A Preliminary Analysis of Fisheries Science Networks in the Eastern Caribbean

KEMRAJ PARSRAM
Centre for Resource Management and Environmental Studies
University of the West Indies, Cave Hill Campus, Barbados

ABSTRACT

Fisheries science networks in the Caribbean comprise interactions between nodes such as fisheries authorities, managers, scientists and policy-making institutions that are tied to each other in a variety of relationships. The Caribbean Regional Fisheries Mechanism (CRFM) fisheries science working groups connect the countries, their fisheries authorities and others in data sharing and some level of collaborative stock and fishery assessment with the aim of tendering scientific advice for management and policy decisions. The quantity and quality of data collected and shared for assessment, and the assessment processes are likely to be, in part, functions of the nature and structure of the networks. This paper presents the results of a preliminary network analysis of the CRFM fishery science networks in the eastern Caribbean, with emphasis upon information exchange. I argue that existing ties illustrate how limited communication and weak linkages in the networks of national fisheries authorities, scientists, and managers result in inadequate science information exchange. Such patterns are not uncommon in the fisheries systems of both developed and developing countries. The findings here are based upon analysis of data collected using surveys, observation and review of reports. However, the data set is small and conclusions that can be drawn from it are tentative and preliminary. Despite these limitations they illustrate the potential use of network analysis as a tool for providing information to manage and improve fishery science networks. This has implications for the broader issues of policy and governance.

KEY WORDS: Networks, fisheries science, eastern Caribbean

Análisis Preliminar de Redes Científicas de Pesca en el Caribe del Este

Redes de pesca científica en el Caribe comprenden las interacciones entre nodos tales como autoridad pesquera, administradores, científicos e instituciones elaboradores de políticas que están unidos unos a otros en una variedad de relaciones. Los grupos de trabajo de ciencia pesquera del Mecanismo Pesquero Regional del Caribe (CRFM) por sus siglas en ingles) conecta los países, sus autoridades pesqueras y otros a nivel de intercambio de datos y cierto nivel de evaluación de pesca y stock colaborativo a fin de efectuar asesoría científica para decisiones de política y manejo. Estos datos cualitativos y cuantitativos recolectados y compartidos para evaluación y procesos evaluativos pueden ser en parte, funciones de la naturaleza y estructura de las redes. Este escrito presenta los resultados de un análisis preliminar de redes de la red de pesca científica del CRFM en el Caribe del este, enfatizando el intercambio de información. Presento que uniones existentes ilustran come limitada comunicación y enlaces débiles en las redes de las autoridades nacionales de pesca, científicos y administradores resultan en un intercambio inadecuado de información científica. Tales patrones son comunes dentro del sistema tanto de los países desarrollados como los no desarrollados. Los resultados se basan en análisis de datos recolectados utilizando encuestas, observación y revisión de documentos. Sin embargo, el set de datos es poco y las conclusiones a los que se puede llegar basándose en estos datos son tentativas y preliminares. A pesar de estas limitaciones ilustran el potencial del uso de del análisis de redes como una herramienta para proveer información para el manejo y mejoramiento de las redes de pesca científica. Esto tiene implicaciones para asuntos mas amplios de políticas y gobernabilidad.

