The Role of Collective Action in the Social-Ecological Resilience of Mangroves and Artisanal Fisheries on the Ecuadorian Coast

Christine M. Beitl[1]

Prepared for the Regional Meetings of the International Association for the Study of the Commons, Tempe AZ. September 29 – October 3, 2010. Panel: Coastal Commons

WORK IN PROGRESS: DO NOT CITE WITHOUT PERMISSION OF AUTHOR

Contact: cbeitl@gmail.com

Abstract: The conversion of coastal mangrove wetlands for shrimp farming has threatened artisanal fisheries and the social-ecological resilience of coastal communities worldwide. This paper examines the role of collective action and common property institutional arrangements in the sustainable harvest of mangrove cockles (*Anadara spp*.) and the social-ecological resilience of Ecuadorian coastal communities. Since the early 1990s on the Ecuadorian coast, grassroots movements in defense of livelihoods and the environment have consolidated into new civil society organizations after decades of mangrove deforestation for the expansion of shrimp farming. To varying degrees of success, they are engaged in mangrove restoration, monitoring, and management, sometimes in collaboration with government agencies. Two kinds of collective action problems are examined: subtraction (how much is harvested) and contribution (how people differentially participate in and uphold local management regimes). Data collection strategies include: 1) observations 2) semi-structured interviews 3) mapping 4) oral case histories 5) surveys and 6) catch-per-unit-effort (CPUE). Through the unique triangulation of ethnographic, survey, and CPUE data, the explicit link between social and ecological systems is examined at two different levels to determine how collective action is reflected in broader patterns of landscape change (mangrove recovery) and differentially reflected in individual fishing effort. It is argued that at the landscape level, the mangrove concessions have great potential to promote ecological and economic sustainability through mangrove conservation and habitat restoration, and to some degree, the sustainable harvest of shellfish. However at the resource level, the fishery is still challenged by the problem of the commons, social exclusion, and overexploitation exacerbated by structural issues. By combining social-ecological resilience and collective action theories to build on common property research, this paper attempts to address theoretical and methodological gaps in the study of common property and resilience to potentially inform policies for the management and conservation of coastal resources.

KEYWORDS: sustainability, social-ecological resilience, collective action, Ecuador, artisanal fisheries, mangroves

[1] Ph.D. Candidate, Ecological and Environmental Anthropology, University of Georgia

INTRODUCTION

Small-scale fisheries are threatened by multiple social, ecological, and economic factors: overexploitation, habitat destruction, increased fishing effort, territorial conflicts, loss of traditional knowledge, lack of effective management, industrialization, and climate change. In Ecuador, four decades of mangrove wetland conversion for urbanization and shrimp farming has exacerbated the overexploitation of the mangrove cockle (*Anadara tuberculosa* and *A. similis*), a bivalve mollusk harvested from the roots of mangrove trees, locally known as *concha prieta*. Recognizing the social-ecological impacts of shrimp farming since the early 1990s, popular movements in defense of mangroves and livelihoods began to consolidate into new civil society organizations dedicated to the management of resources, the restoration of mangroves, and awareness campaigns to educate ancestral users about their property rights. As the shrimp industry weakened in 1999 by White Spot Syndrome Virus (WSSV), a disease in cultured shrimp, the Ecuadorian State began to recognize the importance of mangrove conservation and the resource rights of "ancestral" user groups. Since 2000, the government has granted 34 *custodias,* ten-year concessions to local fishing associations for community-based management and stewardship of mangroves that sometimes draw upon customary rules of resource use and traditional territorial arrangements. This paper examines how collective action—in the form of social movements, their institutionalization, new emergent management regimes, customary norms in fishing, and collaborations between communities and the government—promotes the sustainability of artisanal fisheries and social-ecological resilience on the Ecuadorian coast.

Contemporary environmental problems demand various levels of collective action and cooperation to achieve the goals of sustainability by balancing social, economic, and ecological concerns for present and future generations. Recent scholarship in sustainability science draws attention to the role of collective action in social-ecological resilience, adaptations to various forms of environmental change, and the management of fisheries or other forms of common property (Adger 2003; Adger et al 2005; Alcorn & Toledo 1998; Berkes 2005; Dolsak & Ostrom 2003; Jodha 1998; Kurien 1995; Ostrom 1990). Collective action is often cited as one of the many indicators of social-ecological resilience, or the ability of systems to absorb various kinds of disturbance without changing the general characteristics, components, or relationships that define the social-ecological system (Berkes et al 2003; Berkes et al 1998; Cumming et al 2005).

Broadly defined as cooperation among individuals for a common goal, collective action is often based on common interests, a shared vision, relationships of trust, norms of reciprocity, and communication (Beard 2007; Ostrom 1998; 2000). The scholarly literature has analyzed collective action problems from two slightly different angles: 1) contribution, or participation in a collective action (Beard 2007; Hardin 1982); 2) subtraction, or an individual's withdrawal from public goods or common pool resources (Ostrom et al 1999; Ostrom et al 1994). From the institutional economics perspective,

collective action lies behind common property arrangements which may sometimes serve as a mechanism for averting Garrett Hardin's (1968) "tragedy of the commons."

Common property scholars have long maintained that collective action and strong local institutions can play an important role in resource conservation, stewardship, or management (Agrawal 2001; Becker 1999; 2003; Becker et al 2005; Bromley 1992; Feeny et al 1990; Feeny et al 1996; McCay & Acheson 1987; Ostrom 1990; Smith & Berkes 1991; Smith & Berkes 1993). Ostrom's (1990) argument that long enduring common property regimes and the presence of traditional institutions often provide ripe conditions for the kinds of strong local organization necessary in community-based management, co-management, or the revitalization of customary law and marine tenure in fisheries (Aalbersberg et al 2005; Aswani 2005; Johannes 1978; 2002). This is especially important given the recent concerns raised in the literature about exogenous threats to common property and traditional management institutions, such as economic shifts or changes in demographics and policy (Acheson & Brewer 2003; Cinner 2005; Curran et al 2002; Thomas 2001).

While studies on common property and customary marine tenure have provided valuable insights into the internal processes of social organization, few examine the question of efficacy, which is highly relevant for the study of social-ecological resilience. Questions still remain about the inherent assumptions of environmental stewardship implied by much of the common property literature (Lu 2001; Pollnac & Johnson 2005; Ruttan 1998; Ruttan & Borgerhoff Mulder 1999), especially since too often, little attention is given to ecology (Berkes 1996). Only with the exception of a few studies (Acheson 1987; Smith & Berkes 1991), the direct link between social-ecological systems and the implications of collective action for social-ecological resilience remains poorly understood.

Using a theoretical framework to integrate perspectives from natural and social sciences, this paper uses qualitative and quantitative, social and ecological methods to analyze the role of common property and collective action in resource sustainability and social-ecological resilience on the Ecuadorian coast. Specifically focusing on the role of *custodias* as a common property institution, it is argued that at the landscape level, the *custodias* have great potential to promote ecological and economic sustainability through mangrove conservation and habitat restoration, and to some degree, the sustainable harvest of shellfish. However at the resource level, the fishery is still challenged by the problem of the commons. The benefits of *custodias* are only extended to certain associations and independent shell collectors without access to concessions are further reduced to the margins of mangroves, increasing competition and exacerbating overexploitation in open-access areas. This case study examining the efficacy of collective action at both landscape and fishery levels combines social ecological resilience theory for its emphasis on scale with collective action theories for their attention to the individual level analysis and social differentiation within a social-ecological system for a more nuanced analysis.

MANGROVES AND SHRIMP FARMING

Globally distributed throughout tropical coastal areas, mangrove wetlands supply a variety of goods to coastal communities such as fuelwood, commercial timber, charcoal, construction materials, thatch, fish, mollusks, crustaceans, medicinals, tannin, honey, incense, paper, and dyes for cloth (Glaser 2003; Kaplowitz 2001; Kovacs 1998; Mera Orcés 1999; Snedaker 1986; Walters et al 2008). In addition to the goods for direct human use, mangrove wetlands are increasingly recognized for their multiple environmental services: nutrient cycling, erosion control, sediment trapping, groundwater recharge, water purification, storm surge/ tsunami buffering, carbon sequestration, microclimate stabilization, and essential habitat, shelter, and nursery service for commercial, recreational, and subsistence fisheries (Brander et al 2006; Ronnback 1999). In Ecuador, thousands of artisanal fishers have depended on mangroves for generations for fisheries productivity, subsistence, and as a principal source of income.

Due to their previous stigmatization as “barren wastelands” (Selvam et al 2003: 794), and the general lack of understanding about their environmental services, mangrove wetlands worldwide have been widely undervalued, often leading to their draining for agriculture, urbanization, and tourism or conversion to other uses like aquaculture (Alongi 2002; Ellison & Farnsworth 1996; Smith 2004; Southgate & Whitaker 1994; Valiela et al 2001). While the deforestation rates of mangroves are generally decreasing, they still remain significantly higher than other forest types (FAO 2005). According to Valiela (2001), mariculture contributes to about 52% of global mangrove loss and shrimp farming is the most significant type of aquaculture associated with mangrove deforestation.

