W08-25 10/31/08

Beyond the Tragedy of the Commons

Xavier Basurto[1,2] and Elinor Ostrom[1]

[1]Workshop in Political Theory and Policy Analysis, Indiana University

[2]Duke Marine Lab, Nicholas School of the Environment, Duke University

Abstract

To move beyond Hardin's tragedy of the commons, it is fundamental to avoid falling into either of two analytical and policy traps: (1) deriving and recommending "panaceas" or (2) asserting "my case is unique." We can move beyond both traps by self-consciously building diagnostic theory to help unpack and understand the complex interrelationship between social and biophysical factors at different levels of analysis. We need to look for commonalities and differences across studies. This understanding will be augmented if the rich detail produced from case studies is used together with theory to find patterned structures among cases. In this paper, we briefly illustrate important steps of how we can go about diagnosing the emergence and sustainability of self-organization in the fishing context of the Gulf of California, Mexico. By doing so, we are able to move away from the universality proposed by Hardin and understand how two out of three fisheries were able to successfully self-organize, and why one of them continues to be robust over time.

Keywords: sustainable development; renewable resources fisheries; renewable resources commons

Acknowledgments: The authors wish to acknowledge essential financial support from the National Science Foundation (Grant no. BCS0601320) and from the Workshop in Political Theory and Policy Analysis at Indiana University, as well as the excellent editing of Patty Lezotte.

Introduction

In this paper, we intend to demonstrate the feasibility and challenge of moving beyond "The Tragedy of the Commons" that Garrett Hardin presented in 1968. Hardin portrayed a set of pastoralists—who are inexorably led to overuse their common pasture—as an allegory for what he thought was typical for common-pool resources (CPRs) not owned privately or by a government. CPRs are normally used by multiple individuals and generate finite quantities of resource units where one person's use subtracts from the quantity of resource units available to others (Ostrom and Ostrom 1977). Most CPRs are sufficiently large that multiple actors can simultaneously use the resource system. Efforts to exclude potential beneficiaries are costly. Examples of CPRs include both natural and human-made systems including: Hardin's grazing lands, groundwater basins, irrigation systems, forests, fisheries, mainframe computers, government and corporate treasuries, and the Internet. Examples of resource units derived from CPRs are fodder, water, timber, computer-processing units, information bits, and budget allocations (Blomquist and Ostrom 1985).

In an effort to move beyond Hardin's classic allegory, it is important that one does not dismiss Hardin's predictions for some CPRs. The major problem of his original analysis was that he presented "the tragedy" as a *universal* phenomenon. No set of users could overcome the tragedy. Thus, CPR users were trapped needing external interventions to extract them from gross overuse. Hardin's presumption of universality is what one needs to move beyond.

Having said this, many field settings exist where Hardin is correct. Overharvesting frequently occurs when resource users are totally anonymous, do not have a foundation of trust and reciprocity, cannot communicate, and have no established rules. Massive overfishing of ocean fisheries and deforestation in many countries illustrate the destruction of resources that occurs when appropriate institutions have not been designed and implemented (Ostrom 2008a). In an experimental lab, eight subjects presented with a common-pool resource problem overharvest when they do not know who is in their group, no feedback is provided on individual actions, and they cannot communicate. In fact, they overharvest more than predicted by the Nash equilibrium of the related formal game (Ostrom et al. 1994). They do worse than game theory predicts and fit the behavior predicted by Hardin.

If the experimental subjects are enabled to sit in a circle talking about the puzzle in a face-to-face group, they usually develop trust and reciprocity. Within a few rounds, they reduce overharvesting substantially and do very well (Ostrom et al. 1992). In traditional, noncooperative game theory, communication is not supposed to improve the outcomes obtained, but many groups solve the problem of overharvesting after engaging in face-to-face communication (Ostrom 2007a). Further, many smaller groups that use CPRs—inshore fisheries, forests, irrigation systems, and pastures—have developed a diversity of norms and rules that have enabled them to solve problems of overharvesting. A diversity of studies illustrate that it is not impossible to overcome the temptation to overharvest (NRC 1986, 2002; McCay and Acheson 1987; Berkes 1989; Dolšak and Ostrom 2003; Basurto 2005; Ostrom 2005; van Laerhoven and Ostrom 2007; Lansing 2008).

We need to build a theoretical foundation for explaining why some resource users are able to self-organize and govern the use of a resource over time in a sustainable manner and why others fail or never make the effort. To do this, we face core challenges to overcome two scholarly approaches adopted by many scholars that limit the development of a predictive theory that is useful in policy analysis. The first problem was stimulated by Hardin's analysis, and we call it the "panacea analytical trap." It treats all resources as having basic similarities. This trap has often led to a recommendation of a preferred institutional solution as a simplified blueprint. The second challenge is the "my-case-is-unique" analytical trap. This approach challenges the usefulness of building theoretical explanations about the fit between diverse types of institutions and local ecological and social settings. To build theory, it is necessary to move away from both extremes to develop an interdisciplinary diagnostic framework that helps to provide a foundation for further empirical research and learning (Bardhan and Ray 2008; Chopra 2008).

Avoiding the Panacea Analytical Trap

Historically, the cure-alls that have been recommended most frequently promote government ownership (Ophuls 1973; Feeny et al. 1996: 195) or privatization (Demsetz 1967; Posner 1977; Simmons et al. 1996). Panacea-type solutions can be a by-product of approaches that generate highly abstract models and use simple empirical studies to illustrate general patterns of social phenomena (Bouchaud 2008). For instance, since the important early studies of open-access fisheries by Gordon (1954) and Scott (1955), most theoretical studies by political economists have analyzed simple CPR systems using relatively similar assumptions (Feeny et al. 1996; Ruddle 2007; Ruddle and Hickey 2008). In such systems, it is assumed that the resource generates a highly predictable, finite supply of one type of resource unit (one species, for example) in each relevant time period. Resource users are assumed to be homogeneous in terms of their assets, skills, discount rates, and cultural views. Users are also assumed to be short-term, profit-maximizing actors who possess complete information. As a result, this theory universally assumes that anyone can enter the resource and harvest resource units. Users are viewed as able to gain property rights only to what they harvest, which they then sell in an open competitive market. Under this approach, the open-access condition is a given. The users make no effort to change it. Users act independently and do not communicate or coordinate their activities in any way. Textbooks in resource economics, and law and economics, present this conventional theory of a simple CPR as the only theory needed for understanding CPRs more generally (but, for a different approach, see Baland and Platteau 1996; Clark 2006).

This approach emphasizes collecting information on a large number of cases to be able to find the correlation of dependent and independent variables with a statistical degree of significance. This can come at the cost of being able to develop in-depth knowledge of each of the cases under study. Homogenization assumptions about the cases under consideration are often necessary to conduct quantitative analyses. In the process, the analyst risks losing track of the importance of context and history and faces challenges to be able to effectively convey the sense of complexity and diversity that exists in the empirical world. The basic theory discussed above was applied to all CPRs regardless of the capacity of resource users to communicate and coordinate their activities until the work of the National Academy of Sciences' Panel on Common Property (NRC 1986) strongly challenged this approach. The growing evidence from many qualitative studies of CPRs conducted in the field called for a serious rethinking of the theoretical foundations for the analysis of CPRs (Berkes 1986, 1989; Berkes et al. 1989; Bromley et al. 1992; McCay and Acheson 1987).

Avoiding the "My-Case-is-Unique"Analytical Trap

The rich case-study literature has played a prominent role in illustrating the wide diversity of settings in which appropriators dependent on CPRs have organized themselves to achieve much higher outcomes than is predicted by the conventional theory (Cordell 1989; Wade 1994; Ruddle and Johannes 1985; Sengupta 1991). In being able to tap into the rich case-study literature, however, we also need to move beyond the argument that each resource system, and the people that use it, is unique. At one level, that assertion is true. All humans are unique, and all human organizations are unique as well as the ecological systems to which they relate. The problem comes from assuming that there are no commonalities across cases that can be the foundation for theoretical analysis, explanations, and diagnosis. Ecologists have long dealt with complex systems that at one level are unique (e.g., individual species), but are also able to move outward to larger systems (e.g., populations or ecosystems) and find commonalities among many different species and their behaviors. Medical diagnosis of illness and potential remedies is feasible even though each individual is unique.

