Social-ecological System Interactions in Small-scale Fisheries: Case Studies of the Large Pelagic and Shallow Reef Fisheries of Grenada and St. Lucia Under Construction

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ABSTRACT

The components of social-ecological systems, their interactions in marine fisheries and the resulting outcomes of interaction are not always obvious to many fishery stakeholders. In Grenada and St. Lucia, the small-scale fisheries for large pelagics and shallow reef fish are examples of such complex systems. A pelagic longliner or a pot fisher catching, landing and marketing fish appears to be engaged in simple activities at first glance, but there exists a network of complex relationships and human-nature interactions within these fisheries activities. If stakeholders involved in the governance of such small-scale fisheries had a better understanding of how these complex social-ecological systems function from a network perspective, then it may be possible to improve the outcomes to meet societal goals. In this paper, I provide a preliminary description of the main social-ecological components and their network interactions in the fisheries for large pelagic and shallow reef fish in Grenada and St. Lucia. This research is part of a larger study on the governance of small-scale fisheries in the eastern Caribbean.

KEY WORDS: Social-ecological systems, networks, large pelagic, shallow reef, Grenada, St. Lucia

Systeme de Interacción Socio-ecológico en Pesce de Pequeña Escala: Estudio de Caso de Grandes Pelagicos y Pesca en Arrecifes poco Profundos en Grenada y Sta. Lucia Bajo Construccion

Los componentes de los sistemas socio-ecológicos, sus interacciones en pesca marina y los resultados de la interacción no son siempre obvios para muchos de los stakeholders en pesca. En Grenada y Sta. Lucia, la pesca de pelágicos y en arrecifes poco profundos a pequeña escala son ejemplos de tales sistemas complejos. La captura, descarga y mercadeo de pescados por parte de un pescador de pelágicos con palangre o pescador con nasas da la impresión, a simple vista, de estar involucrados en una actividad sencilla, sin embargo existe una red compleja de relaciones e interacciones de naturaleza humana dentro de estas actividades de pesca. Si los stakeholders involucrados en la gobernabilidad de pesquerías a pequeña escala tuvieran una mayor comprensión de la funcionabilidad de estos complejos sistemas socio-ecológicos desde una perspectiva de redes, quizás entonces seria posible mejorar los resultados para alcanzar las metas sociales. En este escrito, presento una descripción preliminar de los principales componentes socio-ecológicos y sus redes de interacción en la pesca de grandes pelágicos y en arrecifes poco profundos en Grenada y Sta. Lucia. Esta investigación es parte de un estudio más amplio sobre gobernabilidad de pesca de pequeña escala en el Caribe oriental.

PALABRAS CLAVES: Sistemas socio-ecológicos, redes, grandes pelágicos, arrecifes poco profundos, Grenada, Sta. Lucia

Les Interactions dans les Systèms Socio-écologiques de Petite Pêche: Étude de cas de la Pêche de Grandes Pélagiques et Poisson Coralliens en Grenade et St. Lucie—en Développement

Les composants des systèmes socio-écologiques, leurs interactions dans la pêche marine et les résultats de l'interaction ne sont pas toujours évidents. Au Grenada et au St Lucia, la pêche de petite taille pour le grand pélagique et les poissons peu profonds de récif est des exemples de tels systèmes complexes. Un ligneur pélagique ou un pêcheur de pot des poissons attrapant, de débarquement et de commercialisation semble être employé dans des activités simples au premier regard, mais là existe un réseau des rapports et des interactions complexes de humain-nature dans ces activités de pêche. Si les dépositaire d'enjeu impliqués dans le gouvernement d'une telle pêche de petite taille avaient un meilleur arrangement de la façon dont fonction système ces socio-écologique complexe d'une perspective de réseau, alors il peut être possible d'améliorer les résultats pour atteindre des buts sociaux. En ce document, je fournis une description préliminaire des composants socio-écologiques principaux et de leurs interactions de réseau dans la pêche pour de grands poissons pélagiques et peu profonds de récif au Grenada et au St Lucia. Cette recherche fait partie d'une plus grande étude sur le gouvernement de la pêche de petite taille dans les Caraïbe orientales.

MOTS CLÉS: Système socio-écologique, réseaux, grands pélagiques, recifs de hauts-fonds, Grenade, St. Lucie

INTRODUCTION

Small-scale fisheries (SSF) in the eastern Caribbean are threatened by many of the factors that affect fisheries worldwide. These include declining fish stocks due to overfishing, habitat degradation and pollution. The fisheries continue to be open access and despite efforts at participatory approaches, management initiatives, where they occur, primarily continue to take a conventional command-and-control approach. Managers and other stakeholders continue to face difficulty in designing and implementing successful management solutions to the problems in fisheries management. Since the 1950s we have recognized the problems in fisheries and have made attempts at solving them, but why are we still faced with many of the very same problems today? Where have we gone wrong? Have we been too deterministic and linear in our view of natural resource system problems and the technical fixes applied to solve them?