PALABRAS CLAVES: Redes, pesca científica, Caribe del Este

INTRODUCTION

Communication and the exchange of information are vital to the existence of societies, organizations, and other social groups (Fraser, 1994). It is of particular importance in fisheries management, given the large numbers of people involved in fisheries and its importance to society and national economies in the Caribbean. Collaborative management and sound decision-making for the sustainable management of fisheries require continuous communication and sharing of information, and the availability of adequate fisheries science information (FAO 2003). Fisheries science information such as that based upon stock assessment of Caribbean fisheries resources is inadequate (Grant 2006, Parsons 2007). This is partly because many conventional approaches to stock assessment are data-intensive, and most Caribbean countries lack the technical capability and financial resources to carry out such intensive data collection, analysis, and interpretation on their own (Grant 2006). Small fisheries departments may lack local expertise to assess, interpret, and apply the results of stock assessment analysis. They typically rely on 'experts' from developed countries with backgrounds in assessing large stocks, but they lack the financial resources to sustain this approach (Mahon 1997). To address some of these deficiencies, *ad hoc* fisheries science working groups and workshops convened through the efforts of the Food and Agriculture Organization's (FAO), Western Atlantic Fisheries Commission (WECAFC), and the Caribbean Regional Fisheries Mechanism (CRFM) seek to assess particular species and species groups in the region. These fisheries science working groups connect the CRFM member states, their fisheries authorities, ,fisheries managers, scientists, and some experts from across the globe selected as consultants. They form a network of pooled capacity for data sharing and some level of collaborative stock and fishery assessment with the aim of tendering scientific advice for management and policy

decisions.

Each year, in an extended two weeks scientific meeting, CRFM convenes working groups which review the status of stocks and undertake scientific assessments. Regional and international organisations such as the University of the West Indies (UWI), the Organization of Eastern Caribbean States (OECS), and the WECAFC are observers. The assessments are usually conducted on individual species or species groups (e.g. lobsters and queen conch, large pelagics, coastal pelagics, shrimp and groundfish). The reports of the scientific working groups are then presented in a plenary meeting for general discussion of the findings and refinement of the recommendations. A review of the recommendations and participation in the discussions of reports presented at the plenary sessions of the scientific meetings suggest that the quantity and quality of data collected and shared for assessment, and the assessment processes are often inadequate to allow working groups to make concrete recommendations with any certainty. Recommendations are made mainly with the precautionary principle in mind.

This inadequacy of fisheries science data and information may also be, in part, a result of poor communication, collaboration and information-sharing among organizations involved in fisheries science, hence reducing the opportunities to improve management advice for fisheries. In this sense, the structural characteristics of the networks of scientists, managers, policy-makers and organizations involved in fisheries science information exchange in the Caribbean is believed to have direct influence on the potential for successful communication, collaboration and information exchange (see Crona and Bodin 2006). To examine this possibility, the author undertook a preliminary social network analysis of the fisheries science networks of some national fisheries authorities, with emphasis upon information exchange. This study is an initial effort at network analysis that contributes towards the author's PhD research into marine resource governance in the eastern Caribbean.

The objectives of this analysis were to map the network of organizations (nodes) that participate in fisheries science, determine the relationships (ties and links) among these, and determine where fisheries science information is generated and communicated to be used. This paper is not a full explication of fisheries science networks in the Caribbean, but it provides a partial analysis of the structure of the network(s) and the implications of these for fisheries science information exchange.

METHOD

Methods used were drwn from the social sciences with emphasis on social network analysis (SNA) (see Wasserman and Faust 1994, Scott 2004). This provided a toolbox to quantify various theoretically important structural characteristics of the fisheries science networks as a set of interconnected ego networks.

Network Analysis

Networks among actors and stakeholders are gaining attention in studies of natural resource management. Networks have primarily been envisioned as enabling different actors to collaborate and coordinate management efforts (Bodin 2006). Networks are real observable phenomena that can be measured using quantitative techniques (Marsden 1990) and analyzed using social network analysis (Degenne and Forsé 1999, Scott 2000). Janssen *et al.* (2006), Bodin (2006), Carlsson and Sandstrom (2006) and Crona (2006) suggest that network theory has the potential to aid understanding of the interactions between institutional arrangements, individual decisions, and environmental and social outcomes in identifying strategies for improving collective management and governance.

Network analysis is the mapping and measuring of relationships and flows between people, groups, organizations, or other information/knowledge processing entities. The nodes in a network can be the people, organizations etc., while the links show relationships or flows between the nodes. In its simplest form, a network is a map of all of the relevant ties between the nodes being studied. These concepts are often displayed in a social network diagram, where nodes are the points and ties are the lines.

To understand the variation in the nature and structure of a network, several concepts and basic properties are available. The definitions of the network concepts and measures were defined adequately by Hanneman and Riddle (2005). Those that are of interest in this paper are provided below.