Often, the scholarly treatment of social phenomena as unique is the by-product of training scholars in a research strategy that focuses first on understanding the complexity of social phenomena. Qualitative-oriented scholars, such as ethnographers and historians, are usually associated with this approach. Students of this tradition are often interested in understanding how different elements fit together to constitute a case. They examine many parts and attempt to construct a representation from the interconnections among the aspects of each case. In order to be able to do so, it is necessary to acquire in-depth knowledge about the instances under study. Researchers have developed appropriate data-gathering methods and analytical tools to do so. As a result, these scholars are able to uncover complex relationships between causal conditions and outcomes, showing the role that history, context or conjunctural causation, can play in social phenomena. Often, the goal of this research approach is to describe how different aspects constitute the case as a whole, which may then be compared and contrasted with other cases. Given, however, the depth of data that scholars amass about each aspect of their case, qualitative scholars frequently work with one or a few cases at a time. Because of their familiarity with the complexity and in-depth understanding of the particularities of the instances that characterize certain phenomena, qualitative scholars tend to avoid making generalizations about their findings. In fact, generalizing statements about social phenomena is usually not the goal of qualitative research. Sometimes it is precisely the rarity of certain social phenomena, characterized by only one, two, or a handful of instances, that might attract a scholar's attention and curiosity to them in the first place (Ragin 2000, 2008).

The sole focus on such an intensive research tradition can also make it difficult to move beyond a conventional theory of CPRs and toward a more diagnostic approach to CPR management. A recent special issue of the respected *Journal of Human Organization* is a case in point. *Human Organization* devoted a full special issue to a critique of common-pool resources theory[1] for failing to capture the complexity and context under which customary property rights are present in Oceania. In the introductory article, Wagner and Talaki (2007) suggest[2] that a diagnostic theory should be able to capture all the "historic characteristics" and "contemporary patterns of innovations" in which common-pool resource users in Oceania are embedded.[3] A diagnostic theory—to be useful—needs to draw on both general theory related to causal processes and learning how to identify key variables present or absent in particular settings so as to understand successes and failures (see Bardhan and Ray [2008], who self-consciously engage the contribution of both general theory and in-depth case studies).

We agree that to build a diagnostic theory, it is important to better incorporate contextual factors into policy analyses. We also need to avoid falling into the presumption that all

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[1] Mistakenly called common-property theory in the *Human Organization* issue. See McCay (1996) and Dietz et al. (2003) for discussions on the differences between common-property regimes and common-pool resources.

[2] The co-editors state: "What the case studies in this volume make abundantly clear is that neither the historical characteristics of customary practices throughout the Pacific, nor contemporary patterns of innovation, are captured by the overly neat, essentialized categories of private, common, and public property. More specifically, they demonstrate that common property theory cannot provide applied social scientists, development planners, conservationists, or corporate executives with ready solutions to the challenges they face in customary settings" (Wagner and Talaki 2007: 5).

[3] Even more worrisome, Wagner and Talaki (2007) also advocate for CPR theory to be able to provide "ready solutions" to policy analysts, which is what we argue has often led scholars into the path of panacea-type policy making, such as those promoted by Hardin, and from which we urgently need to move away from.

individual settings are so different from one another that all we can do is describe the intricate detail of particular settings. Those of us who study institutions and human behavior, while trying to develop theoretical understanding, do realize that every case, as well as all human beings, is unique. On the other hand, while we have a unique combination of factors affecting our personalities, behavior, and actions, all humans share some attributes. It is always a challenge to determine what those attributes or variables are at any one time. This is what the medical profession has been struggling to do for many eras. The great contribution that medicine has developed is the slow development of a *diagnostic theory* that has enabled medicine to move beyond panaceas. That diagnostic theory enables medical practitioners to dig into the very large number of elements that characterize all humans to determine the specific combination of common elements that are causing a particular medical problem.

Toward a Diagnostic Theory of Common-Pool Resources

So, how can we start moving toward a diagnostic theory of common-pool resources? In the following sections, we provide an overview for how analysts can go about building a diagnostic theory to address two interrelated theoretical puzzles: (1) How do resource users self-organize or create the conditions for institutional change to overcome collective-action dilemmas? and (2) What are the conditions that enhance the sustainability of resources and the robustness of institutions over time?

A Multitier Diagnostic Framework

As a first point of departure, we draw on the multitier framework presented in a recent article in the *Proceedings of the National Academy of Sciences* on "A Diagnostic Approach for Going beyond Panaceas" (Ostrom 2007b). We will illustrate the framework and the two theoretical puzzles we identify above related to the challenge of overcoming collective-action problems to self-organize and the fragility or robustness of organization with three cases from the small-scale fisheries of the Gulf of California in Mexico (see Puerto Peñasco, Seri village of Punta Chueca, and Kino Bay in Figure 1). In building a diagnostic CPR theory, scholars need to be aware of the extremely large potential set of variables that might be relevant for their studies. A promising way is to build a conceptual, ontological framework that organizes the relationships among the many variables, posits how they are causally related across scales and among themselves, where these variables are embedded within a system, and how those systems are linked to even larger systems. An ontological system is able to address the infinite regress problem, where a linguistic construction such as a concept is composed of sub-concepts, which are in turn composed of sub-concepts, and further sub-concepts.

[Figure 1 about here]

The framework starts with a first tier of variables that scholars studying CPRs can use in studying any particular focal system, ranging in scale from a small inshore fishery to the global commons (Figure 2). A scholar would first identify which Resource System (RS) and its Resource Units (RU) are relevant for answering a particular question. These then become the focal system for analysis. In the three cases of the small-scale fisheries discussed below, the Resource System is the inshore-fishery sector and the Resource Units are the benthic sessile and semi-sessile mollusks harvested by fishers. The Social, Economic, and Political Setting (S) is the Gulf of California in northwest Mexico near to the boundary with the United States. As we will describe, all three cases involve diverse patterns of interaction among the four highest-level variables and generate diverse outcomes including both temporary and long-term reduction of harvesting efforts as well as continued overharvesting by fishers. All of them also involve patterns of interaction among Users (U) and Governance Systems (GS) (including the federal and local governments), researchers, nongovernmental organizations, and local and nonlocal fishers interested in gaining access to more profitable fishing areas.

[Figure 2 about here]

To diagnose the causal patterns that affect outcomes such as successful formation of self-organization or its sustainability, one needs to incorporate a set of "second-tier" variables that are contained within the broadest tiers identified in Figure 2. The list of second-tier variables in Table 1 constitutes an initial effort to help group and classify important variables in a tiered ontology specific to the theoretical puzzles related to CPR problems posited above. It is obviously not "final," even though many scholars across disciplines have contributed to the design of the framework over the years. As we make progress in the development of a tiered ontology, and we gain a better understanding of how concepts are embedded and related with each other, the third, fourth, and fifth tiers of the framework will be further elucidated.

[Table 1 about here]

Building ontologies to diagnose policy problems and to design empirical research is a necessary step toward developing better conceptual language and theories. It is important to understand, however, that an analyst does *not* need to include fifty or more variables when studying CPRs. No one can develop a theory or do empirical research simultaneously that includes all of the second-tier variables (or the many lower-tier variables) that may be important factors affecting particular interactions and outcomes. This is definitely not the intention of this framework. The intention is to enable scholars, officials, and citizens to understand the *potential* set of variables and their sub-variables that could be causing a problem or creating a benefit. When we have a medical problem, a doctor will ask us a number of initial questions and do some regular measurements. In light of that information, the doctor proceeds down a medical ontology to ask further and more specific questions (or prescribes tests) until a reasonable hypothesis regarding the source of the problem can be found and supported. When we begin to think about a particular problem, we need to begin to think about which of the attributes of a particular system are likely to have a major impact on particular patterns of interactions and outcomes. So let us now focus on using an evolving diagnostic theory to address theoretical puzzles related to the self-organization and robustness that concern the three small-scale benthic fisheries in the Gulf of California, Mexico.