We have been traditionally accustomed to viewing social systems and ecosystems as distinct and mostly separate (Westley *et al*. 2002). Science and broader society have either treated ecosystems as part of social systems - 'natural' patches within a human-dominated matrix or social systems as part of ecosystems, with ecosystems comprising all life, over which the human species has come to dominate. Both of these views draw from their individual unique disciplinary paradigms, and each has been used to support different approaches to conservation and development problems (Norgarrd 1994). A growing volume of case studies and examples (e.g. Gunderson and Holling 2002, Janssen 2002, Berkes *et al*. 2003) suggests that each of these views has limits when called upon to provide sustainable solutions to management problems and that a more holistic view of natural resource systems is required. Walker *et al*. (2006) suggest that natural resource systems are neither humans embedded in an ecological system nor an ecological system embedded in a human system, but something different altogether. Both the social and ecological systems may be identifiable, but they cannot be easily parsed for either analytic or practical purposes. Where fisheries and other natural resources are concerned, a more meaningful model seems to suggest a complex relationship between humans and ecosystems. Humans are partially at the mercy of ecosystem complexity. They derive services and products from, and have tremendous impact on, natural systems — both adapt to each other and give feedback to the other part (see Berkes and Folke 1998). Human actions affect ecological systems; ecological change in turn affects humans, triggers our responses and shapes ecological dynamics.

Berkes and Folke (1998) coined the term "*social-ecological system*" (SES) emphasizing this integrated concept of humans-in-nature, that social and ecological systems are inevitably linked or better described as interconnected and integrated, and that the delineation between the two systems is artificial and arbitrary. Many theoretical models of coupled human-environment systems have been proposed (see Walker *et al*. 2006). Folke *et al.* (2003) integrated ecological, economic, cultural, socio-political and institutional dimensions of social-ecological interactions in a coherent model/framework that embraces holism and complexity and have argued that this model holds substantial promise in achieving sustainability.

Another dimension has been added to this model by other researchers. Janssen and Ostrom (2006) defined SES as systems with both biophysical and social components, where individuals self-consciously invest time and effort in developing forms of physical and institutional infrastructure. These are embedded in a network of relationships among smaller and larger components that affect the way the system functions over time in coping with diverse external disturbances and internal problems. Davidson-Hunt (2003) conceptualized SES as bounded networks made up of the relationships among individual components and systems. He argued that SES can be described through a description of the components, the network of relationships, the nature of the relationships and the existence of boundaries. SES such as SSF are networks, rather than linear chains, of social, economic and ecological interactions or connections between fishers, other fishery participants, and fish resources occurring at various scales (cross-level and cross-scale as described by Cumming *et al.* (2006)) that influence outcomes and sustainability (Davidson-Hunt and Berkes 2003). Janssen *et al.* (2006) present a brief typology of social-ecological networks, in which they suggest that social components are individuals and/or organizations. Typical ecological components are species, as in food webs, and/or individual patches of habitat in a landscape. Links can be directed or undirected, and they can depict relations of any chosen kind between the linked pair of nodes (Janssen *et al.* 2006). The nature of the relations could be either entirely social, entirely ecological, or a mixture of both social and ecological components. Human activities can create a social-ecological network by linking ecological nodes, i.e., independent ecological systems become connected by the activities of humans. Social connections can be created via ecological connections e.g., transboundary large pelagics connect fishers and people across different countries and regions, thereby creating a social-ecological network. In the eastern Caribbean, SSF such as those involving large pelagics and shallow reef fishes, and others are examples of such networked complex SES.

In Grenada and St. Lucia, A pelagic longline or a pot fisher catching fish appears to be a simple activity at the first glance, but there exists a network of more actors and complicated human-nature and human-human interactions or relationships within the fisheries. The components, the nature of their interactions and the resulting outcomes may not always be obvious to stakeholders. SSF activities may comprise very few participants and may be highly localized. Others have numerous participants from local to international levels. Certain species might be consumed locally, whilst others are processed and packaged for overseas markets. The interactions can be defined as networks that describe who relates to what resource and with whom about what in response to economic, environmental or social conditions. Network theory has been used in many instances to evaluate and describe emergent features of a group of people that can only be identified and defined at the group rather than the individual level (Wasserman and Faust 1994, Scott 2000, Bodin and Crona 2006, Straton and Gerritsen 2005, and many others). 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). Networks can be drawn to describe the numerous features and types of interactions in SSF. For example, a communication network can be drawn that describes fishers who communicate with each

other about where to fish and what technology to use. Generally a network is defined as a set of nodes or actors and how they are related or linked to each other through specified relationships (ties). The relations/links can be characterized by flow or exchange of information, material, and financial resources. The structure of a network can reveal key information about individual actors and the network as a whole. How a network is structured determines its function and performance (Straton and Gerritsen 2005, Carlsson and Sandstrom 2006). The position of nodes and the number of ties or frequency of exchange (strength of ties) can reveal who are key players in a network that for example may have significant influence over discussion and outcomes, or may be critical for passing information to others. Network structure can also reveal the level of social capital among a group or community.

