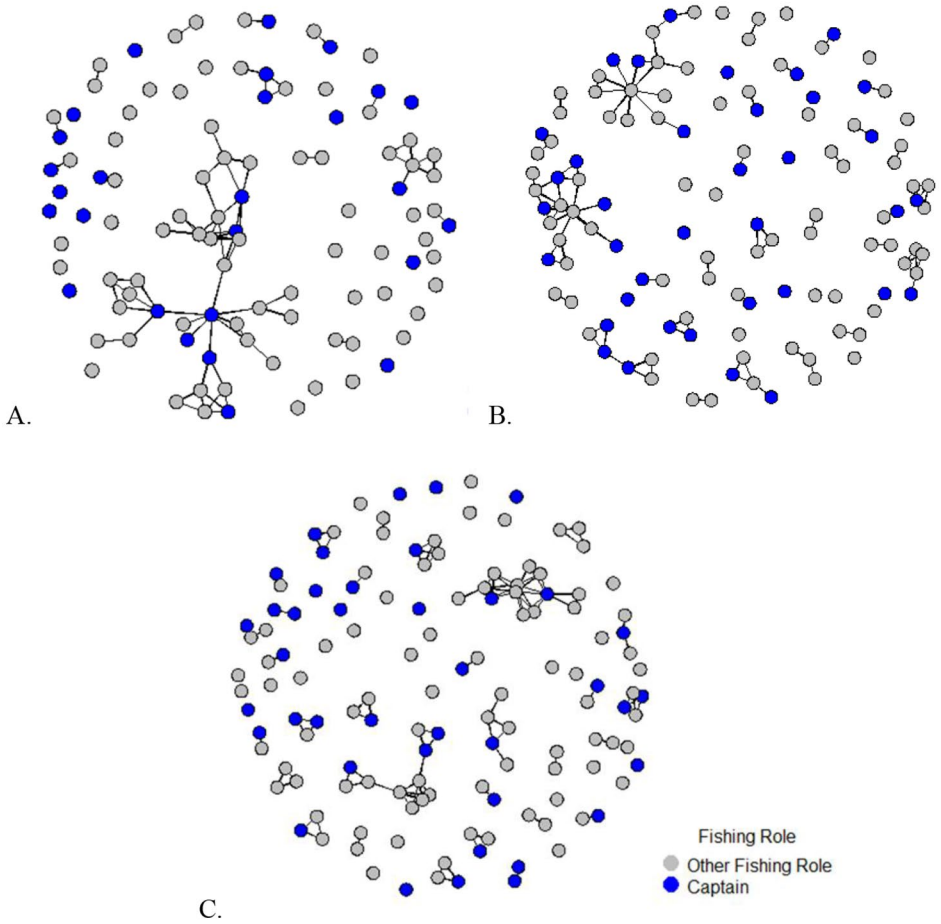

Fig. 2 Visualization of information-sharing networks in small-scale fisheries communities in three parishes in Jamaica (A: Portland, B: Clarendon/St. Catherine, and C: St. Elizabeth)

Table 4 Relationship between centrality measures and fishing roles by parishes

	Fishing Role		F-value	*t*-value	*p*-value	Effect size (r_{pb})
	Captain	Non-captains				
Portland						
Degree Centrality	2.52	2.19	3.13	.593	.555	.06
St. Elizabeth						
Degree Centrality	2.69	2.95	.05	.51	.615	.05
Clarendon/St. Catherine						
Degree Centrality	1.93	3.68	4.74	3.57	.001*	.25

*denotes significant difference between means

Relationship Between Fishing role and Actor Centrality

To assess the relationship between fishing role and centrality, we started by reviewing the mean centrality scores for the two categories of actors. There were no significant differences across the measures of centrality and fishing roles in both the Portland and St. Elizabeth parishes. In the Clarendon/St. Catherine parish, the non-captains had significantly higher degree centrality in comparison to captains (degree p = .001) (Table 4) and the effect size of degree centrality was typical (r_{pb} = 0.25).

Assessing the Relationship Between tie Attributes and Fishing role

In exploring the perceived trust and influence on the information shared in the networks, we reviewed the means across and within the parishes (Table 5). St. Elizabeth had the lowest means for trust and influence in information shared by all fishing actors. On average, the higher means for trust and influence in the information shared by both captains and non-captains was found in Portland. In St. Elizabeth, the information shared by non-captains was perceived as significantly more influential (p = .037) and trustworthy (p = .001)

Table 5 Independent sample t-test results assessing the relationship between tie attributes and fishing role