"Ego" is an individual focal node. In this case it is the organizations that were sampled (national fisheries authorities). "Alters" are all the organizations that the ego has some reported relations with. A "neighborhood" is the collection of egos and all alters to whom the ego has a connection. Differences among actors in how connected they are can be consequential to understanding in this case how science information is communicated through the network. Many connections may mean that actors are exposed to more, and more diverse information and information sharing can be enhanced (information can spread quickly where there are high connections) (Hanneman and Riddle 2005, Bodin 2006). To determine connections in ego networks, network analysis provides specific measures; these include size, density, and in and out neighborhoods. There are others, but the foregoing were of greatest interest and of relevance in this study.

Size of an ego network is defined as the number of nodes that are one-step out neighbors of the ego, plus the ego itself. Density is a measure of the proportion of all ties that could be present that actually are. In other words, the overall integration or cohesion between organizations of the network in realizing its potential or purpose or how connected are all nodes in the network. Density values range from 0 to 1, with 1 being fully connected and 0 being

no connections (Scott 2000). In information networks, higher density indicates a greater degree of interaction among the actors. Neighborhoods in the case of information exchange in ego networks can indicate where information comes from (sources) and where it goes to be used (sinks) in a directed network. Out-neighborhood is the sum of connections from the ego to others, while in-neighborhood indicates how many actors send information to an ego in question. Centrality measures allow for identifying actors who influence or control the network. Degree centrality locates the actors with most number of connections or ties. Betweeness centrality locates the actors that are in structurally advantaged positions in a network, i.e. actors who are in a position that other actors are dependent upon them to make connections with other actors.

With network analysis I investigated whether the nature of communication and linkages reflected in the structure of the fisheries science networks of national fisheries authorities (comprising scientists and managers) can reveal inadequate science information exchange.

Data Collection

The units of analysis were the national fisheries authorities that participated in the CRFM's Annual Scientific Meeting of 2007 which brought together consultants, fisheries scientists, and managers in their various *ad hoc* working groups. Group membership is based mainly upon the importance of particular fisheries resources to the country (see Table 1). The fisheries authorities included those of Belize, Barbados, Jamaica, Guyana, Grenada, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago. Representatives of the national fisheries authorities (Fisheries officers, Research Officers, Fisheries Biologists) that attended the CRFM 3rd Annual Scientific Meeting in St. Vincent 24 - 26 July 2007 were the respondents in personal interviews. One of the observer organizations, the Institute of Marine Affairs, also participated.

Ideally, when collecting data for network analysis, a whole network approach is recommended where information about each actor's ties with all other actors and their ties is collected (Hanneman and Riddle 2005). However, I was not able to interview all possible actors; hence the approach to target focal nodes/actors (egos) was taken. This ego-centered approach although without knowing the connections among alters, provides some useful information on the structure of actors' relationships (Hanneman and Riddle 2005).

Network data were collected by means of a questionnaire administered through personal interviews with the representatives of the national fishery authorities. In some cases, where a personal interview was not possible, respondents were asked to complete the questionnaire on their own following the printed instructions.

The recall method was used to collect network data. This involved each respondent listing, to the best of their knowledge, the organizations with which their fishery authority currently interacts in relation to giving or receiving fishery science information. Thus, a list of organizations at the local, national, regional, and international levels was generated. To capture the relationships between the fisheries authorities and the named organizations, respondents were asked the following questions:

i) What is the level of the organization (International, Regional, National, and Local)?
ii) Which are the features of the fisheries science relationship? (Fisheries raw data, science information, scientific (analytic) advice, funding for science, training in science, actual assistance in doing science (consultant), or other)
iii) For those features you have indicated which is the most defining of the relationship?
iv) For this main feature is your fishery authority mainly the giver, receiver or and equal exchanger?
v) For this main feature, how frequently is the resource in the relationship used? (weekly, monthly or yearly)
vi) Overall, how important is this relationship (all features) to fisheries science in your authority? (not important, important, very important)

In addition, personal attributes of the respondents such as gender, job title, years employed with the fishery authority, and contact information were collected. Respondents were also asked to rank the top three fishery resources of their countries, indicate which of the CRFM working groups they actively participate in, and list five types of fisheries science tasks related to the working groups or fisheries science generally that occupy most of their time. In addition, supporting data and attributes information for the national fishery authorities were collected through direct observation and review of existing reports.