Diagnostics for the Analysis of Self-Organization

As an illustration of the development of diagnostic theory, we will utilize a subset of variables from Table 1 (and some third-tier variables) to analyze three inshore fishery cases—two of which were able to self-organize to overcome the costs of collective action involved in developing their own rules and one was not. Given the extensive work of CPR scholars focused on explaining collective-action outcomes (McKean 2000; Acheson 2003; Wade 1994; Schlager 1990; Tang 1992; Ostrom 1990, 1992; Baland and Platteau 1996; Ostrom et al. 1994), considerable consensus now exists about a number of characteristics of a resource system and of users that can increase the likelihood that a self-governing association will be constituted, or at least, that users will develop rules and norms to limit their harvesting or protect their resource in some manner. Drawing on an earlier theoretical synthesis (Ostrom 2001), the variables that we will use in our analysis are starred in Table 1.

Toward a Theoretical Integration

The key to further theoretical integration is to understand how a subset of the second-tier variables—and some third-tier variables—listed below and starred in Table 1 interact in complex ways in specific settings to affect the basic benefit-cost calculations of a set of users (U) using a resource system (RS). We do not posit that any particular number of second- and third-tier variables discussed here always leads to success or failure in avoiding the tragedy of the commons. Rather, it is the overall combination of these factors that affects how participants judge the benefits and costs of new operational rules.[4] The attributes of resource systems that are potentially relevant include:

> Size of resource system (RS3): The CPR is sufficiently small, given communication and transportation technologies in use, that the users can acquire accurate knowledge about the boundaries and dynamics of the system.
>
> Productivity of system (RS5): The productivity of the CPR has not been exhausted nor is it so abundant that there is no need to organize.
>
> Predictability of system dynamics (RS7): The system dynamics are sufficiently predictable that users can estimate what would happen if they continued old rules or changed the rules and strategies in use.
>
> Indicators of the productivity of the system (RS5a): Reliable and valid indicators of CPR conditions are available at a low cost.

The attributes of users that are potentially important include:

> Leadership (U5): Some users of a resource have skills of organizing and local leadership as a result of prior organization for other purposes or learning from neighboring groups.
>
> Norms/social capital (U6): Users have generally developed trust in one another so as to keep promises and return reciprocity with reciprocity.
>
> Knowledge of the social-ecological system (U7): Users share knowledge of relevant CPR attributes and how their own actions affect each other.
>
> Dependence on resource (U8): Users are dependent on the CPR for a major portion of their livelihood.

In analyzing a particular case, a core question is how the above factors affect the potential benefits and costs that users face in continuing present rules and strategies or changing them.

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[4] Researchers who are interested in understanding collective action to overcome CPR dilemmas in the field should try to obtain empirical measures for this set of variables in their efforts to understand why some groups organize and others do not. In some settings, other variables will also be important and some of these will play no role, but given the role of this set of variables in affecting the benefits and costs of collective action, they constitute an important set of variables potentially able to explain collective action successes and failures.

One would posit that each user (i C U) compares the expected net benefits of harvesting, using the old operational rules (GS5O), with the benefits they expect to achieve using a new set of operational rules (GS5N). Each user i must ask whether their incentive to change (D_i) is positive or negative.

$$D_i = B_i\,(GS5N - GS5O) \qquad [1]$$

If D_i is negative for all users, no one has an incentive to change and no new rules will be established. If D_i is positive for some users, they then need to estimate three types of costs:

C1: Up-front costs of time and effort spent devising and agreeing upon new rules;

C2: The short-term costs of implementing new rules; and

C3: The long-term costs of monitoring and maintaining a self-governed system over time.

If the sum of these expected costs for each user exceeds the incentive to change, no user will invest the time and resources needed to create new institutions. Thus, if

$$D_i < (C1_i + C2_i + C3_i) \qquad [2]$$

for all (i C U), no change occurs.

Obviously, if one could obtain reliable and valid measures of the perceived benefits and costs of collective action, one would not need to examine how diverse resource systems and user characteristics affect likely organization. Gaining information about specific benefits and costs perceived by users at the time of collective-action decisions is, however, next to impossible. Thus, gaining information about the attributes of the resource system and the users, listed above, is an essential step in increasing our theoretical understanding of why some groups do overcome the challenge of collective action and others do not.

In field settings, everyone is not likely to expect the same costs and benefits from a proposed change. Some may perceive positive benefits after all costs have been taken into account, while others perceive net losses. Consequently, the collective-choice rules (GS6) used to change the day-to-day operational rules related to the resource affect whether an institutional change favored by some and opposed by others will occur. If for the collective-choice rule in use, such as unanimity, majority, ruling elite, or one-person rule, there is a minimum coalition of users, K C U, such that:

$$D_k \leq (C1_k + C2_k + C3_k) \qquad [3]$$

no new rules will be adopted.

And, if for at least one coalition K C U, there is a "winning coalition" such that:

$$D_k > (C1_k + C2_k + C3_k) \qquad [4]$$

it is likely that new rules will be chosen.

The collective-choice rule used to change operational rules in field settings varies from reliance on the decisions made by one or a few leaders, to a formal reliance on majority or super-majority vote, to reliance on consensus or near unanimity. If there are substantial differences in the perceived benefits and costs of users, it is possible that K users will impose a new set of rules that strongly favors those in the winning coalition and imposes losses or lower benefits on those in the losing coalition (Thompson et al. 1988). If expected benefits from a change in institutional arrangements are not greater than expected costs for many of the relevant participants, however, the costs of enforcing a change in institutions will be much higher than when most participants expect to benefit from a change in rules over time.

If there are several potential winning coalitions, the question of which coalition will form, and thus which rules will result, is a theoretical issue beyond the scope of this article (see Bianco et al. 2006). This analysis is applicable to a situation where a group starts with an open-access situation and contemplates adopting its first set of rules limiting access. It is also relevant to the continuing consideration of changing operational rules over time.

Three Small-Scale Fisheries in the Gulf of California, Mexico: Why Did Only Two Self-Organize?

The Seri, Kino, and Peñasco fisheries and the species that they target are not actively regulated by the Mexican government. From an administrative point of view, these fisheries are too small and far away physically and psychologically to warrant the attention of fisheries government officials, already understaffed and underbudgeted. As a result, these fisheries enjoy significant levels of autonomy to determine their own operational access and harvesting rules and norms (GS5) unless challenged. These fishers harvest sessile and semi-sessile species of mollusks (mainly sea pen shells—*Atrina* spp, *Pinna rugosa*, but also rock scallops—*Spondylus calcifer*, and murex snails—*Hexaples nigritus*). All of these species—except the murex snails, which are semi-sessile—remain fixed in the same spatial location for life. In all cases, fishers use the same technology of exploitation common among small-scale divers in the region (U9): a rudimentary underwater breathing apparatus called *hookah* adapted to a small (~8 m) fiberglass outboard motor boat. Given that many of these mollusks live on sandy bottoms, often buried, divers need to learn how to spot them and use a hook to detach them from the bottom (Basurto 2006).

The towns of Puerto Peñasco and Kino Bay were first established as totoaba (*Totoaba macdonaldi*)[5] fishing camps around the 1930s (Bahre et al. 2000). The Seri—a nomadic group at the time—had an active participation in the highly profitable Totoaba fishery in Kino, which in 1940 would eventually prompt the Seri to establish their own fishing camp and become a

[5] The totoaba is endemic to the upper Gulf of California and is the largest member of the sciaenid family (sea bass), measuring over 2 m long and weighing over 100 kg (Cisneros-Mata et al. 1995).

sedentary group (Smith 1954). Since their establishment, Puerto Peñasco and Kino attracted fishers from all over Mexico, lured to settle by the promise of local booming fisheries and coastal development-related economic activities. Between 1945 and 1950, the population of Puerto Peñasco, Kino, and the Seri was around 2,500 (Ives 1989), 500 (Moreno et al. 2005a), and 300 (Felger and Moser 1985), respectively. In the early 1970s, fishing of benthic resources with hookah diving equipment began in these villages and all accounts indicate that before the 1980s, no rules were in use to manage these resource systems (Basurto 2006; Cudney and Basurto 2008). In other words, they were "open-access" regimes. It is likely that the abundance of resources and relatively low human population pressure did not create any obvious incentives to self-organize.