While mariculture offers the potential for economic development on the national level by increasing export earnings and generating employment in urban centers, the local reality in marginalized coastal communities has been dramatic landscape change and decreasing in water quality (Barbier 2003; Cruz-Torres 2000; Dewalt et al 1996; Guest 1999; Southgate & Whitaker 1994; Stram et al 2005). Along with ecological degradation, mangrove deforestation has also resulted in numerous social impacts such as community displacement, the loss of livelihoods, the erosion of resource rights, the reorganization of local economies, increase in economic disparity, and social conflict (C-CONDEM 2007; Cruz-Torres 2000; Dewalt et al 1996; Martinez-Alier 2001; Primavera 1997; Stonich 1995; Stonich & Vandergeest 2001).

In Ecuador, despite the existence of laws that protect mangroves since the 1980s, between 1969 and 2006 the original mangrove cover has decreased by 26.5% which seems to be directly related to the increase in shrimp farms (CLIRSEN-PMRC 2007). Some estuaries have lost from 74.6% (Muisne) to 90.2% (Chone) of the original cover (Bravo 2007b). The first shrimp farms of the 1970s and 1980s were built in salt flats and uplands, but as the industry grew, the farmers expanded into mangrove wetlands, disrupting environmental services and the livelihoods of thousands of artisanal fishers. Despite laws to protect mangroves since the 1980s, deforestation

continued and the powerful shrimp industry continued to expand, with shrimp rising to the nation's third largest export behind bananas and oil.[2] Artisanal fishers with little political power or economic resources could do very little but to stand by and watch their fishing grounds be bulldozed away.

Some informants regretfully admitted to me in interviews that they were part of the destruction of what they have now been trying to hold on to with a tenuous grip for the last ten years. In the early years of shrimp farm development, many artisanal fishers and shell collectors took employment with shrimp companies helping in the construction of the shrimp ponds without realizing the consequences. Perhaps they had a false impression that shrimp farming would bring job opportunities to areas like Esmeraldas that suffered from boom-bust development as observed in Whitten's (1994) ethnographic accounts. They did not realize that employment in the shrimp farms was temporary and seasonal and that the industry made more of an impact in urban centers in the packing, processing, and transportation sectors. Many people migrated to Puerto Hualtaco during the 1980s to be part of the development of the shrimp industry in El Oro, and then eventually took up shellfish collecting in the late 1990s when the shrimp industry crashed due to WSSV, further increasing competition in artisanal fisheries.

As in Honduras and Mexico (Cruz-Torres 2000; Stonich & Bailey 2000), some Ecuadorian communities have not been passive in the transformation of landscape and livelihoods for monoculture shrimp production. Since the early 1990s, the resistance movements in defense of mangroves and livelihoods began to consolidate into civil society. Local associations were organized in Muisne with the help of Fundecol, a grassroots environmental defense organization who played an instrumental role in organizing artisanal fishers to stand up to giant shrimp farmers in defense of their resource rights. In Isla Costa Rica, small groups visited shrimp farms with machetes to threaten employees, but this form of protest did little to stop the destructive path of shrimp farming and in some ways caused community tensions since not all agreed with those radical forms of protest. The movements grew when the media began publicizing the struggle and alliances were formed with large international environmental organizations like Greenpeace.

Since the 1990s, several fishing associations have formed to gain more negotiating power and legal defense of common property resources. By 1999, Executive Decree No. 1102 authorized legal recognition of ancestral rights to mangroves introducing a legal framework by which ancestral communities would be able to solicit a concession for sustainable use and stewardship (Bravo 2007a). In August 2000, the Asociación de Pescadores Artesanales, Mariscadores y Afines "Costa Rica" was granted 519.79ha in Isla Costa Rica, one of the first community concessions in the province of El Oro and in the country. "Now all of the associations in El Oro want a mangrove concession, the phenomenon is spreading like a fever!" (Mora, personal communication). But concessions are only granted to groups that are well-organized and prepared with maps, membership lists, detailed management plans indicating

[2] Article 22 of the *Ley Forestal* declared mangroves as national patrimony in 1984, prohibiting any destructive activity, but this regulation was difficult to enforce due to corruption.

sustainable use of resources, a copy of the legal agreement of the association, a designated directive committee, and an agreement of technical assistance with an external organization. Many local associations in Puerto Hualtaco are anxiously awaiting approval as they have long perceived the benefits of the *custodias* in Isla Costa Rica and Las Huacas.[3]

FISHERIES AS COMMON PROPERTY, COLLECTIVE ACTION, AND SOCIAL-ECOLOGICAL RESILIENCE IN COASTAL ECUADOR

In the last decade the cockle fishery has begun to show signs of overexploitation throughout the Ecuadorian coast (Elao & Guevara 2006; Kuhl & Sheridan 2009; MacKenzie 2001; Mora & Moreno 2009; Mora et al 2009). Smaller sizes and catches have indicated signs of stress. The Subsecretaria de Recursos Pesqueros (SRP) established the first measures to regulate the fishery in 2001 by Ministerial Agreement No. 170 which recommends a closed season during the period of reproduction from February 15 to March 31, along with a permanent prohibition to commercialize shells smaller than 45mm. The closed season was difficult to enforce and ended in 2008. The current regulation only prohibits the collection and commercialization of shells below 45mm. Inspectors randomly monitor the situation in various ports, confiscating shells that are below 45mm and returning them to their habitat. However this form of control does little to prevent collectors from hiding small shells in their backpacks or clothing and studies are continuing to show a decline in size and catch (Mora & Moreno 2009; Mora et al 2009).

Popular belief about the reasons for decline by both shell collectors and biologists are that there are too many *concheros*, a classic tragedy of the commons perspective. Because of the two main characteristics of common property and open access resources, *subtractability* and *excludability* (Berkes 2005; Ostrom et al 1999), wetlands and all fisheries have been considered particularly vulnerable to the tragedy of the commons (Barbier et al 2002; Gordon 1954). However, the argument for the tragedy of the commons ignores the resilience of the environment and society: social and cultural complexity, institutional responses, cultural and traditional norms, and the capacity of people to overcome social dilemmas by communication, cooperation, and collective action. Some local associations with *custodias* have included fisheries management as part of their management plan. For example, Costa Rica's management plan has four main objectives: 1) mangrove restoration 2) control of access to the *custodia* 3) recuperation of cockles and crab 4) strengthening of local organization (Bravo 2006).

As a result of the management plan in Costa Rica, there are three *de facto* property regimes in Isla Costa Rica (Table 1): 1) *custodia* with controlled access 2) *custodia* with open access and 3) open access. Since 579 ha is too large of an area for

[3] Isla Costa Rica and Las Huacas are both nearby communities in the mangrove that are believed to have excellent fishing grounds because of the way they are managed. Costa Rica has had legal title to their concession since 2000, but Las Huacas has only received their concession within the past year (2009). The people of Las Huacas are famous for their exclusion tactics and control of territory by force.

40 members to monitor, only four areas are carefully managed with strict access and extraction rules. The four areas are harvested 10 days of the month. During the other 20 days, *concheros* collect in the areas to which they are "*enseñado*" or accustomed to working. Those areas may be part of the *custodia* that is only protected by legal concession against mangrove deforestation, but all users, both members and non-members of the local association have usufruct rights. For the purposes of this study, I classify these areas as *Custodia with open access*. Finally there are areas of open access which are not in any concession, rather property of the Ecuadorian State.

Table 1; Property Regimes in Isla Costa Rica, El Oro, Ecuador

Custodia with controlled access	Areas that are closed managed through strict rules about access, rotation and extraction
Custodia with open access	Areas that are monitored by *socios* for mangrove protection, but all users (including those from Hualtaco) have usufruct rights
Open Access	Areas that are open to all fishers from Costa Rica and Hualtaco

In accordance with Ostrom's (1990) design principles, access to the *custodia* with controlled access is controlled by voluntary patrolling by *socios*. Each socio must be a guard a certain number of days per month based on a system of rotation among all members. Those who do not comply with the rules are sanctioned. In their first offense, they are prohibited from the monthly harvest of the areas with controlled access. In a second offense they are prohibited from the harvest indefinitely.

COCKLE COLLECTING, CUSTODIAS, AND TERRITORIAL CONFLICT IN ISLA COSTA RICA

In Isla Costa Rica, most of the 310 inhabitants depend directly on mangroves for fishing and shellfish collecting. In the province of El Oro, cockle collecting is typically done by men and boys.[4] In Isla Costa Rica, all of the collectors are men with the exception of one woman who accompanies her husband about four or five times a year to collect her 20-25 shells. 70% of households in Isla Costa Rica depend on collecting and almost half of all 70 households have one or more individuals collecting 5-6 times a week. Most collectors are between the ages 17 and 40, but since many of them learn at an early age, children as young as 6 years old have been seen digging in the mud alongside their parents or siblings. Few collectors are older than 60 because of the physical demands of labor. Over 50% of collectors are members of one of the local association and those who are not members are the children of members who are under 18 and still too young to join.