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). 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 of common pool resources such as fisheries. If stakeholders involved in the governance of SSF in the eastern Caribbean had a better understanding of the components and the interactions from network perspectives and how they are influenced by scale and other factors, it may be possible to improve outcomes to meet societal goals.

In this paper, which is part of a larger study on the governance of marine resources in the eastern Caribbean, I adapt the model put forward by Folke *et al.* (2003), adding network perspectives for analyzing and understanding SSF. I provide a preliminary description of some social-ecological components and their network interactions in SSF of the eastern Caribbean using cases from the fisheries for large pelagic and shallow reef fish in St. Lucia and Grenada.

METHODS

The approach to investigation starts with the construction of a conceptual framework. Figure 1 is a simplified view of evolving thinking and understanding of the integrated and networked nature of social-ecological systems in small-scale fisheries.

I have begun to carry-out social ecological inventories of the fisheries for large pelagics and shallow reef fish in Grenada and St. Lucia. By a social-ecological inventory I mean identifying and describing the main fish resources, their key characteristics relevant to the fisheries (ecological components), the actors that are actively involved (social components) and the network interactions that connect them. This paper presents some of the results of this social-ecological inventory focusing mainly on the fish chain of the fisheries for large pelagic and shallow reef fishes in Grenville, Grenada, and for large pelagic fishes in Vieux Fort, St. Lucia, during the period June – July 2008. The fish chain as described in Kooiman *et al.* (2005) suggests a sequence of linked activities from a resource in the marine ecosystem, through capturing, processing and marketing phases. In Grenville, Grenada the researcher

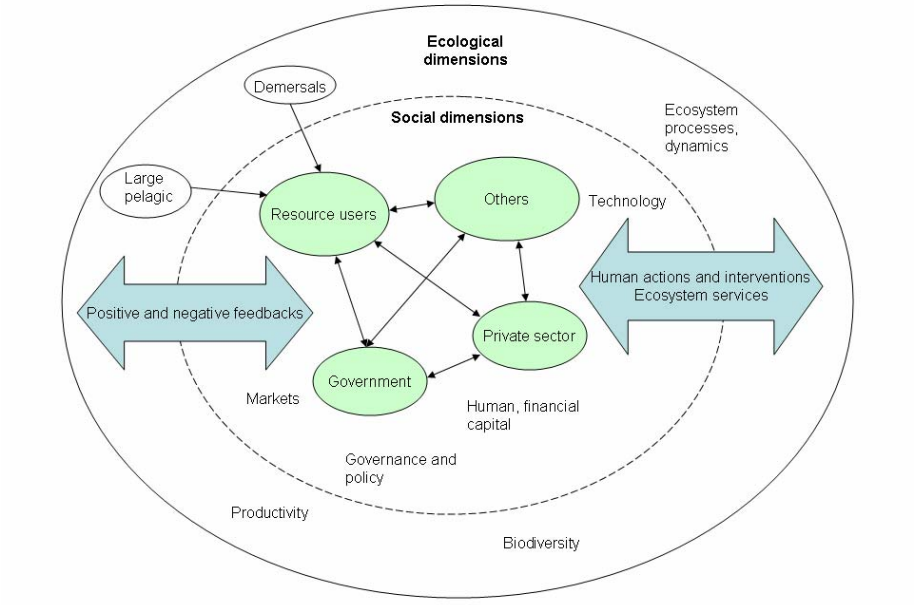

Figure 1. Simplified view of SES in fisheries

followed the activities of three fishers from preparation for a typical fishing trip through to marketing of the catch to identify actors and their interactions with the resource and other stakeholders. In Vieux Fort the focus was on the network interactions of the St. Lucia Fish Marketing Corporation in the large pelagic fishery. Due to the very short and rapid nature of the assessment, and for the purposes of this paper, the focus is only on the major network interactions along the fish chains. The linkages/ interactions between these components were identified through observation, informal interviews and secondary data analysis.

There are several methods for analyzing the interactions among components in common pool resources such as marine SSF. Network analysis (NA) is the study of social relations among a set of actors and has been used in analyzing the structure of interactions among actors e.g. individuals, government, and civil society and so on in social systems such as in health care, the internet, among others. NA is an efficient diagnostic tool for understanding the intricacies and subtleties in networks and for exploring critical linkages that may be driving a system. The social network analysis software package, UCINET 6.05 with NetDraw (Borgatti *et al*. 2002) was used to map and analyse the structure of the networks.

