Gulf and Caribbean Research

Volume 30 | Issue 1

2019

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DOI: 0.18785/gcr.3001.08

GULF AND CARIBBEAN

RESEARCH

Volume 30
2019
ISSN: 2572-1410

Published by

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

GULF COAST RESEARCH LABORATORY
Ocean Springs, Mississippi

Gulf and Caribbean Research Vol 30, GCFI 1-GCFI 7, 2018
DOI: 10.18785/gcr.3001.08
Manuscript received, April 26, 2019; accepted, October 10, 2019

USING COGNITIVE MAPPING AS A METHOD TO SYSTEMATICALLY ASSESS PERSPECTIVES IN FISHERIES MANAGEMENT§

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KEY WORDS: cognitive mapping, mental models, methodology, coastal resource management

INTRODUCTION

Managing natural resources such as fisheries ultimately requires managing the people who influence the resources (Fulton and Adelman 2003). Fisheries management can range from developing new or modifying existing policies, promoting the adoption of new fishing technologies, and implementing education and outreach campaigns, among other activities. As with all behavior change efforts, natural resource managers need to consider the diverse values, motivations, and perspectives of natural resource stakeholders to develop successful management strategies.

In the Caribbean, social constraints such as lack of strong governance arrangements, lack of political support, and limited financial and human resources have led to ineffective or incomplete coastal management (Brown and Pomeroy 1999, Salas et al. 2007). While these are very big issues to tackle, one contribution to these issues is policymakers' and managers' lack of understanding diverse fisher perspectives that can result in misalignment of policy development, implementation, and enforcement (Chakalall et al. 1998, Mahon and McConney 2004, Chakalall et al. 2007). Misunderstandings can be caused by minimal capacity on the part of managers to conduct social research, a general bias that the manager has the only acceptable perspective of the issue, or agency staff assuming that they already know their constituents through frequent interactions and experience on the job (Valdés–Pizzini et al. 2012, Rare 2019). The prevalence of these biases and the recognized limitations of staff capacity strongly suggest a need for the development and implementation of systematic, yet simple, data collection tools that will help fisheries managers and policymakers in the Caribbean understand policy opportunities and assess policy effectiveness.

Systematic measurements of individual values, motivations, and perceptions are those that undertake a rigorous, repeatable approach that limits biases in data collection and interpretation. Social measurement tools may include open–ended interviews, structured surveys, or community workshops (Bernard 2006). The use of open–ended questions can capture rich and detailed information from fishers or policymakers, but there is a substantial risk of interviewers using biased and leading questions to generate favorable responses from participants. In surveys, agency staff may capture an array of quantitative information from resource users which is a highly favored approach that is easy to administer and produces data that are often easier to understand by funders and government agencies. However, using this approach can fail to adequately capture the nuances of respondent perceptions that are more likely to result from stakeholders being allowed to structure their own discussion.

In this communication, we introduce cognitive mapping, a commonly used social data collection tool that is particularly effective in bridging the benefits of structured surveys and open–ended interviews to enable systematic data collection, as well as the qualitative elaboration of stakeholder perspectives. Cognitive mapping often elucidates the underlying values and motivations that influence people's behaviors around resource use, thereby informing managers of the probability of a new management strategy's success, or enables managers to evaluate and redesign strategies that will succeed. Cognitive mapping is easy to administer, can put less cognitive load on the respondent and researcher, and requires minimal data analysis skills to be useful for decision–makers and stakeholders. It has been applied in diverse resource management topics and regions, including, but not limited to: 1) identifying similarities and differences between farmers, managers, and researchers on rangeland use to improve communication and management (Abel et al. 1998); 2) evaluating the impacts of social learning processes on community forest behaviors in the Bolivian Amazon (Biedenweg and Monroe 2013); 3) investigating managers and fishers' responses to new fisheries management regulations in Belize (Wade and Biedenweg 2019); and 4) studying fishers' perceptions and knowledge of the ecosys-

§*This article is based on a presentation given in November 2018 at the 71st annual Gulf and Caribbean Fisheries Institute conference in San Andrés, Columbia*

tem and fishing industry in the Eastern English Channel (Prigent et al. 2008). Because of its success in these diverse contexts, we believe cognitive mapping to have substantial potential for Caribbean fisheries management. In this communication, we introduce a more detailed description of the theory behind the tool and then provide examples of a variety of cognitive mapping methods.