Cockles are harvested from the thick mud surrounding the roots of mangroves during the low tide period in three to six hours, depending on the lunar cycle, whether it is spring tide or neap tide. Spring tides have a longer lag time between rising and falling

[4] Only in the province of Esmeraldas is the activity is traditionally carried out by women and children, but several ethnographic accounts have been documenting changes due to uncertain economic conditions that are forcing more men into the fishery.

tides, allowing fishermen and shell collectors to work longer hours. The collecting schedule or work hours are dictated by the schedule of the tides which varies by one hour every day. Some shell collectors are dedicated to two livelihood activities: collecting during low tide and fishing during high tide, or they may alternate their daily livelihood choices depending on economics (the price of the resource) or natural conditions (weather, abundance of the resource, productivity of alternative fisheries, or mood/ physical health of the collector).

In a day's work, many collectors secure their rubber boots and gloves, bundle their bodies and heads in clothing, and then arm themselves with mosquito repellent to protect themselves against the brutal elements of tropical mangrove wetlands: hot burning sun or cold rain and wind, violently aggressive insects, snakes, and biting fish that burrow in the mud. The work period usually lasts about 3 hours on average for most, but most *concheros* work until they "*completar*" (reach a rounded number of 25, 50, or 100 shells, depending on their level of skill and their luck). There are no designated gathering spots, rather an informal division of territory based on "*donde uno esta enseñado*", or where one is accustomed to going.

After a three to six hours enduring a crouched position and weaving through a thicket of mangrove branches and roots or sinking in thigh-deep mud, the collector will have gathered anywhere between 20 to 100 shells that will sell for $12-20 per 100 in El Oro, depending on season and quality of the catch.[5] Much of one's CPUE is based on level of skill and territoriality, or the way collectors informally divide space and allow them to recuperate between harvests. Territoriality can promote a more sustainable harvest in artisanal fisheries (Acheson 1987; Begossi 1995), but in areas like Muisne and Hualtaco where competition among collectors is high, one's catch is based highly on luck that the site had not been harvested recently by someone else. Some *concheros* have very specified knowledge that enables a more successful catch. Others are successful collectors without knowing or being able to explain why. Age and years of experience seem to play a major role in one's success, but this needs to be verified by statistical analysis and hypothesis testing.

In Isla Costa Rica, the majority of collectors go in one of two boats that bring a group of 10-15 to an area, leaving 1-2 collectors in various spots along the estuary (depending on whether they prefer to work alone). Others go out in groups of 2-5 in their personal motor-powered canoe or on foot. In Puerto Hualtaco, the majority of *concheros* join one of the nine large boats that carry 15-30 collectors and arrive as far up the estuary as Isla Costa Rica, about 45-50 minutes traveling time by boat. Occasionally collectors from Hualtaco try to collect in the community-managed areas of the *custodias*, and is a great concern to the *socios* in Isla Costa Rica.

In general, *socios* perceive benefits of the *custodias*. It has given them legal title and institutional support to defend their mangroves from indiscriminate mangrove

[5] In the province of El Oro, cockles sell for $12-20/100 shells depending on quality (size of shells) and seasonal demand. In Esmeraldas, shells sell for $7-10/100 shells. Demand is highest during Easter week and Christmas/New year holidays.

cutting, it has strengthened and empowered local organizations, and some believe the areas in custody produce a higher catch and a larger shell. But overall, they are still worried about the future of the fishery. In the past, it was common to collect 300-500 shells in 2-3 hours, but today, one should consider himself lucky if they find 50-100 shells, depending on location. In the past, there was no need to take small shells to sell on the market, but today, it is necessary to "*completar*" in order to pay the cost of transportation (gas or canoe rental) or feed one's children. The collectors in Costa Rica are greatly concerned about overexploitation of their areas in *custodia*, particularly by outsiders who they believe engage in destructive fishing practices by stirring up the mud with two hands instead of one and taking all the small shells without allowing them to recuperate, grow, and reproduce.[6] According to collectors in Isla Costa Rica, the catch has declined over the last 10 years due to increased number of *concheros*, outsiders from the highlands and Peru, mangrove deforestation, and chemicals released from shrimp farms. While they see some benefits to the *custodias*, not all believe it is enough to secure their future. The objective here is to assess the effectiveness of the *custodias* in promoting sustainability and social-ecological resilience.

METHODOLOGY

Case Study Selection and Data collection

The fishery for the mangrove cockle was chosen as a case study to investigate the effects of collective action on resource sustainability for several reasons: 1) there has been evidence of overfishing in the last ten years (Elao & Guevara 2006; Mora & Moreno 2009; Mora et al 2009), most likely exacerbated by shrimp farming (Kuhl & Sheridan 2009; MacKenzie 2001; Ocampo-Thomason 2006); 2) collecting shellfish exemplifies a classic commons problem where extraction by one collector subtracts from the welfare of other collectors and exclusion of users is difficult to control (Berkes 2005; Ostrom et al 1999); 3) with the exception of one study by Ocampo-Thomason (Ocampo-Thomason 2006), little is known about the customary norms, traditional institutions, territoriality, or informal rules that may influence fishing behavior; 4) *concheros* (shell collectors) have been among those artisanal fishers most affected by shrimp farming and have collectively organized to defend their common property rights and restore their degraded habitats to cope with environmental change in the Ecuadorian Chocó, a rapidly changing region cherished by conservationists for its high levels of biological and cultural diversity (Beitl 2007; Ocampo-Thomason 2006).

This research is based on 18 months of field research from January 2009 to July 2010. Preliminary exploratory research was conducted during the summers of 2006 and 2008, and from January to March 2009, interviews and observations were carried out in several different ports and communities in the provinces of El Oro and Esmeraldas, often in collaboration with biologists from the Instituto Nacional de Pesca (INP).[7] After

[6] Ocampo-Thomason also observes that women in Esmeraldas make the same complaints about destructive fishing practices of outsiders.

[7] The National Fisheries Institute of Ecuador is a public research institution whose mission is to provide the service of technical and scientific investigation of bioaquatic resources and their ecosystems to the fisheries-aquaculture

the exploratory phases, four sites, two large communities and two small communities were selected for comparative case study: Isla Costa Rica and Port Hualtaco in the province of El Oro, and Muisne and Las Manchas in the province of Esmeraldas (Figure 1). The two large communities, Muisne and Hualtaco, are very important ports for landings of the mangrove cockle in Ecuador (Mora & Moreno 2009; Mora et al 2009). Isla Costa Rica and Las Manchas are small rural fishing communities mainly dependent on mangroves and cockle fisheries as a primary livelihood and subsistence strategy.

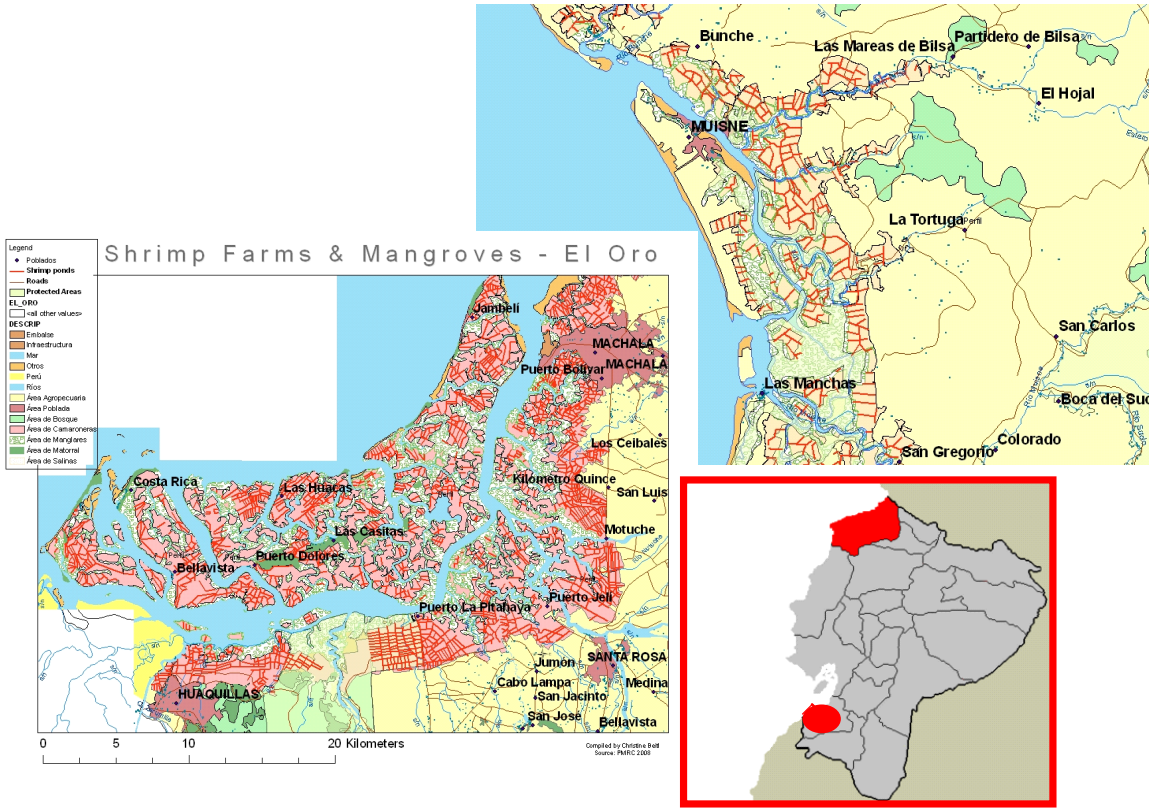

Figure 1: Study sites in El Oro and Esmeraldas

After two months of exploratory observations and interviews with shell collectors, buyers, biologists, public officials, NGO workers, and activists in the port cities of San Lorenzo, Muisne, Puerto Bolivar, Puerto Jeli, and Hualtaco, qualitative research began in Isla Costa Rica. The questionnaire was finalized after several trial runs and revisions based on ongoing observations, unstructured interviews, a review of the grey literature and policy reports, a community census, a fisher diary exercise with 10 participants, focus groups, oral histories, and mapping exercises in Isla Costa Rica, and observations and interviews in other ports.