SES Networks in the Fisheries for Large Pelagic and Shallow Reef Fishes in Grenville, Grenada

The fishery in Grenada for large pelagic fishes is a commercialized, artisanal small-scale fishery, harvesting (regionally and/or internationally) shared and highly migratory species. This fishery has been touted as the most economically important fishery in Grenada, both in terms of quantity of landings and fishing effort (Finlay 1991, Mahon and McConney 2004, Grant 2006). Large pelagic fish species account for approximately 70% of total annual landings in Grenada (Grenada fisheries Division statistics). Since the 1980s the Grenada government has been encouraging increased fish production and development of this fishery. On the other hand, the fisheries for shallow reef fish in Grenada can generally be described as a part-time and subsistence based small-scale fishery, harvesting a nearshore multi-species assemblage. Shallow reef fish comprise approximately 1 percent of total annual landings in Grenada (Grenada Fisheries Division statistics). There are several landing sites across Grenada serving various fisheries. In this paper, the focus is on the community and landing site of Grenville on the east coast of Grenada (Figure 2) highlighting some key social-ecological network interactions.

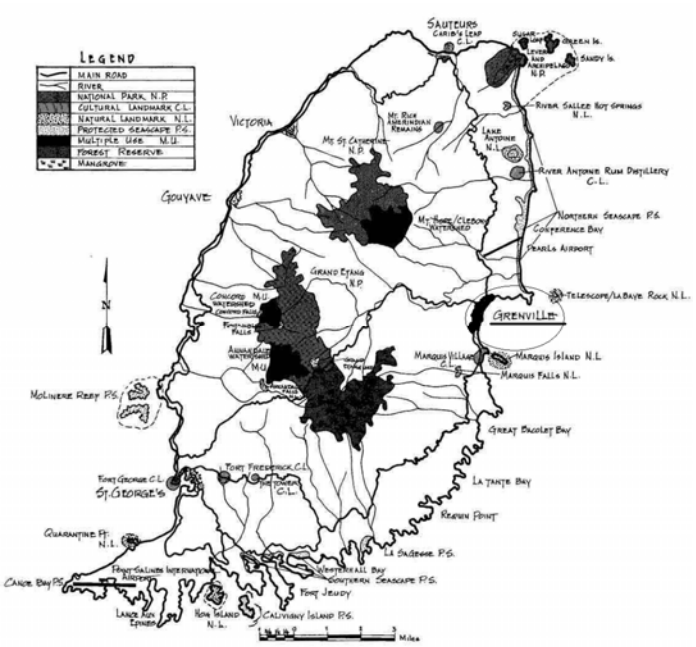

Figure 2. Map of Grenada highlighting location of Grenville .

The ecological components — The east coast of Grenada is fringed by coral reefs, and seagrass beds, and patches of wetlands (ECNAMP 1980). Grenville is the major landing site on the east coast of Grenada. Fishing from Grenville is primarily offshore for pelagic species. A narrow channel between coral reefs provides access from Grenville to the offshore fishing grounds for large pelagic and some demersal shelf fishes. Pelagic species targeted include yellowfin tuna (*Thunnus albacares*), white marlin (*Tetrapturus albidus*), blue marlin (*Makaira nigricans*), common dolphinfish (*Coryphaena hippurus*), sailfish (*Istiophorus albicans*), swordfish (*Xiphias gladius*), blackfin tuna (*Thunnus atlanticus*), wahoo (*Acanthocybium solandri*), bigeye tuna (*Thunnus obesus*), bonito (*Sarda saarda*), and skipjack (*Katsuwonus pelamis*) (Mahon and McConney 2004, Grant 2006). The distribution and abundance of large pelagics in Grenada waters is highly seasonal. The pelagic season is from November to June. There is also fishing to a limited extent for shallow shelf and deep slope demersal fishes such as snappers (*Lutjanidae),* hinds (*Serranidae*), parrot fishes (*Scaridae*), squirrel fishes (*Holocentridae*), grunts (*Pamadasyidae*), surgeon fishes (*Acanthuridae*), and trigger fishes (*Balistidae*). This is mainly during the offseason for large pelagics, during the period July to October each year. Fishers use mainly wooden and fiberglass pirogues of 4-7 metres in length with handlines and longlines as the main types of gear. Fishers fish approximately 50 – 100 km offshore and along the fringing reefs and slope of the coastline.

The social components — There are numerous social actors operating in the fisheries for large pelagics and shallow reef and shelf fish, from local through to international levels. These include fishermen, vendors, consumers, and organizations among others that play particular roles in both of these fisheries. However, we focus on the fish chain at the community level from a typical fishing trip to marketing of landed fish. In Grenville the fish chain comprises six main 'links'. These include:

i) Preparation for fishing;
ii) Fishing;
iii) Landing of fish;
iv) Sale of fresh fish
v) Processing, and
vi) Marketing.

We followed the fish chain of three fishers coded here as fisher 1, fisher 2, and fisher 3. The actors in the fish chain related to these three fishermen at the community level were found to be similar and are presented in the Table 1 below according to one or more of the links in the fish chain in which they operate.

Social-ecological network interactions — There are many kinds of relations and interactions among actors in these two fisheries; however the focus in this paper was only upon the main network interactions in the community level fish chain. These network interactions are characterized by the flow of goods and services such as fish, finance, labour, regulation, subsidies, licenses and gear.