An introduction to mental models and cognitive maps

Mental models are representations of how people perceive and organize information concerning a specific topic (Kearney and Kaplan 1997, Kaplan and Kaplan 2003). All people, whether fishers, policymakers, or funders, hold mental models about numerous topics. A topic could range from something specific, such as "preferred fish species for eating," to something more conceptual, such as "sustainable fisheries in the Caribbean." The mental models associated with these topics are comprised of facts, assumptions, and beliefs (Kolkman et al. 2005) that act as filters through which a person interprets and judges any new information related to the topic. The formation and revision of a person's mental model for a specific topic is like that of a computer simulation, where the mental model is capable of exploring and testing different ways that new ideas can fit into the person's existing perceptions before committing to adopting the new information (Jones et al. 2014). For example, if climate change results in shifting species availability, whether fishers are willing to adopt a new species into their mental model of "preferred fish species for eating" will depend on what they know about that new species fitting with the other components of that mental model. It is important to note that mental models are not static and rarely represent complete views of the topic; rather, mental models are simplified for that person's daily functionality (Jones et al. 2011) based on the person's motives in conjunction with their existing knowledge. People's mental models naturally differ because of their diverse experiences with information they perceive as relevant to the topic.

Understanding mental models is important in marine resource management as the models are a key determinant in a person's behavior and motivations. People use the interrelationships of ideas represented in their mental models to continually evaluate how a system is performing (Rouse and Morris 1986). Moreover, variation in different stakeholders' mental models result in different opinions of a problem that can make policy design and implementation difficult (Kolkman et al. 2005). Elucidating mental models can help identify areas of mutual understanding and potential conflict, enabling interventions to be modified for better adherence.

Cognitive mapping is the term used for the tool that allow turning mental models into data. It can take numerous approaches, where each meets different research objectives (Table 1). For example, in a free–listing activity, the main objective is simply to identify all concepts or ideas that a respondent has about a topic. This approach does not attempt to prioritize the relationship between the concepts, although importance can often be inferred from the order in which people share concepts. The free–listing approach is most useful when the main goal is to obtain an overview of respondents' knowledge of a topic. In contrast, fuzzy cognitive mapping not only expresses the ideas a person holds, but it also allows a participant to illustrate the relationships between ideas, gauge the strength of those relationships, and identify any uncertainty the participant holds about those relationships. For example, a participant can indicate if there is a positive or negative relationship between two concepts and estimate the magnitude of that relationship.

Case Studies in Cognitive Map Applications

Below we summarize 4 case studies that used cognitive mapping to elucidate stakeholder perspectives in marine resource management. Each case describes an application of the approaches outlined in Table 1. Although they are not

TABLE 1. *Comparison of 4 different cognitive mapping approaches and their descriptions.*

Cognitive Mapping Approach	Description	Elicitation	Potential Analyses
Free-listing	Investigates all ideas participants hold about a topic	List of concepts that come to mind about a topic	Frequencies and salience of identified concepts
Q-Sort	Mental objects are organized in a forced normal curve	Card sort concepts into a normal curve based on relative importance	Relative importance of identified concepts.
Conceptual Content Cognitive Mapping	Spatial/visual representation of mental models.	Card sort concepts into groups based on perceived similarity and importance	Emergent clusters of related concepts; cultural consensus of mental model structure
Fuzzy Cognitive Mapping	Participants illustrate connections using arrows and indicate the strength of interactions between connections.	Diagrammatic representations with causal and strength relationships	Interactions between concepts; may identify decision rules for agent-based modeling

