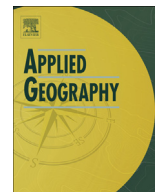




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Mobility in the mangroves: Catch rates, daily decisions, and dynamics of artisanal fishing in a coastal commons

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ABSTRACT

This paper integrates institutional theories of the commons with insights from geography and human behavioral ecology to explore the spatial and temporal dynamics of artisanal fishing in Ecuador's coastal mangrove swamps. The focus is on the cockle fishery commons characterized by a mixture of formal institutional arrangements and an informal division of fishing space that partially influences fisher decisions about where and when to fish. Individual decisions are further explained to a certain degree by the patch choice model since fishers often move on to new grounds when their catch rates fall below average. These optimizing strategies requiring rotation within a socially produced fishing space may contribute to resource renewal, perceived reliable returns for individuals, and a relative stability in fishing effort, potentially mitigating against resource depletion in open-access areas not managed as a common property regime. This study of the interaction between shellfish harvesters, cultural institutions, and the environment contributes to a spatially explicit theory of the commons and points to the crucial role of resource user mobility and dynamic cultural institutions for the ecological sustainability of shellfish fisheries. A better understanding of feedback between individual decision-making and the self-organization of a social-ecological system has critical implications for policy design and fisheries management at similar scales.

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Introduction

As a classic example of common pool resources, fisheries face many management challenges due to the difficulty of excluding individuals whose harvesting efforts are costly for a larger population of resource users who compete for the same resource space (Berkes, 2001, 2005; Feeny, Berkes, McCay, & Acheson, 1990; Gordon, 1954). For geographers, the tragedy of the commons emerges out of mismatched scales in the interaction between the spatial domains of resources and resource users, in which self-interested actions result in resource depletion (Campbell, 2007; Giordano, 2003). Overcoming a mismatch between management and ecosystem scales requires a better understanding of the spatial organization and complex interactions between human and natural systems at finer scales (Johnson, Wilson, Cleaver, & Vadas, 2012; Wilson, 2006).

Over the last several decades, commons theory has advanced understanding about the importance of property rights

institutions, which are often held as an essential mechanism for maintaining or improving resource systems (Agrawal, 2001; Basurto, 2005; Basurto et al., 2012; Bromley & Feeny, 1992; Hanna, Folke, & Mäler, 1996; Hanna & Munasinghe, 1995; McCay & Acheson, 1987; Schlager & Ostrom, 1999). Similarly, customary marine tenure institutions have also been exalted in the literature as social systems that effectively manage resources through controlled access and regulated use (Colding & Folke, 2001; Dyer & McGoodwin, 1994; Johannes, 1978, 2002) notwithstanding some skepticism about the assumed conservation ethics embedded within those institutions (Lu, 2001; Pollnac & Johnson, 2005; Ruttan, 1998; Thomas, 2001). Despite numerous theoretical advances about the crucial role of formal and informal institutions in environmental governance, the commons literature has given less explicit attention to how spatial-temporal dynamics of the commons are produced socially, politically and materially by various forms of human agency (Moss, 2014) and how system-level patterns can emerge out of the self-interested behaviors of individuals as a "precursor of governance" (Wilson, Yan, & Wilson, 2007). These questions are especially critical considering that research on the spatial dimensions of fishing behavior is of burgeoning interest in

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the fisheries science and management literature (Abernethy, Allison, Molloy, & Côté, 2007; Daw, 2008; Salas & Gaertner, 2004; Teh, Teh, & Meitner, 2012).

This paper explores dynamic spatial and temporal patterns in the fishing effort on a micro-scale, focusing on fisher decisions and the role of resource user mobility over fishing space in Ecuador's fishery for mangrove cockles (*Anadara tuberculosa* and *A. similis*). Mangrove cockles are bivalve mollusks harvested from the roots of mangrove trees during low tide periods by artisanal fishers throughout their range from Mexico to Peru (MacKenzie, 2001). I integrate institutional common pool resource theory (CPR) with optimal foraging theory (OFT) for its explicit attention to the human–environment interface to explore how fishers navigate over patchy ecological conditions and under different governance systems. OFT has traditionally been used in anthropology to study how foragers make decisions about resources to best enhance their fitness in a Darwinian sense (Kelly, 1995). However, some OFT models offer appropriate methodological tools to explore how resource users respond to ecological dynamics (Chimello de Oliveira & Begossi, 2011; Sosis, 2002). As such, theories in human behavioral ecology have been increasingly applied to address practical issues in conservation, development, and resource management (Aswani, 1998a, 1998b; Chimello de Oliveira & Begossi, 2011; Heinen, 1995, 1996; Heinen & Low, 1992; Tucker, 2007; Tucker & Rende Taylor, 2007) and are compatible with rational choice theories and classical economic assumptions about human behavior in the fisheries literature (Acheson, 2011; Béné & Tewfik, 2001; Hilborn, 2007).