---

sector to inform policy for the sustainable development of the fisheries sector so that it may achieve its "optimal rational use" (Mora, personal communication 2010). Biologists at INP played an instrumental role in orienting me to different field sites, introducing me to research contacts, and advising me about the fishery throughout the duration of their research.

The final questionnaire is divided into five sections: 1) brief description of the project and informed consent; 2) a shell measurement log that includes information about the site of extraction, preferred sites, rotation of sites, and the collector's understanding of biology and ecology of the species; 3) baseline demographic information including name (optional), age, sex, association, neighborhood, occupation and other jobs, birthplace, migration information, and preferred work; 4) perceptions about environmental change in mangroves and the fishery, opinions about access rights and solutions to the problem of overfishing; 5) participation in collective action and other livelihood strategies as adaptations. All questions were administered orally immediately before or after the measurement of shells with the help of one or two field assistants (n=145).[8] The final questionnaire consisted of structured questions with room for elaboration depending on time, patience, and perceived willingness of each participant.

Data analysis and measurement of concepts

The focus on the fishery for the mangrove cockle (*Anadara tuberulosa* and *A. similis.*) allows for the examination of two kinds of collective action problems: subtraction (how much is harvested) and contribution (how people differentially participate in and uphold local management regimes through participation in civil society and mangrove restoration). Through the triangulation of ethnographic, social, and ecological data, the research examines the explicit link between social and ecological systems at different levels, determining how collective action is reflected in broader patterns of landscape change and differentially reflected in the fishing effort of individuals. The present analysis is limited to the role of *custodias* in promoting resource sustainability and social-ecological resilience.

The concept of resilience at the landscape level is measured by change in mangrove cover over time using data from CLIRSEN (2007). The concept of "resource sustainability" or sustainable harvest is measured by the following indicators: 1) total catch-per-unit-effort (CPUE); 2) foraging efficiency (the number of shells collected per hour of work); 3) size of shells collected; 4) percent of CPUE below different size classes: 45mm, 40mm, and 36mm. According to customary law, shell collectors only collect large shells for both commercialization and personal consumption, leaving behind several small shells in the mangrove so they can continue to grow. As the resource becomes more scarce, more small shells are beginning to appear on the market and sold at an inferior price. Since fishing policy prohibits the capture of shells below the size of 45mm, believed to be the size of their peak reproductive capacity, the INP uses the 45mm as an indicator to assess the state of the stock in five different port cities as part of their national monitoring program for this resource (Mora & Moreno 2009; Mora et al 2009).

[8] In Puerto Hualtaco, all shells were measured and logged during the interviews with the help of two field assistants. The author conducted all interviews while one field assistant separated the two species and measured shells and the other recorded the data. In Muisne and in Costa Rica, all interviews and shell measurements were conducted by the author, occasionally with the help of one field assistant.

There are two problems with INP's approach to assessing stock levels and the overall state of the fishery. First, it does not recognize the subjective discretion and difficulty for a shell collector to determine the legal size with the naked eye. This study groups percent of CPUEs that are below 40mm and less than 36mm as an indicator of degree to which the collector is conscientious in his/her harvesting behavior, despite how they answer the questions in the survey. Shells in the size classifcations below 40mm and 36mm are visibly small enough for the collector to recognize as prohibited for capture by both legal and customary standards. Second, INP's approach does not consider the social institutions that influence fishing behavior, or tenure regimes such as formal and informal common property arrangements. It has been widely documented that territoriality plays a very important role in the productivity or state of fish stocks (Acheson 1987; Begossi 2001; Begossi 2006).

In this study, property regimes are divided into five classifications for comparative analysis of how geography and property arrangements influence the CPUE, foraging efficiency, size, and proportion of CPUE below the indicated size classifications.[9] Three property regime classifications have been created for Isla Costa Rica: Custodia (controlled access), Custodia (open access) and open access. Muisne has two different regime classifications: controlled access (Las Manchas) and open access (Muisne). Each of these classifcations are compared to assess whether common property institutional arrangements promote a sustainable harvest.The concept of resilience is assessed more qualitatively through comparative case study of Esmeraldas and El Oro using the exploratory framework proposed by Cumming et al (2005).

RESULTS

Figure 2 shows that the CPUE and the foraging efficiency is slightly higher in areas that are locally managed with locally designed rules about extraction and rotation of sites and the exclusion of outsiders is enforced. Competition is higher in open access areas for El Oro which includes collectors from both Isla Costa Rica and Puerto Hualtaco. Collectors are able to gather 33-34 shells per hour on average in areas with controlled access in El Oro and in Las Manchas, where access and exclusion of outsiders is also informally enforced. Las Manchas has the lowest CPUE, but this may be explained by the fact that collectors claim to not work the entire three-hour tidal period as people in Muisne and El Oro do. *Custodias* and other areas with controlled access in Costa Rica and Las Manchas both ensure an average of 10 more shells per hour. Multiplied by three hours of work, collectors in areas with controlled access have the potential to 30 shells or generate more than 30% in earnings, based on an average CPUE of 100.

[9] Data on shell size are aggregated. Average shell size and percent of CPUE below size minimums are first calculated for each individual *conchero* for subsequent analysis that analysis factors that influence the fishing effort on an individual level.