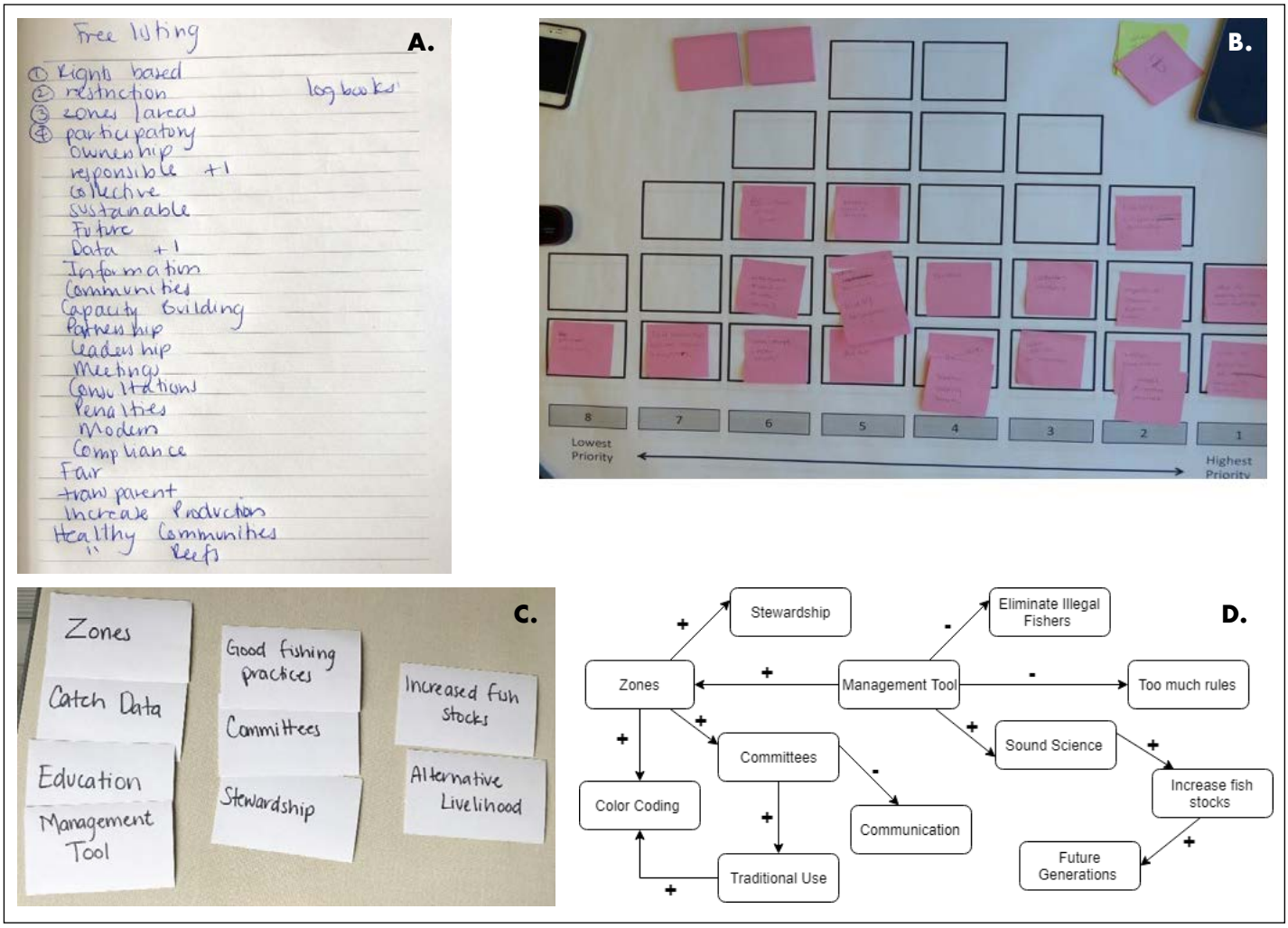

FIGURE 1. Results of case studies using cognitive mapping to elucidate stakeholder perspectives in marine resource management. **A.** Free listing to measure an organizational sense of place in Bocas Del Toro, Panama. **B.** Q-sort to determine what informs a shoreline master plan in the Puget Sound, WA, USA. **C.** Conceptual Content Cognitive Mapping to understand stakeholder's mental models in response to Belize's Managed Access Program. **D.** Fuzzy Cognitive Mapping to model decision-making in complex socio-ecological systems. + indicates perceived positive connections, - indicates perceived negative connections.

all specific to Caribbean fisheries, the variety of examples demonstrates the possibilities for this type of research in the region.

Measuring organizational sense of place in Bocas Del Toro, Panama (Free listing)

The main objective of this study was to understand how natural resource education, management, and business organizations described the contribution of a specific place (in this case, the province of Bocas Del Toro in northern Caribbean coast of Panama) to their mission and professional activities (de Ycaza et al. 2019). To accomplish this, we used a free listing approach. We asked representatives from the aforementioned organizations to identify words that they believed best described why Bocas Del Toro was important to them. Participants listed all words or concepts until they were no longer able to come up with any words (Figure 1A). The task took less than 5 minutes, was often completed informally, and provided a large amount of data. From the lists created by participants, the most frequently mentioned concepts were identified and compared between and across organizational types. As is common in freelisting, we also inferred that the items mentioned early in the lists were likely to be the most important for these mental models (Robbins and Nolan 1997). The results indicated that despite differing missions, organizations shared similar ideas of the province's contribution to their activities, paving the way to potential collaboration across organizations that previously believed they held little in common.