Fishers 1 and 2 targeted large pelagic fish only, while Fisher 3 fished both large pelagics and shallow reef fishes. Fishers acquire loans to invest in boat and gear from financial institutions such as the Grenada Commercial Bank. Fishers in return save with these institutions. Vendors sometimes provide financing in return for a guaranteed fish supply. These fishers invested their labour and sometimes hired labour, cash, gear, engines, and fuel in preparing their boats for a fishing trip. Engines and parts were purchased from McIntyre Brothers and other major outboard engines suppliers in Grenada. Fuel is usually purchased from the mini gas station at the landing site. Fishers interact directly with fish resources through their knowledge of fishing grounds, and fish, and use their skills in seamanship, navigation, safety and use of appropriate gear to harvest either large pelagic or reef species.

The Fisheries Division of Grenada provided infrastructure in the form of the Grenville market, with lockers, cold storage, berths and landing piers, and staff to operate and manage the activities of the market (e.g. Market supervisor, Data Clerk, etc.). The Fisheries Division administers regulations and policy; and provides financial support in the form of a fishing industry fund of up to EC$20,000.00 to fishers for purchase of larger and better equipped boats. They also provide gas rebates to fishers. Several vendors and a processor (Stanley Gill) utilize the facilities of the Grenville Market. Mr. Gill has a dedicated processing and marketing bunker in the Market. Licenses are provided to vendors and cleaners by the market staff. The Fisheries Division conducts research on large pelagic and reef fish ecosystem and technology. Training in technology, health standards, processing, and marketing are also provided to fishers, cleaners, processors and vendors. The Ministry of Health provides health certificates to vendors, cleaners, and processors.

Fish landed at Grenville are gutted and weighed, and the data clerk makes a record of the species and their weight. Fishers, vendors and sometimes Stanley Gill secure the services of cleaners in dressing fish for storage or immediate sale. Cash, or sometimes fish, is provided as payment. Fish for export is handled and stored in accordance to Hazard Analysis Critical Control Point (HACCP) procedures supervised by the market manager. Fish landed at Grenville are usually sold to vendors and Stanley Gill. However, during the period this study was undertaken, fishers 1 and 2 sold their catch directly to consumers on the streets and not to either vendors or Stanley Gill. Fisher 3 however. sold his reef fish and pelagic catch to vendors and Stanley Gill. These in turn sell to the consumers and supermarkets in the community. Stanley Gill sells packaged fish mainly to supermarkets and local consumers. Local consumers frequent his marketing outlet mainly for tunas.

Figure 3 is the network map of these interactions. Fisher 3, vendors, Stanley Gill, cleaners and the Fisheries Division are central actors. The key aspect of this network is that there appear to be two main clusters or groups. One is associated with fishers 1 & 2 who fish only large pelagic fish with five other actors who are mainly on the periphery of the network. The other is the larger group which

Table 1. Stakeholders/actors in the fish chain for large pelagic and shallow reef fish in Grenville, Grenada.

Preparation for fishing	Fishing	Landing	Sale of fresh fish	Processing	Marketing
Fishers 1, 2, and 3 Grenada Bank of Commerce, McIntyre Brothers (engine supplier), Fisheries Division, Fuel supplier.	Fishers 1, 2, and 3 Fisheries Division	Fishers 1. 2, and 3, Market Supervisor, Data Clerk, Cleaners	Fishers 1, 2 and 3, vendors, customers	Stanley Gill (processor and exporter), Cleaners, Ministry of Health, Fisheries Division	Fishers 1 and 2, Stanley Gill, vendors, Supermarkets, customers

includes fisher 3 (who fished both large pelagic and reef fishes), the vendors, Stanley Gill and the Fisheries Division among others. These two groups were evident in the network map due to the behaviour of fishers 1 and 2 who broke ranks with the Grenville market and sold landed fish directly to consumers on the streets instead of selling to vendors and Mr. Gill. Closer observation of this and interviews with fishers, vendors and Mr. Stanley Gill revealed that since the main ocean season had just ended, they have a stock pile of fish, which they have been struggling to sell.

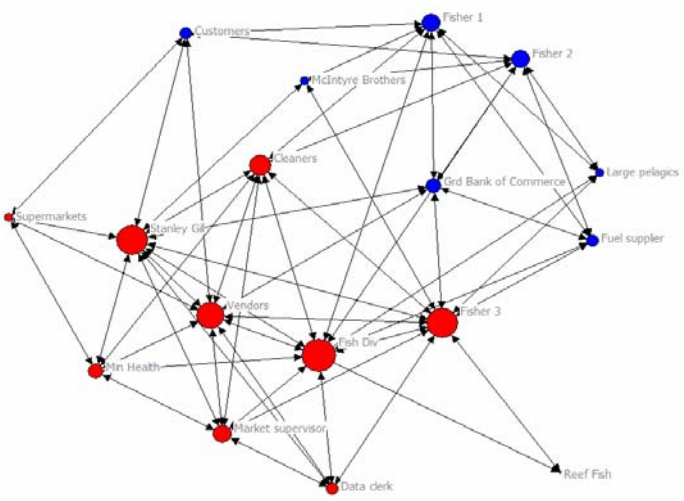

Figure 3. Network map of the Grenville Grenada large pelagic and shallow reef fisheries.