Analysis

Attribute data of respondents were analyzed to get an overview of the characteristics of respondents. This was done using basic statistical routines in Microsoft Excel. The social network analysis software package, UCINET with Netdraw (Borgatti *et al*. 2002) was used to investigate whether the observed inadequacy of fisheries science information for decision-making could be detected, in part, by analyzing the networks nature and structure. Since the data collected represented a set of overlapping ego networks, this analysis was concerned mainly with the connections (size, density, and in/out neighborhood) and centrality of the various egos.

RESULTS

Overview

The cohort of respondents comprised six fisheries officers (66%), a research officer (11%), and a fisheries biologist (11%). Among these, six (66%) were females, while three (33%) were males. The majority of respondents (77%) were employed in their respective national fisheries authorities for more than five years. The *ad hoc* working groups of the CRFM included the conch and lobster, large pelagics, small coastal pelagics, shrimp and groundfish. The majority of the national fisheries authorities present at this meeting participated in the large pelagic and the conch and lobster working groups (Table 1). Respondents indicated that the large pelagics, conch and lobster, and shrimp and groundfish were the most important fishery resources for their respective countries. The majority of respondents reported that data analysis (88%), data collection, data cleaning, and reporting (66%), and giving management advice (33%) were the top five tasks that occupied most of their time.

Table 1. Attribute information for national fisheries authorities and the IMA

Organizations Interviewed	CRFM Working Group	Top 3 fisheries resources	Top 5 tasks
Belize (BELFISH)	Conch and Lobster	Conch and Lobster, Large pelagic, Reef and slope	Data Collection, analysis, Report writing, Fisheries management
Jamaica (JAMFISH)	Conch and Lobster	Conch and Lobster, Reef and slope, Large pelagic	Data collection, cleaning, analysis, report writing and management advice
St. Lucia (SLUFISH)	Conch and Lobster	Large pelagic, Conch and Lobster, Small coastal Pelagic	Data collection, cleaning and analysis
Barbados (BARFISH)	Large pelagic	Large pelagic, reef and slope, conch and lobster	Stock assessment, data collection/ collation, cleaning, report writing, management advice
Grenada (GRDFISH)	Small Coastal Pelagic	Large pelagic, small coastal pelagic, Conch and Lobster	Data collection, analysis, fisheries surveys, Habitat assessments, MPA monitoring and management, fisheries consultations
St. Vincent (SVGFISH)	Large pelagic	Conch and Lobster, Large pelagic, small coastal pelagic	Data collection, cleaning, analysis, report writing
Trinidad (TRINFISH)	Large pelagic	Shrimp and Groundfish, Large Pelagic, small coastal pelagic	Data collection, research, data analysis, Programme planning, report writing, communications
Guyana (GUYFISH)	Shrimp and groundfish	Shrimp and groundfish, large pelagic, small coastal pelagics	Data cleaning, analysis, report writing and presentations, management advice
Institute of Marine Affairs (IMA)	Observer	Shrimp and Groundfish, Large Pelagic, small coastal pelagic	Providing age and growth info.

Network Map

Figure 1a displays the overlapping ego network maps of nodes and ties for each of the eight national fisheries authorities, and the Institute of Marine Affairs, whose representatives were interviewed to collect network data. Nodes and their level in the governance hierarchy are represented by shapes. Circles are organizations at the international level; squares are organizations at the regional level, triangles are organizations at the national level, and diamonds are organizations at the local level as reported by respondents. The information that flows within these ego networks include fisheries raw data, general fisheries information, scientific/analytic advice, funding for science, training in science, and actual assistance in science through consultants. Size of arrows connecting nodes is proportional to the number of ties between any two nodes.