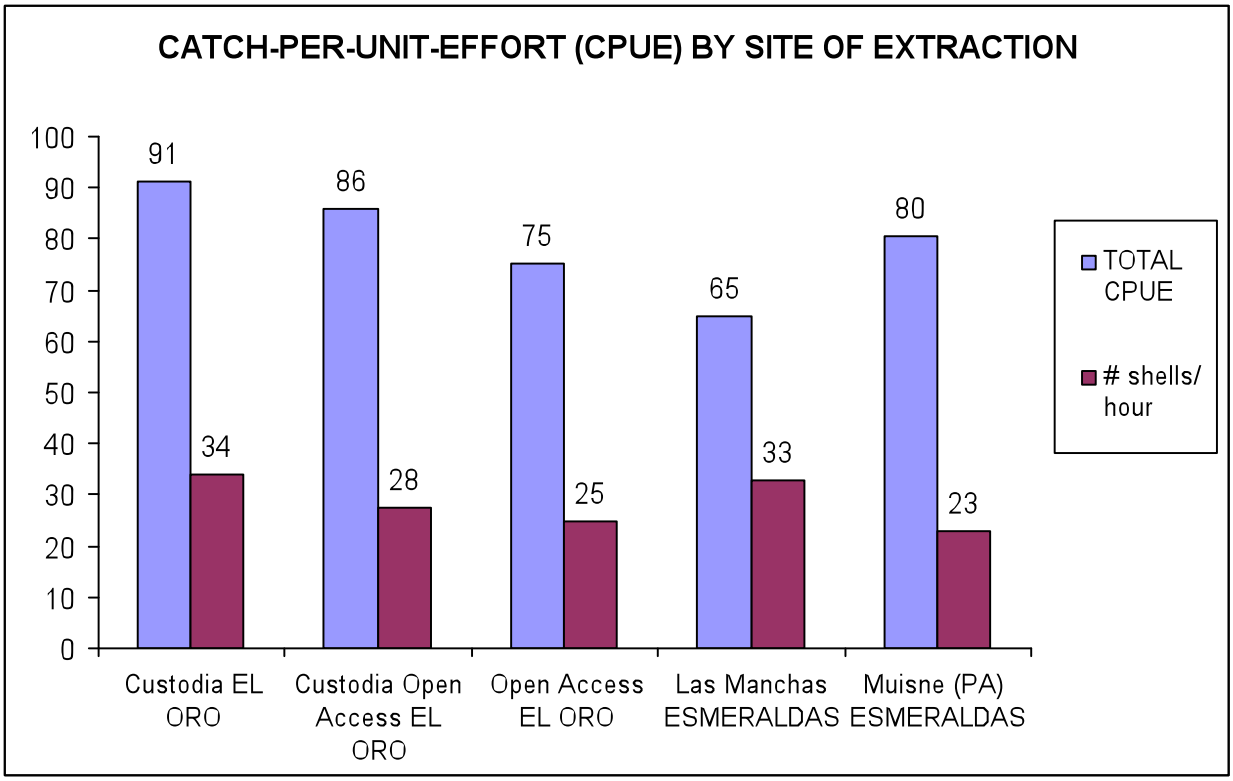

Figure 2: CPUE by Site of Extraction

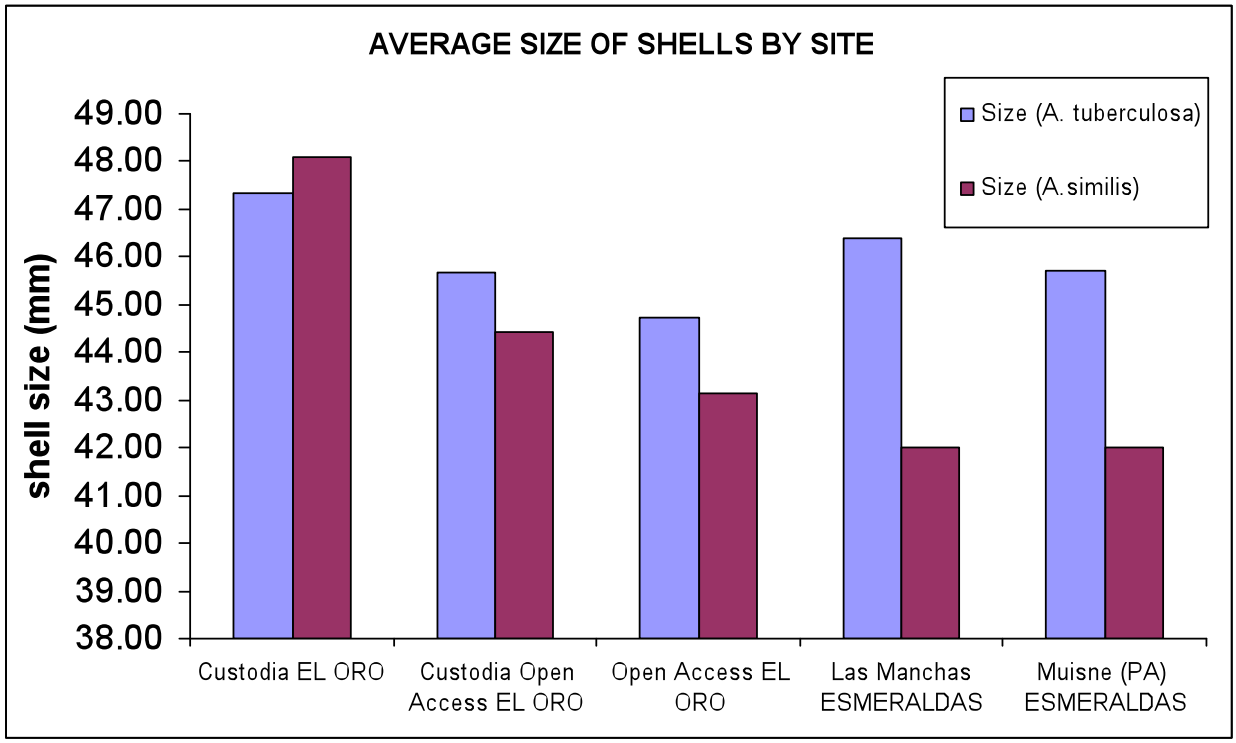

Figure 3: Average Size of Shells by Site

Figure 3 illustrates that the average size of shells is slightly higher in areas that are locally managed and is in accordance with *conchero* perceptions that areas in *custodias* produce more and "better quality" shells, which often sell for a higher price on the market. The average size in Las Manchas may be skewed by the presence of very large shells and small shells in the CPUE of a few informants who gather small shells as seeds for cockle culturing in holding pens.

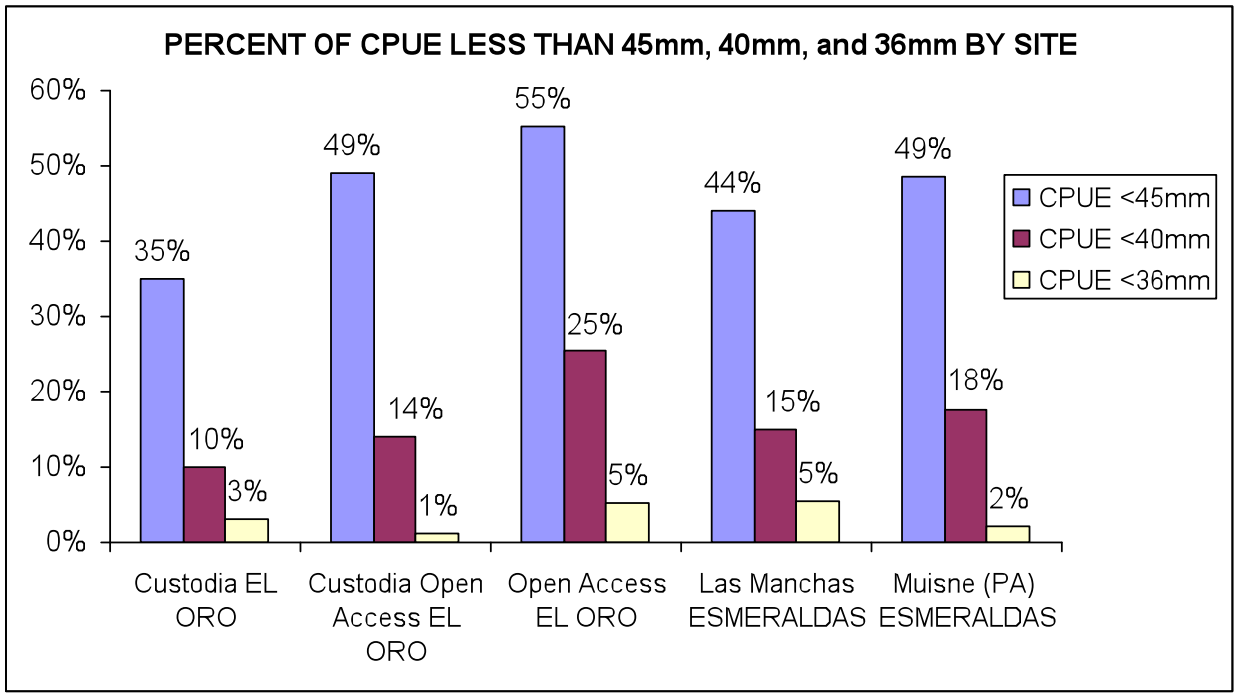

Figure 4: Percent of CPUE less than 45mm, 40mm, and 36mm by site

Figure 4 demonstrates a proxy for fishing behavior or an indicator of sustainable harvesting behavior. The proportion of one's CPUE that falls below different size minimums indicates that the collector is less concerned about customary and legal rules that prohibit the extraction of small shells. The relative higher percentage of shells in the smallest size classification may reflect those collected as seed for mariculture. These data suggest that shells are larger in areas with controlled access and tightly managed rules of rotation. It may also suggest that collectors are less likely to take shells below 40mm in areas that are tightly managed and strictly controlled, but this hypothesis should be tested with more sophisticated tools for statistical analysis and controls.

DISCUSSION

Resilience at the Landscape Level

Shrimp farming in Ecuador is characterized as a non-resilient system in this study. As stipulated by the social-ecological resilience framework proposed by Cumming et al (2005), thresholds refer to a tipping point of disturbance or changes in forest cover and goods extracted that have the potential to redefine the system's

components, relationships, innovations, and continuity. The clear-cutting of mangrove forests crossed a threshold point in which both social and ecological relationships that define the mangroves as a social-ecological system have been altered. A mangrove area that has been clear-cut and converted to shrimp farms no longer has the structure necessary to support the diversity of other species in its conversion to monoculture intensely managed by chemicals, nor is it able to perform the same ecological functions or environmental services. Human relationships are also redefined by the clearcutting and conversion of mangroves to shrimp ponds, as artisanal fishermen are displaced and sometime forced to migrate out if they are unwilling or unable to secure employment in the local shrimp farm. A crash in fisheries with no hope for rebound is also an example of a threshold in which a social-ecological system's identity is lost to changes in both ecological and social relationships that define the system (the food web dependent on the crashed fishery, and the fishermen who depend on the fishery for their livelihood) and many fisheries are dependent on healthy mangrove habitat (Barbier 2003).

However there have been several indicators of resilience of Ecuadorian coastal areas. Collective action in the form of social movements, civil society projects, and community-based management has emerged in Isla Costa Rica. Adaptive management is applied through robust institutional arrangements that bring together local users, government officials, scientists, and students in a "learning by doing" environment and a fusion of scientific and traditional knowledge systems for experimentation in cockle culturing and community-based management of *custodias*. Finally, *custodias* have strengthened property rights of marginalized fishermen who previously had little political influence or economic power to defend their resource rights and maintain the identity of the social-ecological systems upon which they depend.