Fishermen were catching and landing bonitos in abundance at the time of the study, rather than the other high priced tunas and dolphinfish. Not a significant amount of reef fishes were being landed at the time of the study. Interviews with fishers and vendors revealed that fishers still prefer to focus on bonitos because local consumers in Grenville are not that fond of reef fishes, and they do not fetch a good price. Despite a saturated market for bonitos it was observed that consumers were buying them, mainly due to the relatively reasonable bargains on price offered by fishers 1 and 2. The usual price for a pound of fish is between 6 - 9 EC dollars; however, fishers were selling two and three bonitos, each weighing more than 2 pounds for approximately 10 - 25 EC dollars.

The network interactions involving fisher 3, vendors, the Fisheries Division and Stanley Gill suggest a much dense or better connected network. These have stronger ties among themselves. This observation in social network analysis suggest that actors with strong ties regarding natural resource use are more likely to influence one another, and thus, can enhance mutual learning and the sharing of resources and advice (Crona and Bodin 2006, Newman and Dale 2004, 2007) resulting in a resilient network. Resilience is the capacity of a system to experience perturbations, while retaining essentially the same functions, structure, feedbacks and therefore identity. The more resilient a system is, the better it can absorb disturbances and deal with change without shifting into an undesirable state or regime (Berkes and Folke 1998).

Within the context of resource management, weak ties on the other hand, depending on the situation or context, can also make a network more resilient and adaptive to environmental change. A potential drawback to weak ties, however, is that they may be easy to break (Burt 1992, 1997, 2000, Newman and Dale 2004, Volker and Flap 1996), as was the case with fishers 1 and 2 and their interactions with vendors, Mr. Stanley Gill and market staff. This network also shows how significant a role the ecological system plays in determining the type of interactions and linkages that exist between social components. Fisher 3 who was involved in more than one fishery was better connected and perhaps may be better able sustain his livelihood during lean times. However, fishers 1 and 2, despite only fishing large pelagic fishes, can be viewed as showing innovation to ensure their livelihoods, by finding their own markets and adjusting prices.

SES Networks in Fisheries for Large Pelagic Fish in Vieux Fort, St. Lucia

The fishery for large pelagic fishes in St. Lucia can be described generally as a developing small-scale commercial fishery, harvesting a (regionally and/or internationally) shared and highly migratory multi-species as is similar to the rest of the eastern Caribbean islands. Approximately, 67 - 70% of total annual landings in St. Lucia are large pelagic species (St. Lucia Fisheries Division landing statistics). The fisheries for large pelagic species are also the focus for expansion by the government of St. Lucia.

The ecological components — The town of Vieux Fort is situated on the south east coast of St. Lucia (Figure 4). The marine area associated with Vieux Fort consists of long sandy beaches, mangroves, several coral reefs and offshore sand bank. Deep waters are relatively close to the coastline. The large pelagic species targeted in Vieux Fort and St. Lucia in general is the same as in Grenada and the rest of the eastern Caribbean. These include dolphinfish, king mackerel, wahoo, blackfin tuna, skipjack tuna, bonito, and yellowfin tuna. Sharks and billfishes are also caught. The large pelagics species caught are highly seasonal, with the majority of activity and landings occurring between December and June, peaking between January and April (George 1999). The fishery is conducted using small open wooden or fibre glass pirogues usually 5-9 metres long. The gears used include hand lines, trolling lines, and recently longlines (George 1999).

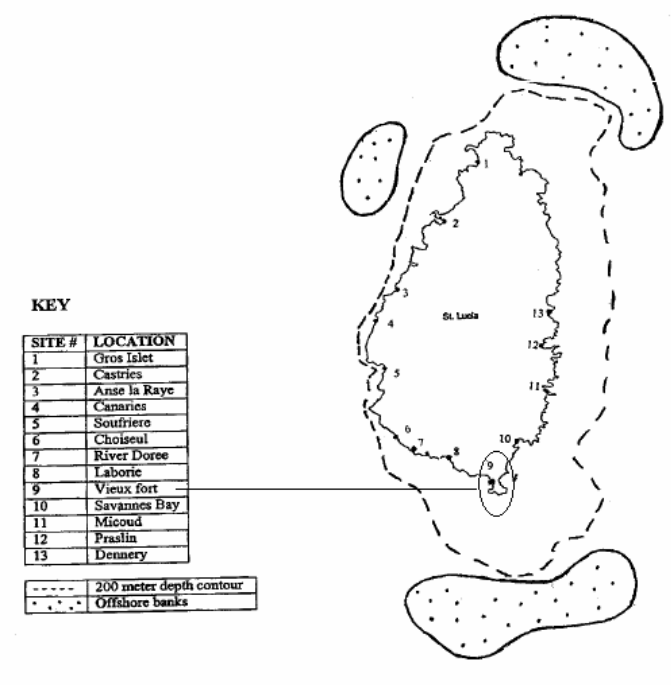

Figure 4. Map of St. Lucia highlighting the location of Vieux Fort.