In these networks most ties (thicker arrows) converge on the national fisheries authorities and the regional and international organizations, particularly CRFM, WECAFC, International Commission for the Conservation of Atlantic Tunas (ICCAT), Organization of Eastern Caribbean States (OECS), UWI, and the Convention for International Trade in Endangered Species (CITES). The least number of ties were mainly among the national and local level organizations. There were no direct ties between any of the national fisheries authorities. Figure 1b is the same network map but the size of the arrows is proportional to the direction of flow of the type of information/ communication that was reported as the main feature of the relationship (thin line = giver, medium line = receiver, thick line = both giver and receiver/bi-directional exchange). Within these overlapping ego networks, there was some amount of bi-directional exchange between national fisheries authorities and the national and local level organizations. However, the majority of bi-directional flow of information mainly occurred between the national fisheries authorities and the international and regional level fisheries management organizations. This bi-directional exchange involved a mix of fisheries raw data, general science info, actual assistance in doing science, and scientific advice.

The national fisheries authorities were givers of fisheries raw data, general science information, and scientific advice mainly to national, international and regional level organizations. St. Lucia stood out in that its national fisheries authority was reported as only a giver of information (fisheries raw data and general science information) to the local and national organizations. Only the national fisheries authorities of Grenada and Trinidad reported any significant receipt of information. Both involved a mix of local, national, regional, and international level organizations and included a mix of fisheries raw data, general scientific information, and scientific advice. Overall, a significant number of actors were disconnected in the network at the local and national levels.

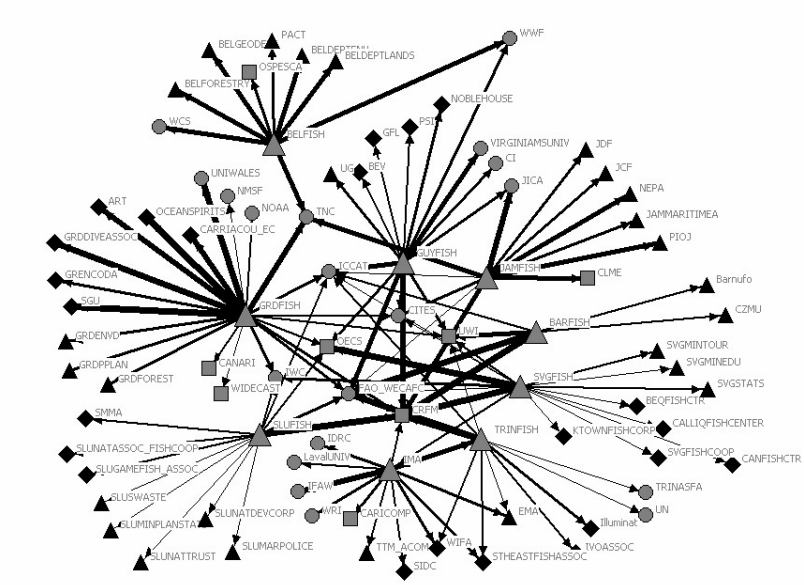

Figure 1a. Map of overlapping fisheries science ego networks of Caribbean national fisheries authorities showing nodes and number of ties (thin lines = 1 tie, medium lines = 2-3 ties, thick lines = > 3 ties)