	Fishing Role		*t*-value	*p*-value	Effect size (r_{pb})
	Captains	Non-captains			
Portland					
Influence	4.54	4.56	.15	.883	.02
Trust	4.56	4.59	.20	.84	.02
St. Elizabeth					
Influence	3.38	3.98	2.13	.037*	.22
Trust	2.9	4.01	3.46	.001*	.33
Clarendon/St. Catherine					
Influence	4.6	4.22	2.87	.005*	.21
Trust	4	4.26	2.51	.013*	.18

*denotes significant difference between means

Trust and influence means are on a 5-point scale of 1 "not influential or trustworthy at all" to 5 "very influential or trustworthy"

than captains. The effect size for influence (r_{pb} =0.22) was small, but the effect size was medium for trust (rpb = 0.33). In Clarendon/St. Catherine, the information shared by captains was perceived as more influential (p = .005), while information shared by non-captains was viewed as more trustworthy (p = .013). The effect sizes for both tie attributes were small (trust r_{pb} = 0.21 and influence r_{pb} = 0.18).

Discussion

The main objective of this study was to look at the relationships between fishing roles and actor prominence and test the relationship between perceived trust and influence in the information received and fishing roles. Generally, we found low network centralization and density across all three networks, coupled with a high number of independent actors. Only in one parish did we find a significant difference between actor role and centrality. We also found mixed results in the relationship between perceived trust and influence in information shared and actor's role. This suggests that in developing information-sharing networks, fishers are not necessarily more likely to seek out information from captains nor do they place higher levels of trust or influence on the information from captains. In addition, these results provide further evidence of the flexibility of information-sharing networks in adapting to social and environmental changes and offer implications for how policymakers can effectively engage with key informants in sharing conservation and management information.

Actor Prominence in information-sharing Social Networks

Over the past two decades, Jamaica's fishing sector has faced various social and environmental challenges, including low employment rates, marine spatial conflict, ecosystem degradation, and decreased fish recruitment (Epstein et al., 2022; Kushner et al., 2011). The configuration of the networks in the three parishes may reflect one approach to how fishers are responding to uncertainties in Jamaica's fisheries industry. Our findings that captains are not as prominent in two parishes may suggest that fishers are using diversified sources of knowledge in responding to social and environmental changes. Our results may also suggest that an actor's status as a formal leader within these networks may not be the most important factor contributing to how valuable and influential information is perceived to be.

The lack of a difference in the prominence of actors' roles in two of the three parishes (Portland and St. Elizabeth) in our study reflects an even distribution of centrality among the actors sampled. This even distribution may contribute to the resiliency of the actor's personal network and may reflect the fishing culture of these parishes. First, by having an even distribution of central actors, networks can better withstand the loss of actors or actor redundancy where actors hold similar access to information and resources (Janssen et al., 2006). Similarly, an even distribution of central actors supports the group's efficiency in solving tasks, an advantage when undergoing change and responding to disturbances (Bodin et al., 2006; Walker et al., 2004). In contrast, in a highly centralized network, if a key actor leaves the network, it potentially affects the ability of the group to share information and accomplish tasks (Borgatti, 1995). Second, the lack of difference between actors in Portland and St. Elizabeth may reflect the fishing culture. For example, in these two parishes, a great proportion of fishers move freely across different fishing boats, which may reflect differences in fishing culture across the three parishes. The presence of significant differences in Clarendon/St. Catherine may reflect an alternative social structure, where information sharing is linked to experience (Díaz-Reviriego et al., 2017), social status (Reyes-García et al., 2019), or assets (Barnes et al., 2020) rather than the perceived authority fishing captains hold. This may be a fruitful approach for future research to further explore the underlying factors that influence information sharing dynamics.

The variation in centrality scores we found may be influenced by the large number of actors without relational connections to other actors, called independent actors. Alexander et al. (2015) described these isolates as a reflection of the fishing culture in Jamaica. However, we would further suggest that the flexibility of these independent actors

in deciding when and whether they connect to a sub-group may serve as both an advantage and disadvantage to potentially increasing access to information. In times of rapid socio-ecological change and uncertainty, being an independent actor with unique information who can join any sub-group may be an advantage (Pellowe & Leslie, 2019; Wood et al., 2014). Indeed, these independent actors may decide on the best individuals to connect with depending on the context or connect with those groups that are most like them (Barnes et al., 2020). This emergent tie formation may also be an advantage for existing sub-groups, as new connections with independent actors bring new sources of information to the group. For example, Yletyinen et al. (2021) highlight that isolates play a significant role in the diffusion of social influence in landowner social networks, introducing new knowledge that can contribute to environmental behaviors. Further, the exclusion of the role of isolates in social networks limits the understanding of the diversity of information sources and information flow that actors depend on when making decisions. The network structures found in Jamaica and the benefit of integrating new knowledge support existing literature on the importance of heterogeneity in networks as one way to withstand shocks and adapt to new situations (Dapilah et al., 2019; Folke et al., 2005; Zhu et al., 2020). However, the presence of the independent actors in our study may also be a result of our study design and the network boundaries. Indeed, the independent actors we found may be more prominent actors in other parishes or fishing beaches. Alternatively, being an independent actor may be disadvantageous as it can limit access to valuable information that may only arise from being embedded in a network. Similarly, without being embedded in a network, a fisher may have limited ability to contribute to decision-making, reducing social capital (Marín et al., 2012; Ramirez-Sanchez & Pinkerton, 2009).