As population increased, however, so did the number of fishers (U1), creating the need to self-organize to be able to control access and use to their benthic resources. According to Mexico's National Institute of Statistics and Geography, INEGI for its acronym in Spanish (INEGI 2005), in 2005 the population of Puerto Peñasco, Kino, and Seri stood at about 40,000, 5,000, and 600 inhabitants, respectively. To self-organize, for instance, Kino Bay made frequent efforts to establish local vigilance and enforcement committees to control access to outsiders. However, some local fishers often found it in their own self-interest to invite outsiders to participate in their fisheries, given that outside fishers would often bring better fishing gear and boats or access to better market prices, undermining the committee's ability to rally all local fishers to monitor and enforce access to their fishing grounds (Ana Cinti personal communication).

Unfortunately, Kino Bay fishers failed time after time in their attempts to self-organize and have eventually overexploited the resource (Moreno et al. 2005a). Statistical data of the

Fisheries Office of *Bahía de Kino,* reported by Moreno and collaborators (2005b), indicates that in 1992 the production in Kino Bay was almost 170 tones of sea pen shells (*Atrina* spp and *Pinna rugosa*). Production has steadily dropped since 1992. Production averaged only 20 tons per year from 1997 to 2003. Local overexploitation of benthic resources has resulted, in turn, in an increased pressure by Kino fishers to attempt to gain access to still other abundant fishing grounds, like those used by Peñasco or the Seri, their neighbors to the north.

Since the early 1980s, recognizing the threat of external fishers capturing "their" benthic resources, the Seri were able to gain sufficient incentives to face the costs of organizing to protect their resources from intruders from Kino Bay and continue enjoying the benefits they produced. The Seri have developed significant knowledge (U7) about their resource system, including a careful "mental map" of the spatial extent of their fishing areas (RS3) (Basurto 2008). This knowledge also enables Seri fishers to make rough predictions (RS7) about the future productivity of their fishing system (RS5) (Basurto 2005). It is likely that developing a holistic knowledge of the system (U7) was facilitated by the Seri inhabitance of the same area and interaction with the same marine species for thousands of years (Felger and Moser 1985). Seri use of mollusks was first for subsistence purposes. In the last three decades, the Seri also engaged in commercial exploitation using diving technology for harvesting (U9) (Basurto 2006). This technology allows fishers to observe and learn significant information about target species and their habitat.

In contrast, Kino Bay and Puerto Peñasco fishers have only been present in the area for about eight decades. Peñasco fishers have specialized in the harvesting of benthic resources. Many Kino Bay divers, however, also harvest other nonbenthic marine resources during the year, requiring the use and knowledge of a wide set of harvesting technologies. This diversity of harvesting practices could be limiting the ability of Kino Bay fishers to observe and develop the same in-depth knowledge and sense of place that is generated by the interaction with one resource system and its units in the same place over time.

Of all three fishing communities, only the Seri have formal property rights (GS4) to their mollusk fishing areas. In 1975, the Mexican federal government granted the Seri with a fishing concession. Only those areas where the Seri most frequently fished, and therefore, developed access controls, became exclusive fishing zones for the Seri community. Over time, these zones were widely recognized by other fishing communities—like Kino Bay or Puerto Peñasco—as of undisputed Seri ownership. All other coastal areas formally granted to the Seri, but not as frequently visited and used or where they could not find cost-effective ways to control access controls, have been claimed by other communities and are a constant source of contestation and conflict. As a result, the Seri are fully aware that if they overexploit their exclusive fishing areas they will not easily find other uncontested areas in which to fish.

Consequently, the Seri are now locked into fishing areas that they cannot abandon and that are also valuable as part of their historic heritage and an integral part of their identity as a distinct ethnic group. All together, their dependence on the resource (U8) for economic and cultural reasons has generated incentives for the Seri to consider future benefits in the design of communally accepted operational rules and norms of access and use (GS5) to govern their exclusive fishing zone. Further, they have been able to find ways to monitor and enforce (GS8) these rules in a cost-effective manner (Basurto 2005). In contrast, there is some evidence that Kino fishers are not as highly dependent on maintaining the productivity of their fishing grounds for their survival. Many Kino fishers are recent immigrants from elsewhere in Mexico, and informal interviews indicate that some still feel that if fishing becomes scarce in this region they will pack up what they own and move elsewhere to harvest (Basurto unpublished data).

It is also important to note that for hundreds of years, the Seri were subject to invasions by other dominant ethnic groups (i.e., Spaniards and later Mexican *mestizos*) in attempts to achieve religious and territorial conquest (Sheridan 1999). The Seri were able to defend themselves and the resources on which they depended for their survival by developing strong relationships based on trust and reciprocity (U6). Over time, the Seri people have built significant experience in organizing collective action and face a wide variety of external threats successfully (U5) (Wilder 2000). The close-knit sense that exists within the Seri community is now most easily observed when it is expressed on the fishing arena. In a way, competition for fishing areas with neighboring communities is just another form in which the Seri perceive outsiders attempting to dominate them, effectively bringing them together for successful collective action.

In contrast, Kino fishers have had a harder time building strong trust and reciprocity relationships with their own community members. Kino Bay is a socially heterogeneous place that experiences the constant arrival and departure of fishers from different parts of the country, with diverse ethnic, social, and cultural backgrounds, needs, and incentives for collective action. This increases the uncertainty of repetitive interactions with the same individuals in the future.

Similar to Kino, Puerto Peñasco is a very dynamic and socially heterogeneous place since it was home to one of the largest shrimp trawler fleets in the Gulf of California. This was the main thrust of local and regional development starting in the 1950s and topping off in the 1990s. More recently, Peñasco has become a booming real-estate and tourism hub in the Upper Gulf of California given its proximity to the U.S. border and the increasing seasonal influx of retirees from Arizona and other ocean-loving southwesterners. Within this dynamism, a group of family-related fishers formed a fishing cooperative in the 1970s, *Sociedad Cooperativa Buzos de Puerto Punta Peñasco,* and in effect transferred many of their previously built trust and reciprocity into the fishing arena. The fishing co-op specializes in harvesting benthic mollusks and is locally recognized as the established harvesters of benthic resources. For the last thirty years, the co-op has been harvesting benthic mollusks from rocky reefs and adjacent coastal sandy areas. This is about the same time that Kino and Seri fishers were also developing their commercial fishing activities.

Peñasco divers' specialization on benthic resources makes them very aware of the fact that they would be the first to suffer the consequences of overexploiting them. Starting in 2000, they began to experiment with the rotation of mollusk beds, in the hopes that this would enable them to avoid overexploitation scenarios. That same year, facing the increased competition with fishers and other stakeholders using the same coastal resources, divers approached researchers and a non-governmental organization (NGO) for support to quantify changes in one of their most important fishing areas. The diving co-op received significant support and leadership from university researchers and funding organizations that enabled it to afford the costs of self-organizing into a common-property regime. They implemented a local network of marine reserves, designed to protect and enhance stocks of the benthic resources on which the co-op depended to maintain their livelihood.

Researchers and the NGOs trained divers on safe diving procedures, provided arenas for the discussion and exchange of ideas, and took on some of the financial, logistic, scientific, and implementation burdens related to the establishment of the network of marine reserves. This helped to build important linkages with environmental and local government fisheries management agencies and led to the informal recognition among local stakeholders that the fishing co-op had de facto property rights over the benthic resources being protected at the reserves. In addition, local divers were fully engaged in biological monitoring and scientific knowledge development. Within the above setting, co-op divers were able to design and successfully establish monitoring and enforcement rules-in-use for the benthic resources held within the reserves and after two years of limiting fishing in these areas, biological monitoring confirmed minimal harvesting activity (Cudney and Basurto 2008). Further, the biological monitoring generated strong evidence for a sharp increase in the density of benthic resources inside the marine reserves, as compared to before their establishment. Early positive results allowed divers to link their monitoring and enforcement efforts with an increase in the stock of their benthic resource units (Cudney and Basurto 2008).