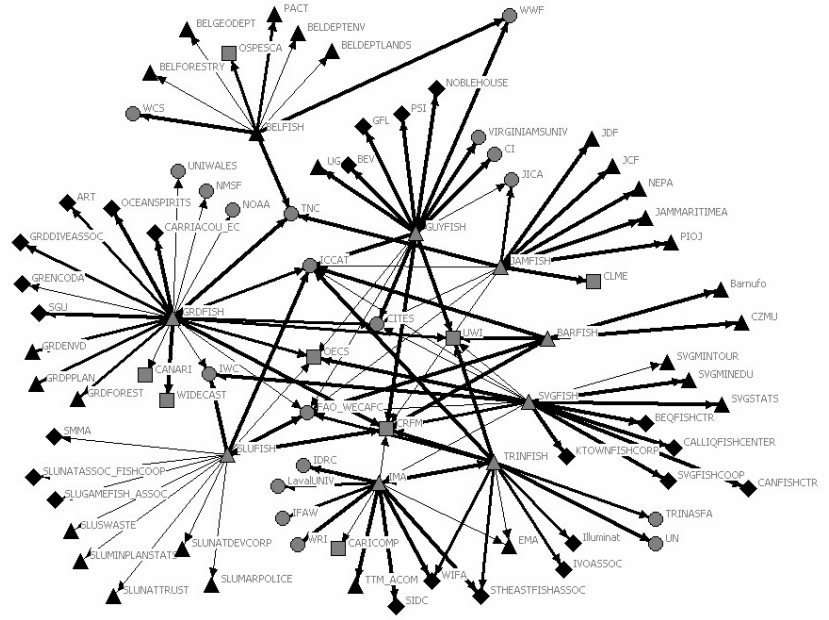

Figure 1b. Map of overlapping fisheries science ego networks of Caribbean national fisheries authorities showing direction of flow of information between egos and alters (Thin lines = giving, medium lines = receiving, thick lines = equal exchange)

Connections

A total of 85 actors resulted from the survey. These actors covered organizations at the international, regional, national and local levels, numbering 19, 8, 35, and 23, respectively. Among all actors in the overlapping ego networks, a total of 117 ties were reported. The formula K*K-1 (where K = total number of nodes) was used to calculate the total number of possible ties. This resulted in a total of 7,140 possible ties for the combined ego networks. The size of the ego networks across the varying levels are presented in Table 2. International level organizations were the most occurring within the networks of the national fisheries authorities of Grenada, Guyana, and the IMA of Trinidad and Tobago accounting for 36%, 46%, and 33% of all the actors, respectively. Local level organizations were the highest in St. Vincent and the Grenadines (31%). National level actors were the highest in Belize and St. Lucia, 55% and 38%, respectively. International and national level actors were equally the highest in Jamaica (41%). No local level actors were reported. International and local level actors were equally the highest in Trinidad (33%). Barbados reported equal numbers of international, regional and national level actors, but none at the local level.

Table 2. Size and density scores of main actors

Name of Organization	Size of ego network (actors) across each level				Neighborhood	
	International	Regional	National	Local	in	out
Barbados Fisheries Division (BARFISH)	2	2	2	-	0	6
Belize Fisheries Authority (BELFISH)	3	1	5	-	0	9
Grenada Fisheries Department (GRDFISH)	8	5	3	6	0	22
Guyana Fisheries Division (GUYFISH)	7	3	1	4	0	15
Institute of Marine Affairs Trinidad (IMA)	4	2	3	3	2	12
Jamaica Fisheries Division (JAMFISH)	5	2	5	-	0	12
St. Lucia Fisheries Division (SLUFISH)	3	2	5	3	0	13
St. Vincent and the Grenadines Fisheries Division (SVGFISH)	4	3	4	5	0	16
Trinidad and Tobago Fisheries Division (TRINFISH)	4	2	2	4	0	12
Caribbean Regional Fisheries Mechanism (CRFM)	-	-	8	-	8	0
Convention on International Trade in Endangered Specie (CITES)	-	-	4	-	4	0
Food and Agriculture Organization-Western Atlantic Fisheries Commission (FAO_WECAFC)	-	-	7	-	7	0
International Commission for Conservation of Atlantic Tunas(ICCAT)	-	-	7	-	7	0
International Whaling Commission(IWC)	-	-	3	-	3	0
Japan International Cooperation Agency (JICA)	-	-	2	-	2	0
Organization of Eastern Caribbean States(OECS)	-	-	4	-	4	0
South EAST Fisheries Association (STHEASTFISHASSOC)	-	-	2	-	2	0
The Nature Conservancy (TNC)	-	-	3	-	3	0
University of the West Indies (UWI)	-	-	5	-	5	0
Women in Fisheries Association (WIFA)	-	-	2	-	2	0
World Wildlife Fund (WWF)	-	-	2	-	2	0