The social components — There are numerous actors from fishermen to consumers who are involved in the fisheries for large pelagics operating from local through to international levels as well in St. Lucia. In this paper however, we focus on the some of the social-ecological network interactions in the purchasing and marketing of large pelagic fish by the St. Lucia Fish Marketing Corporation (SLFMC) in Vieux Fort St. Lucia. The SLFMC is the largest marketing facility in St. Lucia. It is a statutory body set up to promote proper processing, cold storage and marketing of fish and fish products. Increased cold storage capacity now allows for local fish to remain available to the local and rapidly expanding tourism market throughout the year. In Vieux Fort there more than 300 registered fishers which include both part-time and full-time fishers and boat owners (Espeut 2006). Most of these fishers fish several species of fish. The SLFMC provided several names of fishers, supermarkets, restaurants, and hotels that they specifically interact with for purchase and sale of large pelagics. A randomly selected portion of these actors are presented in Table 2 below.

Social-ecological network interactions — The social-ecological network interactions are characterized by flow of knowledge of ecological conditions and fishing grounds, labour, fish, and cash. The SLFMC opened a major fish processing and marketing facility at the main fish landing base of Vieux Fort and provides cold storage and processing facilities, a fish market, fishermen's facilities (lockers, a gear mending shed, fueling point and cooperative building) and a protected harbour for the area's fishermen and fleet. The Fisheries Division provides the necessary licenses to fishers for fishing operations. They also provide a variety of concessions from waiver of import duties on fishing vessels and gear and fish processing equipment etc. to a fuel subsidy comprising a refund of duty based upon volume of gasoline and oil purchased. This is usually channeled through Goodwill Fishermen's Cooperative Society operating out of Vieux Fort. The Fisheries Division has installed FADs and trained fishers in their use in fishing. Fishers use their knowledge of fishing grounds, Fish Attracting Devices (FADs), and the different species, gear, and landing facilities at Vieux Fort to catch and land fish. Fishers are members of the Goodwill Fishermen's Cooperative Society. The SLFMC purchase fish landed from each of these fishers. The SLFMC has a guaranteed market to supply fish to various supermarkets, hotels, restaurants and other individual customers in St. Lucia. This arrangement has allowed the SLFMC to buy approximately greater than 60% of all large pelagics landed at Vieux Fort (Lambert Vitalis pers. Comm.) and hence ensure that fishers fish and land large pelagics when they are available and even during the "snapper" or off-season for large pelagics. Fishers set out to catch large pelagics, but if they do not then they will attempt to catch other species *e.g.* snappers to at least cover their fishing costs. An analysis of SLFMC purchases over the last 4 years and a check of their processing operations at Vieux Fort suggest that large pelagics are the most important species, making up the bulk of the purchases. Other species

Table 2. Stakeholders/actor in the SLFMC network interactions in fisheries for large pelagics in Vieux Fort, St. Lucia

Fishers	Processing/Marketing	Restaurants	Hotels	Other
Joseph George	SLFMC	Carib Jewel	Anse Chastanet	Chicos Supermarket
Steven McFarlane		JJ's Restaurant	Bay Gardens	Victoria Hospital
Rufus Stevens		SLU Catering	Cara Suite	Police Training School
André Miller		Memories of Hong Kong	Club St. Lucia	PM Resident
Julius Edwin			Coconut Bay	Golden Hope Hospital
			Glen Castle	Intersea Corporation (Miami)
			Jalousie Hilton	
			La Haut Plant	
			Rex St. Lucia	
			Sandals	

are either non-existent or purchased in very limited quantities. Fishers also suggest that it is much more worthwhile and profitable to fish large pelagics since they are guaranteed a market from the SLFMC.

Figure 5 is the network map of the interactions among these components. The map suggests a highly centralized network of the SLFMC marketing operations at Vieux Fort. The SLFMC appears to hold a key position as a central hub connecting other stakeholders (hotels, restaurants etc.) who do not interact directly with the network of fishers, fish, and management. In the language of social network analysis this scenario suggests a highly centralized network mainly around the SLFMC. A highly centralized network is one characterized by one or a few individuals holding the majority of ties with others in the network. Centralized networks are helpful for the initial phase of forming groups and building support for collective action (Crona and Bodin 2006, Olsson *et al*. 2004). However, research suggests that such centralized networks are disadvantageous for long-term planning and problem solution. Take for example, if the SLFMC was to close operation for whatever reason, linkages will be broken between the fishers/fish and the hotels and restaurants resulting in lost of regular income for fishers, and hotels and restaurants losing a regular supply of fish. The social-ecological network interactions suggest that the large pelagic fish resources and the SLFMC are the major drivers in this network. The demand for these species and guaranteed markets provided by the SLFMC results in fishers focusing there labour, finances and other resources on this fishery.