In sum, consistent with our theoretical model, the Seri and Peñasco fishers developed positive incentives to change (D_i) from an open access to a common property-rights regime. These two groups of fishers found that developing a new set of operational rules (GS5N) to control access and use to their fishing grounds would bring them more benefits than the *status quo* of open access (GS5O). Furthermore, in their ability to implement institutional change successfully, they also needed to be able to surpass the perceived costs of changing their rules ($C1_k + C2_k + C3_k$). As we described above, their ability to do so was likely a function of the *combination* of specific second and third tier of variables starred in Table 1. Peñasco and Seri fisheries showed the presence of key variables related to their users (U), their governance system (G) and resource system (R), while these same variables were mostly absent in the Kino Bay case. More specifically, Table 2 shows that while the Peñasco and Seri fisheries had the presence of local leadership (U5), high levels of trust and reciprocity (U6), high levels of collective local knowledge about the resource (U7), and were highly dependent on their benthic fisheries (U8), all these elements were absent or lacking in the Kino Bay case. Regarding their governance system (G), Seri and Peñasco fishers had mostly in place a monitoring and sanctioning system (GS8) to maintain their operational rules, while in the Kino case such system was mostly absent. In relation to the resource system, Peñasco and Seri fisheries had similar resource sizes (RS3), availability of indicators (RS5a), and had developed similar levels of predictability (RS7). In contrast, the size of Kino Bay fishing areas were large, in relation to the communication and transportation technology available to them, and they had been the least able to develop indicators and predictability of their system dynamics. In sum, the absence of all these factors at Kino Bay likely elevated the costs of organizing to the extent that surpassed the likely expected benefits of organizing into a common-property regime. Thus, Kino fishers were not able to find enough incentives to move away the open access *status quo*. As a consequence—just as Hardin had predicted—their benthic resources were eventually overharvested.

[Table 2 about here]

Diagnostics for the Sustainability of Self-Organization

Now that we have diagnosed why two local fisheries were able to overcome collective-action problems and establish effective new rules while the third was not, let us address the question of the sustainability of such self-organized systems. While some self-governed CPR systems are capable of surviving long periods of time, others falter and fail. The particular set of rules used by long-surviving, self-governing systems varies substantially from one another (Schlager 1994; Tang 1994; Ostrom 2005). After working with Schlager and Tang on the development of the CPR database, coding an extensive set of case studies of fishery and irrigation systems around the world (described in Ostrom et al. 1994), Ostrom tried to identify specific rules associated with robust systems. She searched a large number of cases to find specific institutions, such as government, private, or communal ownership, that were close to universally successful. After an extensive search and study, no specific set of rules was found to be associated with long-surviving CPR institutions. Instead, she proposed a set of eight design principles (listed in Table 3). Most of these principles are present in well-documented, long-lasting systems and are missing in failed systems.[6] Long-term sustainable self-organizations tend to be characterized by the presence of most of these design principles, while fragile institutions tend to be characterized by only some of them, and failed institutions by few (Ostrom 2008b). For other studies of long-term sustainable self-organization, see Lam (1998), Weinstein (2000), Acheson (2003), Hilborn (2006), Frangoudes et al. (2008), Lam and Ostrom (2008), Lansing (2008), and as well as fragile and failed institutions (Schweik et al. 1997; Morrow and Hull 1996; Hilborn et al. 2005; Medina et al. 2007).

Let us be clear, a design principle is not a synonym for a "blueprint." We borrow the use of the term from architecture. When applied to institutional arrangements by design principle, we mean an "element or condition that helps to account for the success of these institutions in sustaining the [common-pool resources] and gaining the compliance of generation after generation of appropriators to the rules in use" (Ostrom 1990: 90). The design principles work to enhance participants' shared understanding of the structure of the resource and its users and of the benefits and costs involved in following a set of agreed-upon rules.

[6] Costello et al. (2008) have a new analysis of fisheries that does provide strong support for a variety of Individual Transferable Quota (ITQ) systems to be associated with reduced likelihood of the collapse of valuable commercial fisheries, but the specific ways that successful ITQ systems have been designed and implemented vary substantially from each other.

The Robustness of the Seri and Peñasco Fisheries in the Gulf of California, Mexico

We now take a look at the robustness of the self-organized systems of the Seri and Peñasco fisheries. Examining these cases is useful because the Seri benthic fishery continues to be able to self-organize to control access and use to their fishing grounds to current times, while Peñasco fishers were not able to successfully withstand the external shock of an increased pressure for access to their benthic marine reserves. Their self-organized system collapsed in 2004 (Cudney and Basurto 2008).

In 2002, two years after Peñasco fishers stopped harvesting in their marine reserves, the local co-op fishers started to note the increased abundance of benthic resources in them. There was also little evidence of poaching by outside or co-op fishers. Eventually, however, news about the increased abundance started to spill out to other fishers in the region (Cudney and Basurto 2008). For many fishers facing scarcity in their own fishing grounds, like those of Kino Bay and other fishing communities shown in Figure 1, it became worthwhile to travel far and away to seek access and harvest at the co-op's reserves. Also, in 2002, abrupt changes in local government leadership took place. The informal support provided by local authorities to the co-op's efforts to monitor and control access to the reserves ceased. Given that the divers' efforts to self-organize were not recognized at the regional and federal levels of the Mexican government, co-op divers found themselves unable to withstand the increased fishing pressure. Their local monitoring and enforcement mechanisms became increasingly inadequate. As soon as poaching from outsiders became apparent, it was no longer worthwhile for the Peñasco Cooperative to abstain from harvesting the product of their own hard-built investment. After all, those were "their resources." So, they proceeded to engage in a "free-for-all" race and harvest as many benthic mollusks as they could before other outsiders would do the same. After a month of intense harvesting, the measured abundance of the two main species of benthic mollusks monitored in the reserves was reduced to half (Cudney and Basurto 2008).

In sum, Peñasco fishers were also unable to nest their fishing system in multiple layers of governance. Sadly, they were not able to find the support of the highest levels of governance to formalize their successful self-organization efforts at the local level. Without the formal recognition of the federal government, the Peñasco divers' governance system was not robust over the longer term to the external shocks of poaching from regional roving bandits.

The Seri and Peñasco fisheries both had the presence of six of the eight design principles listed in Table 3. In both cases, the fishers had been able to develop clearly defined boundaries, congruence, collective-choice arrangements, monitoring, graduated sanctions, and conflict-resolution mechanisms. The Peñasco self-organized system lacked formal recognition from higher levels of governance and the integration of their self-governance local regime with multiple layers of nested enterprises. The Seri system was characterized by both of these design principles.

Nested enterprises are particularly important for those CPRs that are part of larger systems, like coastal fisheries, where appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple institutional layers (Young 2002). The Seri and Peñasco cases enjoyed a minimal recognition of rights to organize—at least informally—by the local government. Unfortunately, the efforts of the Peñasco divers were never formally recognized at the federal level when the impacts of their activities scaled up. Local fishers did recognize that Peñasco fishers were the owners of the local marine reserves. When it became economically feasible for roving bandits from far-away communities (Berkes et al. 2006) to travel and poach at the local reserves, however, Peñasco fishers could not do much to protect the boundaries of their reserves. Under federal law, ocean resources belong to *all* Mexicans. Thus, roving bandits from other Mexican fisheries were not formally breaking the law (Cudney and Basurto 2008).

The importance of building appropriate nested enterprises for the sustainability of self-organization cannot be understated. In larger resources with many participants, nested enterprises that range in size from small to large enable participants to solve diverse problems involving different scale economies. In base institutions that are quite small, face-to-face communication can be utilized for solving many of the day-to-day problems in smaller groups. By nesting each level of organization in a larger level, externalities from one group to another can be addressed in larger organizational settings that have a legitimate role to play in relationship to the smaller entities.

Many variables in Table 1 that affect perceived costs and benefits of self-organization are strongly affected by the type of larger setting in which a resource and its users are embedded—particularly the type of resource policies adopted by the larger political regimes (S4). Larger regimes may facilitate local self-organization by providing accurate information about natural resource systems, arenas in which participants can engage in discovery and conflict-resolution processes, and mechanisms to back up local monitoring and sanctioning efforts. Perceived benefits of organizing are greater when users have accurate information about the threats facing a resource.

When the authority to make and enforce their own rules is not recognized, the costs of monitoring and sanctioning those who do not conform to these rules can be very high. The probability of participants adapting more effective rules in macro regimes that facilitate their efforts over time is higher than in regimes that ignore resource problems entirely or, at the other extreme, presume that all decisions about governance and management need to be made by central authorities. If local authorities are not formally recognized by larger regimes, it is very costly—if not impossible—for users to establish an enforceable set of rules. On the other hand, if external authorities impose rules without consulting local participants in their design, local users may engage in a game of "cops and robbers" with outside authorities.