Using catch-per-unit-effort (CPUE) data collected over four months in Isla Costa Rica, Ecuador, the scope of this paper is confined to three specific questions. First, how do catch rates of a previous day influence a fisher's decision about where to fish and when to move on? Second, how does the cultural and institutional context shape broader spatial patterns of mobility over fishing space? Finally, what are the management implications of this fine-scale analysis of the spatial-temporal dimensions of fishing effort? The activity of harvesting shells represents the human–environment interface where artisanal fishers interact with their biophysical environment and their cultural-institutional context.

This case study of cockle fishing in Isla Costa Rica offers a unique opportunity to observe how changing social constructions of the commons influence dynamics of artisanal fishing and how fishers' alternate between two kinds of governance systems: 1) open-access fishing grounds with an informal division of fishing space and 2) fishing grounds formally managed as a common property regime. Ecuador's cockle fishery has experienced harvesting pressures in the last 10 years (Mora & Moreno, 2009; Mora, Moreno, & Jurado, 2011) further exacerbated by habitat destruction due to decades of mangrove deforestation associated with shrimp aquaculture (MacKenzie, 2001; Ocampo-Thomason, 2006). Shifts from top-down to bottom-up approaches in coastal management during the late 1990s signaled an unprecedented recognition of ancestral rights for coastal inhabitants, resulting in new property arrangements called *custodias*. The *custodias* represent agreements between Ecuador's Ministry of Environment and local associations, which aim to protect mangrove forests and provide a framework for community-based management of mangrove-associated artisanal fisheries. To date, there are 51 *custodias* distributed throughout the five coastal provinces (Mestanza, 2014). The arrangement is similar to co-management institutions in other parts of Latin America (Gallardo Fernandez & Friman, 2011; Gelcich, Edwards-Jones, Kaiser, & Castilla, 2006; Pinto da Silva, 2004; Van Holt, 2012).

The local association in Isla Costa Rica was one of the first in the southern province of El Oro to receive a *custodia*. Their

management plan based on collective choice agreements specifies closure periods, rules of use and access to a particular set of specially managed cockle beds within the *custodia* boundaries (Bravo & Altamirano, 2006) similar to Ostrom's design principles of a common property regime (Beitzl, 2011; Ostrom, 1990). Other cockle beds within the *custodia* are harvested daily, operating on a first-come, first-served basis. These open-access areas within the *custodia* and beyond its boundaries are informally divided among individuals based on personal preferences, habitual use, avoidance, and mutual respect (Beitzl, 2014). The following sections will explore the complementary nature of these two systems at a local scale illustrating the ways in which common pool resource theory and human behavioral ecology are well-positioned to contribute to a spatially explicit theory of the commons with critical implications for fisheries management.

Spatializing commons theory

Theoretical framework

Common pool resource (CPR) theory has typically classified social-ecological systems into a typology of property regimes including public, private, common property, and open-access (Feeny et al., 1990; Ostrom, Burger, Field, Norgaard, & Policansky, 1999). Giordano's (2003) spatially-explicit theory of the commons is based on a typology of resource characteristics along the lines of fugitive, migratory, and open-access, which reflects variations in geography to better understand the interaction between the spatial domains of the resource base and its users. Moss (2014) points out that spatial concepts like space, place, territory, and scale have been treated more as a fixed means of categorization in the commons literature rather than an object of analysis in and of itself. Moss further highlights the essentializing tendencies of the institutional literature on the commons, which has narrowly conceived of *space* as a static biophysical realm, thereby failing to appreciate the dynamic human–environment interactions, cultural-political dimensions, various forms of agency, and alternative geographies that shape the production, use, and regulation of the commons (Moss, 2014). Combining ethnographic research on the fishery commons with human behavioral ecology has the potential to address some of these deficiencies in commons theory since spatial and temporal patterns in harvesting behavior represent a dynamic human–environment interface.

From a human behavioral ecology perspective, cockles are sessile and predictable like other shellfish, making them susceptible to overexploitation (Thomas, 2007a). This is especially true in open-access situations where the domains of multiple users overlap because of poorly defined property rights (Giordano, 2003) and low communication levels among resource users (Janssen & Ostrom, 2008). On the other hand, from the perspective of CPR theory, it is because of the sedentary nature of shellfish that resource users may find it easier to devise institutions and invest in a management strategy, as in the case of Maine's soft shell clam fishery (Hanna, 1998) and other benthic fisheries (Basurto et al., 2012). The relatively stationary characteristics of lobsters may have also contributed to the widely documented emergence of a governance system in Maine's lobster fishery characterized by an informal system of territoriality among “lobster gangs,” and a more formal system of co-management (Acheson, 1988, 2003; Acheson & Gardner, 2004; Wilson et al., 2007). Wilson and colleagues have argued that such forms of collective action have emerged out of the self-interested behavior of competing fishers (Wilson, Acheson, & Johnson, 2013; Wilson, Hill, et al., 2013, 2007).

Different OFT models have allowed researchers to test predictions about what kinds of strategies allow foragers to optimize

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