Table 2 presents the results from the ego network density analysis of only the actors (egos and alters) with a neighborhood greater or equal to 2. The relative density measures of in-neighborhood and out-neighborhood are presented. From the out-neighborhood analysis of actors the national fisheries authorities were the reported sources of information. Grenada, St. Vincent and the Grenadines, Guyana, St. Lucia were the top four sources of information with 22, 16, 15, and 13 ties reported, respectively. Trinidad and Tobago and Jamaica reported 12 ties each. Barbados and Belize had 6 and 9 ties, respectively. From the in-neighborhood analysis, the international and regional organizations seem to be the main sinks for information. CRFM, ICCAT, and WECAFC were the top three sinks with 8, 7 and 7 ties, respectively. UWI, OECS, CITES, IWC and TNC had 5, 4, 4, 3 and 3 ties, respectively.

Centrality

Figures 1a and 1b revealed that the actors at the core of the overlapping ego networks were mainly the national fisheries authorities, and the regional and international fisheries organizations. The NetDraw software puts the central actors at the core of the map. Table 3 presents the relative degree and betweenness centrality for actors with neighborhood greater or equal to 2 in the overlapping ego networks. Among the national fisheries authorities, Grenada, St. Vincent and the Grenadines, and Guyana were the most connected actors, with degree centrality 26 19, and 17, respectively. The CRFM and UWI were the most connected actors at the regional level with degree centrality 9 and 5, respectively. WECAFC and ICCAT were the most connected at the international level, both had a degree centrality of 8. At the national level, the national fisheries authorities of Grenada, Guyana and St. Vincent and the Grenadines had the highest betweeness centrality scores of 36, 22, and 20, respectively. At the regional and international levels, the CRFM had the highest betweeness centrality of 25, followed by TNC with 12. ICCAT and FAO/WECAFC had a similar betweeness centrality score of 11.

Table 3. Relative centrality scores of main actors

Name of Organization	Centrality	
	Degree	Betweeness
Barbados Fisheries Division (BARFISH)	7	4
Belize Fisheries Authority (BELFISH)	10	16
Grenada Fisheries Department (GRDFISH)	26	36
Guyana Fisheries Division (GUYFISH)	17	22
Institute of Marine Affairs Trinidad (IMA)	15	18
Jamaica Fisheries Division (JAMFISH)	14	18
St. Lucia Fisheries Division (SLUFISH)	15	18
St. Vincent and the Grenadines Fisheries Division (SVGFISH)	19	20
Trinidad and Tobago Fisheries Division (TRINFISH)	14	13
Caribbean Regional Fisheries Mechanism (CRFM)	9	25
Convention on International Trade in Endangered Specie (CITES)	4	3
Food and Agriculture Organization- Western Atlantic Fisheries Commission (FAO_WECAFC)	8	11
International Commission for Conservation of Atlantic Tunas(ICCAT)	8	11
International Whaling Commission(IWC)	3	2
(JICA)	2	0
Organization of Eastern Caribbean States (OECS)	4	4
South EAST Fisheries Association (STHEASTFISHASSOC)	2	0
The Nature Conservancy (TNC)	3	12
University of the West Indies (UWI)	5	5
Women in Fisheries Association (WIFA)	2	0
World Wildlife Fund (WWF)	2	5

DISCUSSION AND CONCLUSION

In general, network analysis has served to provide some general but useful observations about the overall structure of the fisheries science networks of the respective national fisheries authorities. The observed underlying structure of these overlapping ego networks has implications for communication and information exchange at all levels, particularly with regards to the difficulty experienced with poor quality data used in informing the assessments of the various fisheries working groups (see CRFM 2007). The results of the network analysis suggest that the respective ego networks of the national fisheries authorities are not realizing their potential for fisheries science information exchange (i.e. the national fisheries authorities are not adequately connected across all levels). Their existing communication and information exchange linkages seemed to be directed mainly to particular organizations at the international and regional levels and not so much at the local to national levels.