Conclusion

In this paper, we have argued that one way in which we can go beyond Hardin's tragedy of the commons is by building a diagnostic theory of CPR management. We believe that it is fundamental to avoid falling into "panacea" or "my-case-is-unique" analytical traps. A diagnostic theory needs to be able to help us understand the complex interrelationship between social and biophysical factors at different levels of analysis. This understanding will be augmented if the rich detail produced from case studies is used together with theory to find patterned structures among cases.

When rich detail is to argue that theoretical analysis focusing on more general variables is not useful, we will continue to fall into "my-case-is-unique" analytical traps. This does not enable scholars to move away from merely describing a particular case or region. Even worse, without a tested diagnostic theory, policy analysts cannot produce theoretically informed public policy that can form the basis of adaptive governance. We cannot forget, however, that uncovering patterns of commonalities and differences among cases without considering the role of context and history can lead to "panacea" analytical traps, such as those that have prevailed throughout the history of fisheries.

A quick view to such history shows that it is rich with examples of technical fixes like individual transferable quotas (ITQs), marine protected areas (MPAs), and community-based management (CBM). As Degnbol and colleagues (2006: 537) argue:

> each of the fixes may alone, or in combination with other management tools, be perfectly adequate and justified in specific situations where the context and management concerns match the assumptions and properties of these tools. But when they are promoted as universal remedies, they cease to be useful tools and enter the category of technical fixes, diverting attention away from the full range of potential solutions to a particular management problem. Fixes are not likely to adequately represent the complexity of a problem nor are they likely to solve a range of problems simultaneously.

Indeed, further development and testing of a diagnostic theory will not be an easy task. In this paper, we have briefly illustrated important steps for how we can go about diagnosing the emergence and sustainability of self-organization in the fishing context of the Gulf of California, Mexico. By doing so, we were able to move away from the universality proposed by Hardin and understand how two out of three fisheries were able to successfully self-organize, and why one of them continues to be robust over time. Using the same diagnostic approach, we also learned that CBM is not a panacea for sustaining self-governance arrangements over the long term. Without the presence of cross-scale linkages with higher levels of governance, the self-organized CBM effort could not resist exogenous shocks and eventually collapsed (Cudney and Basurto 2008). This was a detriment to the fishers as well as to the biodiversity associated with their fishing activities, which also depends on sustainable human organization to survive.

References

Acheson, J.M., 2003, *Capturing the Commons: Devising Institutions to Manage the Maine Lobster Industry*, University Press of New England, New Haven, CT.

Bahre, C.J., Bourillon, L., Torre, J., 2000, "The Seri and commercial Totoaba fishing (1930–1965)", *Journal of the Southwest* 42, no. 3: 559–575.

Baland, J.-M., Platteau, J.-P., 1996, *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?*, Clarendon Press, Oxford.

Bardhan, P., Ray, I., 2008, *The Contested Commons: Conversations between Economists and Anthropologists*, Blackwell Publishing, Oxford.

Bardhan, P., Ray, I., 2008, "Economists, anthropologists, and the contested commons", in: P. Bardhan, I. Ray (eds), *The Contested Commons: Conversations between Economists and Anthropologists*, Blackwell Publishing, Oxford.

Basurto, X., 2005, "How locally designed access and use controls can prevent the tragedy of the commons in a Mexican small-scale fishing community", *Journal of Society and Natural Resources* 18: 643–659.

Basurto, X., 2006, "Commercial diving and the Callo de Hacha fishery in Seri territory", *Journal of the Southwest* 48, no. 2: 189–209.

Basurto, X., 2008, "Biological and ecological mechanisms supporting marine self-governance: The Seri Callo de Hacha fishery", *Ecology and Society* 13, no. 2: 20. [online] http://www.ecologyandsociety.org/vol13/iss2/art20/

Berkes, F., 1986, "Local-level management and the commons problem: a comparative study of Turkish coastal fisheries", *Marine Policy* 10: 215–229.

Berkes, F. (ed), 1989, *Common Property Resources: Ecology and Community-Based Sustainable Development*, Belhaven Press, London.

Berkes, F., Feeny, D., McCay, B.J., Acheson, J.M., 1989, "The benefits of the commons", *Nature* 340, no. 6229: 91–93.

Berkes, F., Hughes, T. P., Steneck, R.S., Wilson, J.A., Bellwood, D.R., Crona, B., Folke, C., Gunderson, L.H., Leslie, H.M., Norberg, J., Nyström, M., Olsson, P., Österblom, H., Scheffer, M., Worm, B., 2006, "Globalization, roving bandits, and marine resources", *Science* 311, no. 17: 1557–1558.

Bianco, W., Lynch, M., Miller, G., Sened, I., 2006, "A theory waiting to be discovered and used: a reanalysis of canonical experiments on majority-rule decision making", *Journal of Politics* 68, no. 4: 838–851.

Blomquist, W., Ostrom, E., 1985, “Institutional capacity and the resolution of a commons dilemma”, *Policy Studies Review* 5, no. 2: 383–393.

Bouchaud, J.P., 2008, “Economics needs a scientific revolution”, *Nature* 455, no. 30: 1181.

Bromley, D.W., Feeny, D., McKean, M., Peters, P., Gilles, J., Oakerson, R., Runge, C.F., Thomson, J. (eds), 1992, *Making the Commons Work: Theory, Practice, and Policy*, ICS Press, San Francisco, CA.

Chopra, K., 2008, “Commentary 4: disciplinary perspectives and policy design for common-pool resources”, in: P. Bardhan, I. Ray (eds), *The Contested Commons: Conversations between Economists and Anthropologists*, Blackwell Publishing, Oxford.

Cisneros-Mata, M.A., Montemayor-Lopez, G., Roman-Rodriguez, M.J., 1995, “Life history and conservation of Totoaba Macdonaldi”, *Conservation Biology* 9: 806–814.

Clark, C.C., 2006, *The Worldwide Crisis in Fisheries: Economic Models and Human Behavior*, Cambridge University Press.

Cordell, J.C. (ed), 1989, *A Sea of Small Boats*, Cultural Survival, Inc., Cambridge, MA.

Costello, C., Gaines, S.D., Lynham, J., 2008, “Can catch shares prevent fisheries collapse?”, *Science* 321: 1678–1681.

Cudney, R., Basurto, X., 2008, “Lack of cross-scale linkages reduces robustness of community-based fishery management”, Working Paper, Indiana University, Workshop in Political Theory and Policy Analysis, Bloomington, IN.

Degnbol, P., Gislason, H., Hanna, S., Jentoft, S., Raakjær Nielsen, J., Sverdrup-Jensen, S., Wilson, D.C., 2006, “Painting the floor with a hammer: technical fixes in fisheries management”, *Marine Policy* 30: 534–543.

Demsetz, H., 1967, “Toward a theory of property rights”, *American Economic Review* 57: 347–359.

Dietz, T., Ostrom, E., Stern, P., 2003, “The struggle to govern the commons”, *Science* 302: 1907–1912.

Dolšak, N., Ostrom, E. (eds), 2003, *The Commons in the New Millennium: Challenges and Adaptations*, MIT Press, Cambridge, MA.

Feeny, D., Hanna, S.S., McEvoy, A.F., 1996, Questioning the assumptions of the ‘tragedy of the commons’ model of fisheries”, *Land Economics* 72: 187–205.

Felger, R.S., Moser, M. B., 1985, *People of the Desert and Sea: Ethnobotany of the Seri Indians,* University of Arizona Press, Tucson.

Frangoudes, K., Marugán-Pintos, B., Pascual-Fernández, J.J., 2008, “From open access to co-governance and conservation: the case of women shellfish collectors in Galicia (Spain)”, *Marine Policy* 32: 223–232.

Gordon, H.S., 1954, “The economic theory of a common property resource: the fishery”, *Journal of Political Economy* 62: 124–142.

Hilborn, R., 2006, “Fisheries success and failure: the case of the Bristol Bay salmon fishery”, *Bulletin of Marine Science* 78: 487–498.