The low-density scores across the networks suggest low cohesion across the parishes. Our results are consistent with those of other network studies in the Caribbean that recorded similar low cohesion across information-sharing networks (Alexander et al., 2015). Similarly, Díaz-Reviriego et al. (2017) found that low density in Amazonian fishing networks may be reflective of fishers either fishing alone or in small groups. They argue that the network arrangement might represent different fishing strategies. In Jamaica, our network configuration may reflect the informal relationships between fishers and fishers' declining dependence on fishing as a livelihood. These informal arrangements are supported by Campbell (2018), who found that 35% of fishers in Jamaica utilized informal groups for their fishing activities. Similarly, many fishers indicate that there has been a gradual decline in full-time fishers over the past five years. Instead, many community members now see fishing as an opportunistic job when there is a need for economic stimulus (ibid.). However, this informal nature may undermine the resilience of the networks, affecting fishers' ability to access valuable information that may improve their catch and effort. Indeed, Moghfeli et al. (2022) illustrated that the low reciprocity and low density in farmer's networks in Iran reflect contextual factors, including low social capital, high cost of operations, and lack of adequate governmental support. These factors may also be contributing to the network density and cohesion of Jamaican fishers. For example, Jamaican fishers consistently noted a lack of support services from government agencies and low interest in local-level fisher organizations as factors contributing to the declining interest in the fisheries industry.

Our results must also be further interpreted within the context of Jamaica's small-scale fishing sector. Fishers are often reluctant to share their networks with researchers since they consider this information confidential and sacred to their fishing practice. Our results may represent the protectiveness of fishers over sharing their networks. This additionally highlights methodological considerations for the collection of social network data in similar contexts. Similarly, the positionality of our data collectors may also contribute to the network data collected. Given the positionality of the research assistants in the communities, participants may have been reluctant to divulge their information networks. Alexander et al. (2018b) noted similarly that fishers in Jamaica were unwilling to report illegal fishing activity to avoid being labeled a "snitch" by their counterparts. Similarly, Espeut (1992) found that in both Belize and Jamaica there was little interest among fishers to "turn other fishers in" for illegal activities. While our study did not elicit data on illegal fishing activities, requesting fishers to share whom they exchange information with when developing fishing strategies may have similar connotations. As an illustration, many fishers interviewed were curious about the use of the network data and whether government officials would have access to their networks. At the same time, it is worth noting that the COVID-19 pandemic may have affected the information-sharing strategies of fishers, as national restrictions on social gatherings may have limited their opportunities to share information on the fishery at key venues such as fishing boats, beaches, and fish markets. These results offer insights into the interpretation and collection of network data in similar common pool resource contexts, where resource users heavily guard information related to their fishing activity.

Trust and Influence in information-sharing Social Networks

The prominence of actors within networks is also a reflection of the perceived trust and influence placed on the information received. In St. Elizabeth, significantly greater trust and influence were placed on the information shared by non-captains, but there was no significant difference in the centrality between captains and non-captains. This may suggest that fishers in this parish put more weight on information quality and content than the actor's role. This finding supports the findings of Bodin and Crona (2009) and Yletyinen et al. (2021) that an individual can be influential within a network without being in a central position. On the other hand, our findings in Clarendon/St. Catherine demonstrate that fishers' trust and influence in the information shared were tied to the actor's role but not the one we hypothesized as non-captains' information was perceived as more influential and trustworthy. This may suggest that simply being a fishing captain does not translate to greater weight placed on the information shared. At the same time, this outcome could be attributed to variables not included in our study, such as gear heterogeneity, fishing experience, and access to more resources. Similarly, the designation as a captain or crew and therefore a fisher's possession of formal power may also be influenced by other factors, including years of fishing experience, capital to purchase a vessel, or social status. At the same time, in some instances, the boat owner and captain are not the same individual. In these instances, the boat owner may consider the same factors, but may also select a captain based on kinship. Therefore, the perception of the trust and influence of the information shared by a captain may be influenced by other confounding attributes.