Civil society has played a major role in habitat restoration and defense. After decades of decline, mangrove areas are now recovering in most provinces with the exception of El Oro where the trend of loss is has been slowing, but 14.5% of total mangrove area was lost between 1999 and 2006. The mangrove recovery trends are expected to continue due to several collective action efforts and collaborations between the government, civil society, and resource users. A new presidential decree recently passed in March 2009 calls for reorganization and regulation of the shrimp industry. Recognizing that many shrimp farms were established illegally due to corruption and vague interpretations of tenure laws, Decree 1391 requires all shrimp farmers to reforest 10-20% of their ponds, depending on how many hectares occupy what were once historically mangrove areas. Farmers are required to have their shrimp ponds assessed for production, ecology, and economic productivity before turning in their folder to three government institutions involved by March 2010. As shrimp farms are now breaking down the old walls and reforesting, civil society and those who were once the enemies are forced to work together after years of struggle and conflict over territory to restore degraded wetlands. Some reforested areas in Muisne are already producing cockles and considered decent gathering grounds by those who know about them.

Table 2: Mangrove Change by Province in Ecuador 1969-2006

	1969-1999	1999-2006
Esmeraldas	-28.3%	4.7%
Manabí	-85.1%	43.7%
Guayas	-14.7%	0.6%
El Oro	-46.2%	-14.5%
Total Ecuador	-26.5%	-0.2%

Source: CLIRSEN-PMRC 2007

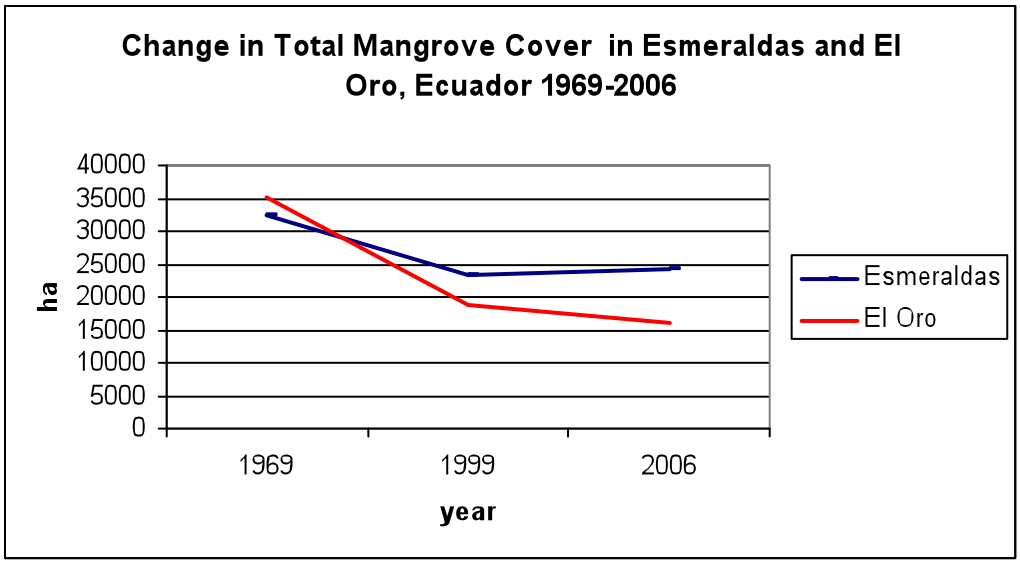

Figure 5: Change in Mangrove cover over time

Sustainability at the Resource Level

Collective action is the aggregate of individual behaviors and choices for the purpose of creating collective benefits often based on shared concerns or beliefs. The data indicate that many people interviewed in this study share concerns about overexploitation and mangrove loss, and many collectors share similar kinds of knowledge about the resource despite the level of experience and whether they can be considered “ancestral” or not (table 2). Most of the variation can be seen action: levels of participation in collective actions such as mangrove planting, workshops, marches in defense of mangroves, or other civil society activities, and in the degree of overexploitation (figure 4). Not all users participate in the collective actions that contribute to the recovery of mangroves. In Muisne and Hualtaco, many informants commented that they have not participated because they have not been invited. Those activities are designated only for *socios* and not for independents. Independents are further marginalized by their exclusion from *custodias* and the stigma by both *socios* and government officials that they are freeriders who will bring the fishery to ruin.

Table 3: Perception of Overxploitation and Issues of Territoriality by Study Site

	Hualtaco (n=21)	Isla Costa Rica (n=38)	Muisne (n=40)
CPUE is less today than 10 years ago	95%	100%	97%
Express concern or worry about the future of the fishery	100%	96%	71%
There are sites one can lo longer go	100%	92%	81%
Have had a conflict with another *conchero*	55%	59%	14%
Have had a conflict with a shrimp farmer	80%	37%	51%

Source: Fieldwork 2009-2010

Comparing perceptions of overexploitation and incidence of territorial conflict, the surveys reveal little difference in opinion and perception between *concheros* based on study area (table 3). Most *concheros* perceive a difference in the CPUE over time and are worried about the future of the fishery. Most of them have share the same knowledge about the biology and ecology of the species, recognizing that sites should be left to rest for at least 2-4 weeks and small shells should be left behind. As the CPUE data reveal, these perceptions do not prevent *concheros* from taking small shells or frequenting some sites everyday. When asked what they usually do with the small shells, many replied that they take small shells out of necessity because they have to "*completar*." Others say they take small shells for their family to eat or as seed for their holding pen. Other blame outsiders and express great concern over those who take all the small shells, even though a good portion of their CPUE is below the size minimum. A few informants confessed that they take the small shells because if they leave them there for tomorrow, someone else will come and take them before they have a chance to grow, a classic problem of the commons.

The data suggest that this problem of the commons may be alleviated by institutional arrangements since the percent of one's CPUE below the size minimums and the average size is slightly higher in areas that are protected with local rules and rotation. However it is not clear whether the *custodia* actually promotes this restraint on behavior, or if the environmental conditions of the site influence this outcome. More vigorous statistical analysis is needed to further explore this hypotheses about the factors that influence fishing behavior at the individual level.

CONCLUSION

The present study on the case of the fishery for the mangrove cockle in "Isla Costa Rica" presents the opportunity to study two types of collective action identified in the literature:

1) ***Collective action as a contribution***: when a person participates or contributes his/her time and/or resources to advance the interests of the group (Beard 2007; Hardin 1982). For example, in the case of Costa Rica, individuals contribute to

management regimes by participating in association meetings, workshops about the resources, mangrove reforestation projects, and occasionally political marches in defense of mangroves and the environment as a form of not only supporting the community, but also lending support on a national level to other ancestral user groups engaged in the same struggle throughout the country.

2) ***Collective action as subtraction***: in a situation of common property or open access, collective action means that the resource users decide voluntarily to restrain themselves in their tendency to maximize their exploitation of common pool resources to conserve them for the benefit of the group or future generations, but usually under the pressure of institutional rules or cultural norms (Agrawal 2001; McCay & Acheson 1987; Ostrom et al 1994). For example, in the case of Costa Rica, it means greater yields of cockles when all of the collectors respect the self-imposed closed seasons and areas (areas designated for limited collection of shells, defined by the members of the association themselves) that protect common property or the space shared by the entire group.

Freeriding is a problem in both kinds of collective action. First, not all are inclined to participate. Some are not interested and some simply do not have time or resources to contribute to the cause. In Muisne, many who used to participate have stopped because they have been disappointed by failed efforts by NGOs to make the benefits reach the most vulnerable of participants. Second, access to participation may be limited by structural factors, as also argued by Beard (2007). For example, only *socios* are invited to participate in reforestation projects and according to some informants in Muisne "they already have their people picked out" meaning the local NGOs have a certain group of people with whom they work and everyone else is excluded. Finally, because not all have equal access to participation, the benefits are not evenly distributed. Not all collectors know about the new gathering grounds or have access to that information. In El Oro, only *socios* are permitted access to the common property *custodias.*

According to Ostrom *et al*. (1999), there are four kinds of property: 1) private 2) property of the state 3) common property 4) open access. Common property is defined as property that is shared by one or more resource users and containing two main characteristics that contribute to its vulnerability to a tragedy of the commons if there is no collective action among the individual users because of two characteristics, subtractibility and the problem of exclusion. However, these classifications are not very rigid in reality. The three property regimes (private, state, and common property) all have the potential to function as open-access situations to different degrees. For example in Ecuador, mangroves are considered patrimony of the state, but user groups have usufruct rights. Even when concessions are granted to particular groups, sometimes local groups in control grant usufruct rights to nonmembers, as the the case of custodias with open access in Isla Costa Rica. The *Ley Forestal* permits its exploitation by way of authorized concession, which results in various degrees of open access situations in which resources are vulnerable to a tragedy of the commons. In the case of in Isla Costa Rica, the mangrove concessions have provided the local

association and its members several benefits. First, it empowers them and provides them the institutional support to defend their common property areas from mangrove deforestation. Second, it promotes ecological health through mangrove restoration within abandoned shrimp farms and management of artisanal fisheries through the creation of tightly managed reserve areas. Third, concessions provide economic benefits since data indicate that CPUE and size of shells harvested from the custodias are slightly higher than other areas.