What informs a shoreline master plan in the Puget Sound, WA, USA? (Q—sort)

The state government of Washington requires that cities, counties, and regions develop shoreline master plans for coastal and river zoning. In 2010, spatial data concerning social uses and values of landscapes were collected for the

entire Olympic Peninsula, located in northwestern Washington (Schwarz 2014). We wanted to determine whether the policymakers proposing shoreline master plans in this region would take into consideration this spatialized social data. Fourteen politicians and planners were asked to identify the factors influencing their shoreline master plan (e.g., ideas, people, and places) and write each one on a separate card. They were then asked to sort each card onto a large printed chart within spots designated into a normal curve – the Q—sort (Figure 1B). The x—axis of the curve represents the concepts of least to most important for influencing their plan. The y—axis represents the proportional number of responses allowed in each x—axis category to force the normal curve of responses.

Once the cards were initially placed onto the chart, policymakers were given 20—45 minutes to explore the spatial data about resident values and uses of the landscape. After exposure to these relevant social data, they were asked to recreate their Q—sort, adding any new cards and creating any new order to the importance of items for shoreline planning. As with most card sorting activities, respondents were encouraged to share their thinking as they were completing the ranking exercise.

The Q—sort builds upon the free—list activity in that it allows respondents to intentionally prioritize items so that we can empirically determine differential values for each item's contribution to one's mental model. The normal curve allows them to do so without having to fully rank each item independently, which can be a cumbersome task.

Analysis of these Q—sorts revealed that policymakers were considering their perceptions of stakeholder needs in their planning, but not the systematically—collected data about stakeholder values and uses. After engaging with the landscape values and uses data from stakeholders, 13 of the 14 managers changed the items in their Q—sort to better represent the diversity of stakeholder values. Conducting this study enabled us to identify the biases influencing the type of information that policymakers were using to represent their constituents' interests when making decisions about coastal zoning. The ability to quantitatively demonstrate that exposure to validated social data immediately shifted prioritization of that data in their mental model allowed the policymakers to rethink the types of information they brought to bear when making policy decisions.

Understanding stakeholder's mental models in response to Belize's Managed Access Program (Conceptual Content Cognitive Mapping)

In this study, our main objective was to understand and explore potential differences and similarities in stakeholder perceptions of a new fisheries policy introduced in Belize (Wade and Biedenweg 2019). The recent introduction of Belize's Managed Access Program brought a host of different reactions from fishers, government, and non—governmental stakeholders (Wade et al. 2019). Using the Conceptual Content Cognitive Mapping approach (Kearney and Kaplan 1997), we sought to understand how managers and fishers were differentially interpreting the new policy and clarify assumptions of stakeholders' perceptions of the policy (Fujita et al. 2017).

Following a freelist exercise to collect concepts for a card sort and ensure participants understood the activity, we carried out a full mapping exercise with 90 managers and fishers across the country. Participants were asked to choose from 30 cards the items they would use to respond to the prompt: "When you think of the Managed Access Program and you are explaining it to someone unfamiliar with the program, what words/phrases/concepts would you use to describe it? You can choose any number of concepts or add concepts you feel are not here." After selecting the cards, participants grouped the concepts based on what the participants perceived as the relationship between concepts and then ranked those grouped concepts based on each group's importance (Figure 1C). We found that fishers and managers were equally knowledgeable about the fundamentals of the new fisheries regulations, but their differing experiences in the industry resulted in different interpretations of the policy. For example, despite the commonly held assumption that fishers were mostly concerned with the economic outcomes of the fishery, the cognitive mapping approach was able to highlight that fishers held other concepts as more important. We found that fishers frequently selected and grouped as similar the concepts 'home', 'fishing zones' and 'license' in one cognitive group and 'meetings', 'committees', 'fisher participation' and 'rights—based' in another cognitive group, while policy—makers selected these terms less frequently and grouped them separately. These results determined that fishers perceived the licensing of zones as a formal policy affecting their home and that the new policy logistically required them to attend meetings and committees to maintain their rights. These ideas were not distinctly connected in the mental models of policymakers who developed and implemented the policy, and can explain some of the resistance to the program. By clarifying these key points in stakeholders' mental models, this approach directly responds to the call for the increased understanding of factors that can influence the sustainability of a given policy (Fujita et al. 2019, Wade et al. 2019).