Hilborn, R., Orensanz, J.M., Parma, A.M., 2005, “Institutions, incentives and the future of fisheries”, *Philosophical Transactions of the Royal Society B* 360: 47–57.

Ives, R.L., 1989, *The Land of Lava, Ash, and Sand: The Pinacate Region of Northwestern Mexico*, Arizona Historical Society, Tucson.

Lam, W.F., 1998, *Governing Irrigation Systems in Nepal: Institutions, Infrastructure, and Collective Action*, ICS Press, Oakland, CA.

Lam, W.F., Ostrom, E., 2008, “Trying to avoid the ‘best practices’ trap”, Working Paper, Indiana University, Workshop in Political Theory and Policy Analysis, Bloomington, IN.

Lansing, J.S., 2008, *Perfect Order: Recognizing Complexity in Bali*, Princeton University Press, Princeton, NJ.

McCay, B.J., 1996, “Common and private concerns”, in: S. Hanna, C. Folke, K.-G. Maler (eds), *Rights to Nature: Ecological, Economic, Cultural, and Political Principles of Institutions for the Environment*, Island Press, Washington, DC.

McCay, B.J., Acheson, J.M., 1987, *The Question of the Commons: The Culture and Ecology of Communal Resources*, University of Arizona Press, Tucson.

McKean, M.A., 2000, “Common property: what is it, what is it good for, and what makes it work?”, in: C. Gibson, M. McKean, E. Ostrom (eds), *People and Forests: Communities, Institutions, and Governance*, MIT Press, Cambridge, MA.

Medina, B., Guzman, H.M., Mair, J.M., 2007, “Failed recovery of a collapsed scallop (argopecten ventricosus) fishery in las Perlas Archipelago, Panama”, *Journal of Shellfish Research* 26, no. 1: 9–15.

Moreno, C., Weaver, A., Bourillón, L., Torre, J., Égido, J., Rojo, M., 2005a, *Diagnóstico Ambiental y Socioeconómico de la Región Marina-Costera de Bahía de Kino, Isla Tiburón, Sonora México: Documento de trabajo y discusión para promover un* *desarrollo sustentable*, Comunidad y Biodiversidad, A.C. [online] www.cobi.org.mx/index.php?pag=publicaciones&idioma=esp

Moreno, C., Torre, J., Bourillón, L., Durazo, M., Weaver, A.H., Barraza, R., Castro, R., 2005b, *Estudio y evaluación de la pesquería de callo de hacha (Atrina tuberculosa) en la región de Bahía de Kino, Sonora y recomendaciones para su manejo*, Comunidad y Biodiversidad, A.C. [online] www.cobi.org.mx/index.php?pag=publicaciones&idioma=esp

Morrow, C.E., Hull, R.W., 1996, "Donor-initiated common pool resource institutions: the case of the Yanesha forestry cooperative", *World Development* 24, no. 10: 1641–1657.

NRC (National Research Council), 1986, *Proceedings of the Conference on Common Property Resource Management*, National Academy Press, Washington, DC.

NRC (National Research Council), 2002, *The Drama of the Commons*, Committee on the Human Dimensions of Global Change, E. Ostrom, T. Dietz, N. Dolšak, P. Stern, S. Stonich, E. Weber (eds), National Academy Press, Washington, DC.

Ophuls, W., 1973, "Leviathan or oblivion", in: H.E. Daly (ed), *Toward a Steady State Economy*, Freeman , San Francisco, CA.

Ostrom, E., 1990, *Governing the Commons: The Evolution of Institutions for Collective Action,* Cambridge University Press, New York.

Ostrom, E., 1992, *Crafting Institutions for Self-Governing Irrigation Systems*, ICS Press, San Francisco, CA.

Ostrom, E., 2001, "Reformulating the commons", in: J. Burger, E. Ostrom, R. Norgaard, D. Policansky, B. Goldstein (eds), *Protecting the Commons: A Framework for Resource Management in the Americas*, Island Press, Washington, DC.

Ostrom, E., 2005, *Understanding Institutional Diversity*, Princeton University Press, Princeton, NJ.

Ostrom, E., 2007a, "Collective action and local development processes", *Sociologica* 3: 1–32.

Ostrom, E., 2007b, "A diagnostic approach for going beyond panaceas", *PNAS* 104, no. 39: 15181–15187.

Ostrom, E., 2008a, "The challenge of common-pool resources", *Environment* 50, no. 4: 8–20.

Ostrom, E. 2008b, "Design principles of robust property-rights institutions: what have we learned", paper presented at the conference on "Land Policies and Property Rights," Lincoln Institute of Land Policy, Cambridge, MA, June 2–3, 2008.

Ostrom, E., Gardner, R., Walker, J., 1994, *Rules, Games, and Common-Pool Resources*, University of Michigan Press, Ann Arbor.

Ostrom, E., Walker, J., Gardner, R., 1992, "Covenants with and without a sword: self-governance is possible", *American Political Science Review* 86, no. 2: 404–417.

Ostrom, V., Ostrom, E., 1977, "Public goods and public choices", in: E. S. Savas (ed), *Alternatives for Delivering Public Services: Toward Improved Performance*, Westview Press, Boulder, CO. Reprinted in: M. McGinnis (ed), *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*, University of Michigan Press, Ann Arbor, 1999.

Posner, R.A., 1977, *Economic Analysis of Law*, 2nd ed., Little, Brown, Boston, MA.

Ragin, C.C., 2000, *Fuzzy-Sets Social Science*, University of Chicago Press, Chicago, IL.

Ragin, C.C., 2008, *Redesigning Social Inquiry: Fuzzy Sets and Beyond*, University of Chicago Press, Chicago, IL.

Ruddle, K., 2007, "Misconceptions, outright prejudice", Samudra report no. 48, *Samudra: The Triannual Journal of the International Collective in Support of Fishworkers*, International Collective in Support of Fishworkers, Chennai, India.

Ruddle, K., Hickey, F.R., 2008, "Accounting for the mismanagement of tropical nearshore fisheries", *Environment, Development, and Sustainability* 10: 565–589.

Ruddle, K., Johannes, R.E. (eds), 1985, *The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific*, Unesco, Jakarta.

Schlager, E., 1990, "Model specification and policy analysis: the governance of coastal fisheries", Ph.D. dissertation, Indiana University.

Schlager, E., 1994, "Fishers' institutional responses to common-pool resource dilemmas", in: E. Ostrom, R. Gardner, J. Walker (eds), *Rules, Games, and Common-Pool Resources*, University of Michigan Press, Ann Arbor.

Schweik, C.M., Adhikari, K., Pandit, K.N., 1997, "Land-cover change and forest institutions: a comparison of two sub-basins in the southern Siwalik hills of Nepal", *Mountain Research and Development* 17, no. 2: 99–116.

Scott, A.D., 1955, "The fishery: the objectives of sole ownership", *Journal of Political Economy* 63: 116–124.

Sengupta, N., 1991, *Managing Common Property: Irrigation in India and the Philippines*, Sage, New Delhi.

Sheridan, T.E., 1999, *Empire of Sand: The Seri Indians and the Struggle for Spanish Sonora, 1645–1803*, University of Arizona Press, Tucson.

Simmons, R.T., Smith Jr., F.L., Georgia, P., 1996, *The Tragedy of the Commons Revisited: Politics versus Private Property*, Center for Private Conservation, Washington, DC.

Smith, W.N., 1954, "The ethno-history of the Seri Indians from 1890 to 1953: a study in native conservatism and adaptability", unpublished paper written in 1953; corrected in 1954; filed at the Special Collection Library of the University of Arizona, Tucson.

Tang, S.Y., 1992, *Institutions and Collective Action: Self-Governance in Irrigation*, ICS Press, San Francisco, CA.

Tang, S.Y., 1994, "Institutions and performance in irrigation systems", in: E. Ostrom, R. Gardner, J. Walker (eds), *Rules, Games, and Common-Pool Resources*, University of Michigan Press, Ann Arbor.

Thompson, L.L., Mannix, E.A., Bazerman, M.H., 1988, "Group negotiation: effects of decision rule, agenda, and aspiration", *Journal of Personality and Social Psychology* 54, no. 1: 86–95.

van Laerhoven, F., Ostrom, E., 2007, "Traditions and trends in the study of the commons", *International Journal of the Commons* 1, no. 1: 3–28.