On the other hand, not all user groups benefit from the *custodias*. Independents shell collectors are reduced to even smaller gathering grounds, exacerbating the problem of overexploitation in open-access areas. Mangrove concessions have also promoted conflicts between independents and *socios* who have *custodias.* Thus the *custodias* promote social-ecological resilience at the landscape scale, but at the level of the resource, the problem of the commons still persists. By combining collective action theories with a social-ecological resilience framework it is possible to study complexity and nuances with attention to both issues of scale and social differentiation within a social-ecological system. This approach has the potential to advance understanding about the human dimensions of environmental change and to fill gaps in knowledge about the complexities in small-scale fisheries.

ACKNOWLEDGMENTS

The author wishes to thank several people and institutions for their support during this investigation: friends and colleagues at the Instituto Nacional de Pesca in Ecuador, Elba Mora, Juan Moreno, Luis Flores, Walter Ruiz, and Fedra Solano; Dr. Pilar Cornejo from Escuela Superior Politécnica del Litoral (ESPOL); Rafael Elao from Ecocostas; Tito Navia, Manuel Feijóo, and Ruben López from the Subsecretaria de Recursos Pesqueros; Nelson Zambrano and Manfred Altamirano from the Subsecretaria de Gestion Marina y Costera - Ministerio del Ambiente; Segundo Coello and Diana Vinueza at Ecobiotec; and Frank Navarette at C-Condem. This research would not have been possible without the willingness and kind-heartedness of research participants in Isla Costa Rica, Muisne, Las Manchas, and Hualtaco, in particular, field guides and research assistants, Adrian Vargas in Muisne, and Adolfo Cruz, Estela Cruz and Sonia Cruz in Isla Costa Rica. The author also wishes to thank her dissertation committee for their support throughout the development of this research: Dr. Robert Rhoades, Dr. Bram Tucker, Dr. Peter Brosius, Dr. Julie Velazquez-Runk, and Dr. Tommy Jordan at the University of Georgia. Finally, this research was made possible with generous support from the National Science Foundation, the Wenner Gren Foundation, and the Fulbright Student Program.

REFERENCES

Aalbersberg W, Tawake A, 2005. TP. 2005. Village by Village: Recovering Fiji's Coastal Fisheries UNDP, UNEP, World Bank, WRI

Acheson J. 1987. The Lobster Fiefs Revisited: Economic and Ecological Effects of Territoriality in the Maine Lobster Fishery. In *The Question of the Commons: The Culture and Ecology of Communal Resources*, ed. BJ McCay, JM Acheson, pp. 37-65. Tucson: University of Arizona Press

Acheson J, Brewer JF. 2003. Changes in the Territorial System of the Maine Lobster Industry. In *The Commons in the New Millennium: Challenges and Adaptation*, ed. N Dolsak, E Ostrom, pp. 37-59. Cambridge, MA: MIT Press

Adger WN. 2003. Social Capital, Collective Action and Adaptation to Climate Change. *Economic Geography* 79:387-404

Adger WN, Hughes TP, Folke C, Carpenter SR, Rockstrom J. 2005. Social-Ecological Resilience to Coastal Disasters. *Science* 309:1036-9

Agrawal A. 2001. Common Property Institutions and Sustainable Governance of Resources. *World Development* 29:1649-72

Alcorn J, Toledo V, M. 1998. Resilient Resource Management in Mexico's Forest Ecosystems: The Contribution of Property Rights. In *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*, ed. F Berkes, C Folke, J Colding, pp. 216-49. Cambridge ; New York: Cambridge University Press

Alongi DM. 2002. Present State and Future of the World's Mangrove Forests. *Environmental Conservation* 29:331-49

Aswani S. 2005. Customary Sea Tenure in Oceania as a Case of Rights-based Fishery Management: Does it Work? *Reviews in Fish Biology and Fisheries* 15:285-307

Barbier EB. 2003. Habitat-fishery linkages and mangrove loss in Thailand. *Contemporary Economic Policy* 21:59-77

Barbier EB, Strand I, Sathirathai S. 2002. Do open access conditions affect the valuation of an externality? Estimating the welfare effects of mangrove-fishery linkages in Thailand. *Environmental & Resource Economics* 21:343-67

Beard VA. 2007. Household Contributions to Community Development in Indonesia. *World Development* 35:607-25

Becker CD. 1999. Protecting the Garua Forest in Ecuador: The Role of Institutions and Ecosystem Valuation. *Ambio* 28:156-61

Becker CD. 2003. Grassroots to Grassroots: Why Forest Preservation was Rapid at Loma Alta, Ecuador. *World Development* 31:163-76

Becker CD, Agreda A, Astudillo E, Costantino M, Torres P. 2005. Community-Based Monitoring of Fog Capture and Biodiversity at Loma Alta, Ecuador Enhance Social Capital and Institutional Cooperation. *Biodiversity and Conservation* 14:2695-707

Begossi A. 1995. Fishing Spots and Sea Tenure: Incipient Forms of Local Management in Atlantic forest Coastal Communities *Human Ecology* 23:387-406

Begossi A. 2001. Mapping spots: Fishing Areas or Territories Among Islanders of the Atlantic Forest (Brazil) *Reg Environmental Change* 2:1-12

Begossi A. 2006. Temporal Stability in Fishing Spots: Conservation and Co-Management in Brazilian Artisanal Coastal Fisheries. *Ecology and Society* 11:25

Beitl CM. 2007. Shrimp Farming, Livelihoods, and Local Environmentalism in an Ecuadorian Coastal Community. In *XXVII International Congress of the Latin American Studies Association. After the Washington Consensus: Collaborative Scholarship for a New América*. Montréal, Canada

Berkes F. 1996. Social Systems, Ecological Systems, and Property Rights. In *Rights to Nature: Ecological, Economic, Cultural, and Political Principles of Institutions for the Environment*, ed. S Hanna, C Folke, K-G Mäler, pp. 87-107. Washington, D.C.: Island Press

Berkes F. 2005. Commons Theory for Marine Resource Management in a Complex World. *Senri Ethnological Studies* 67:13-31

Berkes F, Colding J, Folke C. 2003. *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge, U.K. ; New York: Cambridge University Press. xxi, 393 pp.

Berkes F, Folke C, Colding J. 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge ; New York: Cambridge University Press. 459 pp.

Brander LM, Florax R, Vermaat JE. 2006. The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature. *Environmental & Resource Economics* 33:223-50

Bravo M. 2006. Actualización del Plan de Manejo del Manglar Concesionado a la Asociación de Pescadores Artesanales, Mariscadores y Afines Costa Rica: Archipiélago de Jambelí, Guayaquil, Ecuador

Bravo M. 2007a. Analisis de la Base Legal Para el Otorgamiento de las Concesiones de Manglar, Responsabilidades Jurídicas Respecto a Talas en Zonas Concesionadadas, y Competencias para Expedir los Acuerdos de Uso Sustentable y Custodia del Manglar, Guayaquil, Ecuador

Bravo M. 2007b. Analisis de los *Acuerdos de Uso Sustentable* Ortogados a Usuarios Tradicionales para la Protección y Manejo del Ecosistema Manglar: Estudios de Caso de las Concheras 18 de Octubre (Provincia Esmeraldas); Cangrejeros Seis de Julio (Provincia Guayas) y Mariscadores Costa Rica (Provincia el Oro), Guayaquil, Ecuador

Bromley DW. 1992. *Making the Commons Work*. San Francisco: Institute for Contemporary Studies

C-CONDEM. 2007. Certificando la Destrucción: Análisis integral de la certificación orgánica a la acuacultura industrial de camarón en Ecuador, Corporación Coordinadora Nacional para la Defensa del Ecosistema Manglar, Quito, Ecuador

Cinner JE. 2005. Socioeconomic Factors Influencing Customary Marine Tenure in the Indo-Pacific. *Ecology and Society* 10:36

CLIRSEN-PMRC. 2007. Actualización del Estudio Multitemporal de Manglares, Camaroneras y Áreas Salinas en la Costa Continental Ecuatoriana al Año 2006, Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos & the Programa de Manejo de Recursos Costeros, Guayaquil, Ecuador