While participants completed the task easily, some expressed difficulty in grouping the concepts, a shortcoming that has been found in other studies (e.g. Biedenweg and Monroe 2013) As such, this method should be pilot—tested with a sample of the intended population to ensure that it will work in that situation. The grouping of cards is a useful exercise as it provides insight into how people organize concepts in their minds, which is a deeper assessment of one's mental models than the Q—sort. Previous studies have also

included pictures of the concepts to help participants better visualize the concepts.

Modeling decision—making in complex socio—ecological systems using fuzzy cognitive mapping

Elsawah et al. (2015) used a fuzzy cognitive mapping approach to identify and model stakeholder decision rules to inform future groundwater management for viticulture in Australia. Farmers participated in open—ended, in—depth interviews focused on how they made irrigation and groundwater decisions when managing their vineyards. Interview transcripts were analyzed by the researchers to identify farmers' goals associated with water management, perceived water management options, activities and decisions related to water management, drivers associated with those activities, and directional relationships between these concepts. From the interview analyses, the authors created a collective cognitive map that represented generalized pathways of groundwater decisions for regional farmers (Figure 1D). The map was then translated into decision rules that were used to populate an agent—based model (ABM) that could simulate the impacts of different groundwater policies on farmer water use behavior. For example, the model was programmed such that farmers with certain attributes (such as having the goal of quality over quantity, having a farm that was ≥100 acres, or having a specific annual crop productivity) would be more likely to make certain decisions (such as increasing irrigation or selling their water allocations). These decision rules thus linked any proposed policy change that would affect any attribute to a related water use decision. The addition of the interrelationships between decision factors that are foundational to fuzzy cognitive mapping enabled the development of the ABM, presenting a unique opportunity to model future behaviors and further understand what factors, when, and to what degree, would influence farmers' choices to trade or sell their water allocations. This has particularly practical implications for any type of policy development that involves complex stakeholder decision—making. However, this form of cognitive mapping is notably more time and skill intensive, as it requires collecting, designing, and validating entire decision processes.

Conclusions – Putting Mental Models to work in the Caribbean

Marine resource management is a complex process involving myriad actors at various scales with varying levels of expertise and experience. Actors' perceptions and behaviors are driven by their beliefs about social norms, their fundamental values, their attitudes toward desired behaviors, their prior experiences, and relationships, and infrastructural factors, among others (Vaske and Donnelly 1999, Clayton and Brook 2005, Wynveen et al. 2015). The open nature of cognitive mapping allows respondents to express which of these different cognitive constructs affect their mental models around marine conservation while allowing the researcher to systematically assess patterns in these perspectives across the study population. This process also reduces the probability of data collection bias in that participants can freely express their understanding with limited control and direction by researchers (Austin 1994, Kearney and Kaplan 1997). This approach also provides the potential for greater emphasis to be placed on areas that may not have been previously explored by questionnaires or workshops, including an in—depth exploration of contentious topics. An additional advantage of cognitive mapping is that participants frequently acknowledge the approach as more engaging than other data collection methods.

The examples described here demonstrate a range of application and complexity in using cognitive map tools, from participants being asked to list words relating to a topic in less than 10 minutes to the spatial and diagrammatic representation of how those words are connected to each other using positive and negative interactions, the strength of those relationships, and rules for how the relationships occur. The range of options allows cognitive mapping to complement existing approaches used to study social processes. The simplicity of execution and analysis of the results allows for ease of interpretation, which in turn allows for a wide distribution of easily digestible results.

Cognitive maps can be used as a tool to produce data on people's behavioral motivations and understanding of resource management in the Caribbean. The examples discuss the context, advantages, and disadvantages of several approaches. Importantly, researchers must carefully consider their context (e.g., geography, socioeconomics) and participants when designing a cognitive mapping exercise, to ensure that the approach adopted achieves the study goals. Given cognitive mapping's diverse approaches, however, we believe its broad applicability can promote greater discussion and collaboration across stakeholders.

Acknowledgments

Bessie Schwartz implemented the Q—sort study on shoreline master plans in Washington State. We thank the Human Dimensions Lab at Oregon State University for administering the free—listing component in Panama. The Environmental Defense Fund supported the execution of the cognitive mapping exercise in Belize in 2017.

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