These results offer further insights into the role of trust in actors as mediating tie strength (Granovetter, 1973; Jones & Shah, 2021; Levin & Cross, 2004). Rather than focusing on trust and influence in the actor, as has been theorized and emphasized (Ho et al., 2016; Phong et al., 2018), the perception of whether the information is viewed as trustworthy or influential may be the product of frequent and reciprocal interactions between actors over time, independent of their formal status (Grabner-Kräuter & Bitter, 2015). Attributes that could affect the quality of one's information may include the actor's familiarity with resource dynamics, higher social status in the community, or a reputation of past adaptive behaviors (Goodreau et al., 2009; Hu et al., 2021; Levin & Cross, 2004).

Limitations

It is important to qualify our study with a few key limitations. First, we collected the personal social networks of fishers so our results are difficult to generalize to the whole network and fishers outside those we sampled. This is a central consideration in interpreting our results, as we cannot use the current results to describe patterns for all information-sharing relationships in the parishes (Guerrero et al., 2020). Similarly, personal networks rely on participants' self-reports, which may lead to incomplete networks and limit our study from understanding dynamics beyond those actors in our study. Second, there are methodological considerations for collecting network data in small-scale fishing contexts. The use of a Likert scale to assess trust and influence in information received may oversimplify the complex phenomena of social dynamics and information flow in fishing communities, potentially leading to subjective interpretations, limited contextual understanding, and a narrow scope of assessment. In our study, the collection of node alters outside the parish boundaries proved to be resource intensive, which, along with the informal nature of fishing in Jamaica, where fishers frequently enter and exit the fishery, limited our ability to capture the full network. As such, we are limited in our scope of inference. Recently, however, there has been increased attention on the methodological challenges of collecting network data in informal contexts, with greater consideration for mixed-method approaches (Guerrero et al., 2020; Lindkvist et al., 2022).

Conclusions

Understanding the attributes contributing to actors' centrality in a network may be useful for policymakers in identifying appropriate key informants to share information. Understanding the structural configurations of fishing networks is a useful step in supporting conservation-related interventions (Arlidge et al., 2021). Indeed, our findings may demonstrate that the approach used by policymakers needs to consider local dynamics. For example, using captains as the key informants to share information in St. Elizabeth and Portland may not be the most effective approach, as their centrality in those parishes is not significantly different from non-captains. By recognizing the factors that contribute to actors' centrality and understanding the unique social structures at play, policymakers can identify appropriate key informants and design targeted interventions that harness the power of information sharing to support sustainable fisheries management. Indeed, our findings of different network configurations in each parish provides evidence that a one-size-fits-all approach may not be suitable for information sharing initiatives across different communities. Therefore, tailoring strategies to the specific dynamics of each community can enhance the effectiveness of conservation efforts.

Exploring the information-sharing networks of resource users contribute to the broader governance of small-scale fisheries. Our study revealed that in Jamaica, there are nuances between the perceived formal authority of an actor, their centrality within a network, and the perceived trust and influence placed on the information they share. Indeed, we found that fishers' networks vary by parish and are generally diffused, with few consistent differences in the trust or influence attributed to information from captains and non-captains. This supports the findings of other authors that show that factors such as familiarity with resource dynamics, social status, and reputation of past adaptive behaviors contribute to the trust and influence in these information-sharing networks. Leveraging this study and existing work in the area, future studies should consider how networks combine different sources of knowledge in generating adaptive strategies. A deeper understanding of information facilitation and social influence in similar contexts could offer opportunities to explore the role of opportunistic tie formation as an adaptive strategy. Equally important, an expanded exploration of actor and tie attributes may offer further insights into actor positions within information-sharing networks in common-pool resources. Our study contributes to growing interest in common-pool resource governance that explores how network approaches can be used to understand underlying motivations in resource users' decision-making strategies to adapt to change. It also contributes to how policymakers can develop effective ways to engage diverse resource users, not only those actors with perceived authority.

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Author Contributions EW conceived the ideas, designed the methodology, supervised data collection, analyzed the data, and led the writing of the manuscript; KB and SMA contributed to methodology design and idea conceptualization; SMA and DG contributed to data analysis and data interpretation. All authors contributed critically to the drafts and gave final approval for publication.

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Data Availability The datasets generated and analyzed during the current study are not publicly available due the fact that they constitute an excerpt of research in progress but are available from the corresponding author on reasonable request.

Declarations

Ethics Approval The study was approved by Oregon State University Institutional Review Board, IRB-2020-0861.

Consent to Participate Due to variation in literacy, all participants were read the consent document and asked to provide verbal consent to participate.

Conflict of Interest The authors declare no competing interests.

Consent to Publish All authors approved this manuscript for publication.

Competing Interests The authors have no competing interests to declare that are relevant to the content of this article.

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