CONCLUSIONS

Existing literature and research have called for understanding the integrated nature of social-ecological systems such as SSF in designing and implementing solutions to typical problems in governance and management [refs]. To do this requires identifying critical social and ecological components and their interactions. We argue that social and ecological components in a fishery are linked by their interactions in a network. This paper highlighted key social and ecological components in the SSF for large pelagics and shallow reef fishes and outlined through a network perspective their social-ecological interactions using two cases in the eastern Caribbean. Both of these cases, although focusing on the local community level, demonstrate the integrated nature and feedback linkages between the social and ecological components in the respective fisheries. Specifically, they show that activities from fish harvesting through to marketing do not simply consist of a linear chain of actors and activities, but are more of a web of interactions among stakeholders occupying certain roles and positions.

In both of these cases it was the roles and positions of certain actors and the availability of certain types of fish that determined whether fishers invest in fishing activities and to what extent and the species targeted. In other words fish and key players such as fishers, and markets were the drivers of the social-ecological interactions in the fisheries.

However, even more importantly, the cases demonstrate that the network approach can be used to analyzing small-scale fisheries. The structure of these networks revealed how components are linked and provides the

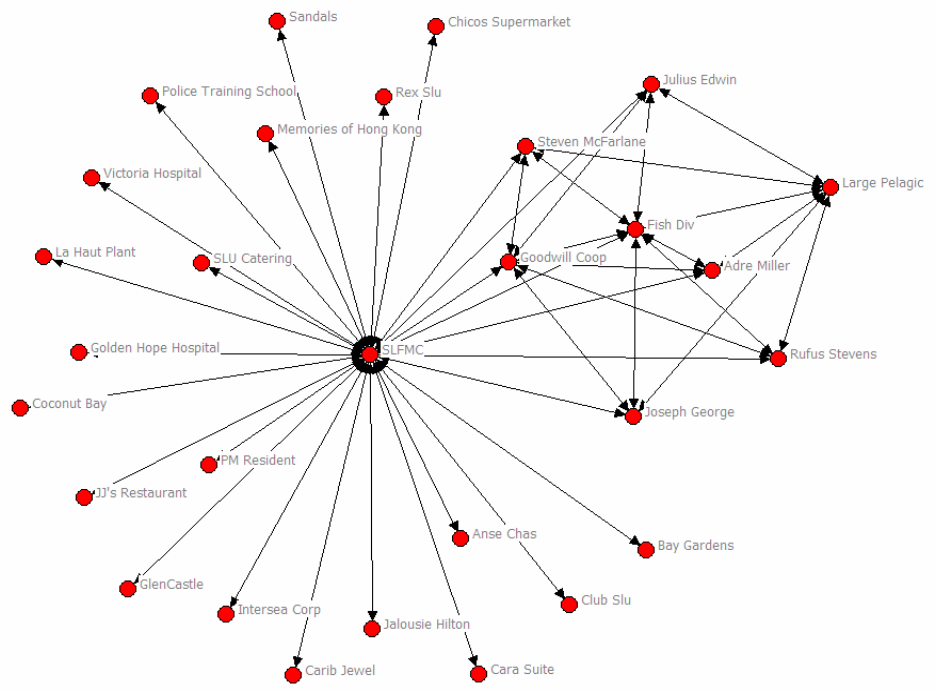

Figure 5. Network map of the SLFMC network interactions in fisheries for large pelagics in Vieux Fort St. Lucia

opportunity for analysing performance and identifying potential problems and solutions in the respective systems. Analyzing social-ecological interactions from network perspectives can help explain many emergent features of a system. For example, in Vieux Fort, St. Lucia the number of part-time fishers has been increasing, while the number of those registered as full-time has declined to half between 2002 and 2004 (see Espeut 2006). What could have been the causes for such changes? Was it because less money was being made from fishing? Or could it be due to the fact that higher prices are paid for the seasonal large pelagics with a guaranteed market from SLFMC? Hence a significant number of full-time fishers changed to part-time to focus their efforts and capital on fishing mainly during the ocean season of January- April.

It is usually assumed by managers and other stakeholders that if rules, regulations and markets are in place, a system will function well and achieve desired outcomes. The Grenville case demonstrated that actors do not always sustain relationships and interactions if the existing conditions are not to their liking. Finding solutions to problems such as these. and a myriad others that characterize SES such as SSF, may come from understanding networks.

The findings from these two case studies are consistent with those of Grant (2007) who identified and described interactions in the pelagic longline fishery in Gouyave Grenada. She described the flow of fish and cash, labour mobility, resource user expectations and management regulations in the pelagic fishery SES that includes fishers, community, marketing, private sector, and management. She concluded that sustainable management of the system required identifying and understanding the roles of the major components in the fishery; knowing the interactions among components; and determining weak and strong ties to connecting the actors in order to make targeted interventions. If fisheries managers and other stakeholders involved in the governance of such SSF have a better understanding of how these complex social-ecological systems are structured (actors roles and positions) and function (emergent features and outcomes) from network perspectives, they can then focus on managing for resilience, to improve outcomes to meet societal goals.

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