It is logical for national fisheries authorities to have strong communication and information sharing linkages with the international and regional fisheries management and policy-making organizations that require information on a regular basis as part of their mandate. Such organizations include the CRFM, WECAFC, and ICCAT. These international and regional fisheries management organizations exist to provide the national fisheries authorities management advice, funding, training, and assistance in doing science, especially, with regards to management of trans-boundary and shared fishery resources such as the large pelagic species etc. National fisheries authorities are required to share information with these regional and international level organizations on their national fisheries, such as when they participate in the *ad hoc* working groups of both the CRFM and FAO/WECAFC. The CRFM Secretariat acts as a focal point for scientific information exchange with ICCAT, while some countries are also directly communicating with ICCAT in their own right. The National fisheries authorities and regional and international organizations (CRFM, WECAFC, ICCAT, UWI, OECS, and TNC) seem to be in a position to control the information flow in the overlapping ego networks. They are therefore likely to coordinate some of the flows within these network exchanges around their specific mandates. These have the potential to improve the communication and coordination at the other levels.

While it seems that national fisheries authorities and the regional and international fisheries organizations drive the communication and information exchange, the national fisheries authorities would benefit from improving linkages with the other components, such as national and local fisheries organizations. The results of the in and out neighbourhoods density measures suggest that there is little or no communication and information exchange between the national fisheries authorities and fishers, fisher's organizations, and other national level organizations. The national fisheries authorities are expected to have strong communication and information linkages with relevant organizations at the national and local levels. For example, local and national fisher folk organizations should ideally be sources of fisheries raw data and should be receiving management advice and general science information mainly from the national fisheries authorities. They also should be receiving opportunities for funding, training and assistance in doing science from regional and international organizations through the national fisheries authorities, and sometimes even directly from regional fisheries management organizations such as the CRFM.

There are numerous small fisher folk organizations (FFOs) operating mainly at the local level. Most of these were not revealed in the ties reported. McConney (2007) suggests that there are seemingly fairly well developed sub-regional non-management social networks among groups of fisher folk in various islands, and that there exist strong informal social networks through which fishing information and other resources are exchanged. These could be tapped into to improve national through to regional communication and fisheries science information exchange. McConney and Parsram (2007) suggest that there would appear to be widespread interest among these local resource users and fisheries organizations in collaborating for regional or sub-regional fisheries management. However, there is limited input and interaction generally from them at the national and regional levels. The majority of these resource users and post-harvest workers are not formally organized. Could this be a reason for the limited communication and information sharing with national fisheries authorities?

Importantly, among the national fisheries authorities themselves, in light of their already limited human and financial capacity, it would be prudent for these organizations to improve collaboration and exchange of information among themselves with regards to the fisheries resources they share. This is even more importantly required in light of the development and possible implementation by CARICOM of a Common Fisheries Policy and Regime for the governance of fisheries in the region.

The results and the conclusions that were drawn from them are tentative and preliminary. The dataset was small and limited (i.e. not collecting information from all national fisheries authorities and on ties between alters). Additionally, data collection relied mainly on the respondent's perceptions and recollection of fisheries science communication and information exchange of their respective national fisheries authorities. Hence, the results generated are only based on what was reported. However, a detailed or whole network and rigorous analysis is warranted. Collecting and analyzing relational data from alters is required to provide a more comprehensive analysis and more firm conclusions. Despite these limitations this study illustrates the potential use of network analysis as a tool for highlighting areas that may require attention for

improving communication and information exchange in the fishery science networks of national fisheries authorities. The social network analysis methodology provides a unique perspective and assessment of the network organization that traditional organizational analysis may not. Based upon this preliminary study network analysis is a promising method. However, its assumed usefulness must be tested in more detailed analysis of information networks and actual governance situations in fisheries management in order to confirm its practical application for improving policy.

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