Cruz-Torres ML. 2000. "Pink Gold Rush:" Shrimp Aquaculture, Sustainable Development, and the Environment in Northwestern Mexico. *Journal of Political Ecology* 7:63-90
Cumming G, Barnes G, Perz S, Schmink M, Sieving K, et al. 2005. An Exploratory Framework for the Empirical Measurement of Resilience. *Ecosystems* 8:975-87
Curran SR, Kumar A, Lutz CG, Williams MJ. 2002. Interactions between Coastal and Marine Ecosystems and Human Population Systems: Perspectives on How Consumption Mediates this Interaction. *Ambio* 31:264-8
Dewalt BR, Vergne P, Hardin M. 1996. Shrimp Aquaculture Development and the Environment: People, Mangroves and Fisheries on the Gulf of Fonesca, Honduras. *World Development* 24:1193-208
Dolsak N, Ostrom E. 2003. The Challenges of the Commons. In *The Commons in the New Millennium: Challenges and Adaptation*, ed. N Dolsak, E Ostrom, pp. 3-34. Cambridge, MA: MIT Press
Elao R, Guevara G. 2006. Las Poblaciones de Moluscos en el Estuario del Cojimíes, Ecocostas. www.ecocostas.org. Accessed 7/22/07
Ellison AM, Farnsworth EJ. 1996. Anthropogenic Disturbance of Caribbean Mangrove Ecosystems: Past Impacts, Present Trends, and Future Predictions. *Biotropica* 28:549-65
FAO. 2005. Twenty percent of the world's mangroves lost over the last 25 years: Rate of deforestation slowing, but still a cause for alarm. *FAO News*:available online at: http://www.fao.org/forestry/newsroom/en/news/2005/highlight_108389en.html
Feeny D, Berkes F, McKay BJ, Acheson JM. 1990. Tragedy of the Commons: Twenty-two years later. *Human Ecology* 18:1-19
Feeny D, Hanna S, McEvoy AF. 1996. Questioning Assumptions of the `Tragedy of the Commons'. *Land Economics* 72:187
Glaser M. 2003. Interrelations between mangrove ecosystem, local economy, and social sustainability in the Caeté Estuary, North Brazil. *Wetlands Ecology and Management* 11:265-72
Gordon HS. 1954. The Economic Theory of a Common-Property Resource: The Fishery. *The Journal of Political Economy* 62:124-42
Guest GS. 1999. Global Vision and Local Lives: Policy, Participation, and Coastal Management in Ecuador. *Culture and Agriculture* 21:1-13
Hardin G. 1968. Tragedy of the Commons. *Science* 162:1243-8
Hardin R. 1982. *Collective Action*. Baltimore: Published for Resources for the Future by the Johns Hopkins University Press. xvi, 248 p. pp.
Jodha NS. 1998. Reviving the social system--ecosystem links in the Himalayas. In *Linking social and ecological systems: management practices and social mechanisms for building resilience*, ed. F Berkes, C Folke, J Colding, pp. 285-310. Cambridge ; New York: Cambridge University Press
Johannes RE. 1978. Traditional Marine Conservation Methods in Oceania and their Demise. *Annual Review of Ecology and Systematics* 9:349-64
Johannes RE. 2002. The Renaissance of Community-Based Marine Resource Management in Oceania. *Annual Review of Ecology and Systematics* 33:317-40

Kaplowitz MD. 2001. Assessing Mangrove Products and Services at the Local Level: The Use of Focus Groups and Individual Interviews. *Landscape and Urban Planning* 56:53-60
Kovacs JM. 1998. Assessing mangrove use at the local scale. *Landscape and urban planning* 43:201 (8 pages)
Kuhl L, Sheridan MJ. 2009. Stigmatized Property, Clams, and Community in Coastal Ecuador. *Ecological and Environmental Anthropology* 5
Kurien J. 1995. Collective Action for Common Property Resource Rejuvenation: The Case of People's Artificial Reefs in Kerala State, India *Human Organization* 54
Lu FE. 2001. The Common Property Pegime of the Huaorani Indians of Ecuador: Implications and Challenges to Conservation. *Human Ecology* 29:425(23)
MacKenzie C. 2001. The Fisheries for Mangrove Cockles, Anadara spp., from Mexico to Peru, With Descriptions of Their Habitats and Biology, the Fishermen's Lives, and the Effects of Shrimp Farming *Marine Fisheries Review* 63:1-39
Martinez-Alier J. 2001. Ecological Conflicts and Valuation: Mangroves versus Shrimps in the Late 1990s. *Environment and Planning C-Government and Policy* 19:713-28
McCay BJ, Acheson JM. 1987. *The Question of the Commons: The Culture and Ecology of Communal Resources*. Tucson: University of Arizona Press. xvi, 439 p. pp.
Mera Orcés V. 1999. *Género, Manglar, y Subsistencia*. Quito, Ecuador: Abya Yala. 171 pp.
Mora E, Moreno J. 2009. La Pesqueria Artesanal del Recurso Concha (Andara tuberculosa y A. similis) en la Costa Ecuatoriana durante el 2004. *Boletín Cientifico y Técnico* 20:1-16
Mora E, Moreno J, Jurado V. 2009. La Pesquería Artesanal del Recurso Concha en las Zonas de Esmeraldas y El Oro, Durante el 2008. *Boletín Cientifico y Técnico* 20:17-36
Ocampo-Thomason P. 2006. Mangroves, People and Cockles: Impacts of the Shrimp-Farming Industry on Mangrove Communities in Esmeraldas Province, Ecuador. In *Environment and Livelihoods in Tropical Coastal Zones: Managing Agriculture-Fishery-Aquaculture Conflicts*, ed. CT Hoanh, TP Tuong, JW Gowing, B Hardy, pp. 140-53. Oxon, UK: CAB International
Ostrom E. 1990. *Governing the Commons: Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press. 280 pp.
Ostrom E. 1998. A Behavioral Approach to the Rational Choice Theory of Collective Action: Presidential Address, American Political Science Association, 1997. *The American Political Science Review* 92:1-22
Ostrom E. 2000. Collective Action and the Evolution of Social Norms. *Journal of Economic Perspectives* 14:137-58
Ostrom E, Burger J, Field CB, Norgaard RB, Policansky D. 1999. Revisiting the Commons: Local Lessons, Global Challenges. *Science* 284:278-82
Ostrom E, Gardner R, Walker J. 1994. *Rules, games, and common-pool resources*. Ann Arbor: University of Michigan Press. xvi, 369 p. pp.
Pollnac R, Johnson J. 2005. Folk Management and Conservation of Marine Resources: Towards a Theoretical and Methodological Assessment. In *Indigenous Use and*

Management of Marine Resources, ed. N Kishigami, JM Savelle, KM Hakubutsukan., pp. 33-50. Suita, Osaka: National Museum of Ethnology
Primavera JH. 1997. Socio-Economic Impacts of Shrimp Culture. *Aquaculture Research* 28:815-27
Ronnback P. 1999. The ecological basis for economic value of seafood production supported by mangrove ecosystems. *Ecological Economics* 29:235-52
Ruttan L. 1998. Closing the Commons: Cooperation for Gain or Restraint? *Human Ecology* 26:43-66
Ruttan L, Borgerhoff Mulder M. 1999. Are East African pastoralists truly conservationists? *Current Anthropology* 40:621-52
Selvam V, Ravichandran KK, Gnanappazham L, Navamuniyammal M. 2003. Assessment of community-based restoration of Pichavaram mangrove wetland using remote sensing data. *Current Science* 85:794-8
Smith AH, Berkes F. 1991. Solutions to the "Tragedy of the Commons": Sea-urchin management in St Lucia, West Indies. . *Environmental Conservation* 18:131-6
Smith AH, Berkes F. 1993. Community-Based Use of Mangrove Resources in St. Lucia. *The International Journal of Environmental Studies* 43:123-32
Smith RL. 2004. *Coastal-Marine Conservation: Science and Policy*. Malden, MA: Blackwell Publishing. 327 pp.
Snedaker SC. 1986. Traditional uses of South American mangrove resources and the socio-economic effect of ecosystem changes. In *Man in the Mangroves*, ed. P Kunstadter, E Bird, S Sabhrasi, pp. 104-12. Tokyo: The United Nations University
Southgate DD, Whitaker MD. 1994. Shrimp Mariculture and Coastal Ecosystems. In *Economic progress and the environment: one developing country's policy crisis*, pp. 90-100. New York: Oxford University Press
Stonich S. 1995. The environmental quality and social justice implications of shrimp mariculture development in Honduras. *Human Ecology* 23:143-68
Stonich S, Vandergeest P. 2001. Violence, Environment, and Industrial Shrimp Farming. In *Violent environments*, ed. NL Peluso, M Watts, pp. 261-86. Ithaca: Cornell University Press
Stonich SC, Bailey C. 2000. Resisting the Blue Revolution: Contending Coalitions Surrounding Industrial Shrimp Farming. *Human Organization* 59:23-36
Stram DL, Kincaid CR, Campbell DE. 2005. Water Quality Modeling in the Rio Chone Estuary. *Journal of Coastal Research* 21:787-810
Thomas F, R. . 2001. Remodeling Marine Tenure on the Atolls: A Case Study from Western Kiribati, Micronesia. *Human Ecology* V29:399-423
Valiela I, Bowen J, York J. 2001. Mangrove Forests: One of the World's Threatened Major Tropical Environments. *BioScience* 51:807-15
Walters BB, Rönnbäck P, Kovacs JM, Crona B, Hussain SA, et al. 2008. Ethnobiology, Socio-economics and Management of Mangrove Forests: A Review. *Aquatic Botany* 89:220-36
Whitten NE. 1994. *Black Frontiersmen: Afro-Hispanic Culture of Ecuador and Colombia*. Prospect Heights, IL: Waveland Press, Inc. xvii, 221 p. pp.