Wade, R., 1994, *Village Republics: Economic Conditions for Collective Action in South India*, ICS Press, San Francisco, CA.

Wagner, J., Talakai, M., 2007, "Customs, commons, property, and ecology: case studies from Oceania", *Human Organization* 66, no. 1: 1–10.

Weinstein, M., 2000, "Pieces of the puzzle: solutions for community-based fisheries management from native Canadians, Japanese cooperatives, and common property resources", *Georgetown International Environmental Law Review* 12, no. 2: 375–412.

Wilder, J. (ed), 2000, "Seri hands", special issue, *Journal of the Southwest* 42, no. 3: 385–635.

Young, O.R., 2002, *The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale*, MIT Press, Cambridge, MA.

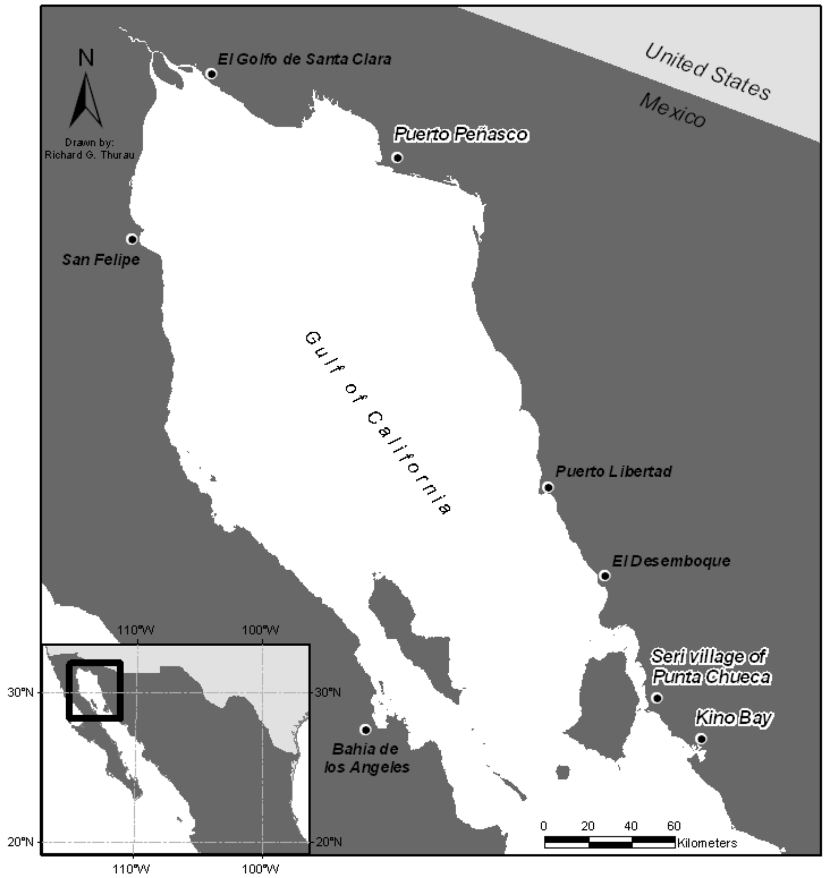

Figure 1. Selected fishing villages in the northern Gulf of California, Mexico

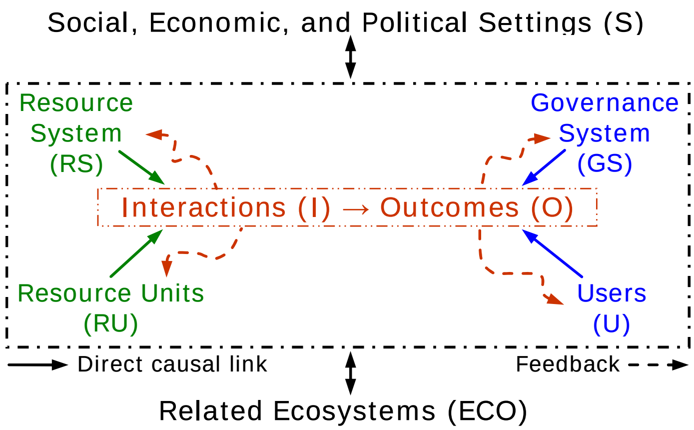

Figure 2. A multitier framework for analyzing a social-ecological system

Source: Ostrom (2007b: 15182).

Table 1. Second-tier variables in framework for analyzing a social-ecological system

Social, Economic, and Political Settings (S)	
S1- Economic development. S2- Demographic trends. S3- Political stability. S4- Government resource policies. S5- Market incentives. S6- Media organization.	
Resource System (RS)	**Governance System (GS)**
RS1- Sector (e.g., water, forests, pasture, fish) RS2- Clarity of system boundaries* RS3- Size of resource system* RS4- Human-constructed facilities RS5- Productivity of system RS5a. Indicators of the system* RS6- Equilibrium properties RS7- Predictability of system dynamics* RS8- Storage characteristics RS9- Location	GS1- Government organizations GS2- Non-government organizations GS3- Network structure GS4- Property-rights systems* GS5- Operational rules* GS6- Collective-choice rules* GS7- Constitutional rules* GS8- Monitoring & sanctioning processes*
Resource Units (RU)	**Users (U)**
RU1- Resource unit mobility* RU2- Growth or replacement rate RU3- Interaction among resource units RU4- Economic value RU5- Size RU6- Distinctive markings RU7- Spatial & temporal distribution	U1- Number of users* U2- Socioeconomic attributes of users U3- History of use U4- Location U5- Leadership/entrepreneurship* U6- Norms/social capital* U7- Knowledge of SES/mental models* U8- Dependence on resource* U9- Technology used*
Interactions (I) → Outcomes (O)	
I1- Harvesting levels of diverse users * I2- Information sharing among users I3- Deliberation processes I4- Conflicts among users * I5- Investment activities I6- Lobbying activities	O1- Social performance measures (e.g., efficiency, equity, accountability) O2- Ecological performance measures * (e.g., overharvested, resilience, diversity) O3- Externalities to other SESs
Related Ecosystems (ECO)	
ECO1- Climate patterns. ECO2- Pollution patterns. ECO3- Flows into and out of focal SES.	

Source: Adapted from Ostrom (2007b: 15183).

Table 2. Comparison of key variables for three coastal fisheries in the Gulf of California

	Kino	Peñasco	Seri
Users (U)			
U1 (number of users)	Rapid growth	Rapid growth	Slow growth
U5 (local leadership)	Absent	Present	Present
U6 (trust and reciprocity)	Lacking	High levels	High levels
U7 (shared local knowledge-mental models)	Lacking	High levels	High levels
U8 (dependence on resource)	Low	High	High
U9 (technology)	Same	Same	Same
Governance System (G)			
GS4 (formal property rights)	Absent	Absent	Present
GS5 (operational rules)	Present	Present	Present
GS8 (monitoring and sanctioning)	Mostly absent	Mostly present	Mostly present
Resource System (R)			
RS3 (resource size)	Large	Small	Small
RS5a (indicators)	Least available	Moderately available	Mostly available
RS7 (predictability)	Least predictable	Moderately predictable	Moderately predictable
Resource Units (RU)			
RU1 (Resource unit mobility)	Low	Low	Low
Successfully self-organized	No	Yes	Yes

Table 3. Design principles illustrated by long-enduring common-pool resource institutions

1. Clearly Defined Boundaries Individuals or households with rights to withdraw resource units from the common-pool resource, and the boundaries of the common-pool resource itself, are clearly defined.
2. Congruence A. The distribution of benefits from appropriation rules is roughly proportionate to the costs imposed by provision rules. B. Appropriation rules restricting time, place, technology, and quantity of resource units are related to local conditions.
3. Collective-Choice Arrangements Most individuals affected by operational rules can participate in modifying operational rules.
4. Monitoring Monitors, who actively audit common-pool resource conditions and user behavior, are accountable to the users or are the users themselves.
5. Graduated Sanctions Users who violate operational rules are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other users, from officials accountable to these users, or from both.
6. Conflict-Resolution Mechanisms Users and their officials have rapid access to low-cost, local arenas to resolve conflict among users or between users and officials.
7. Minimal Recognition of Rights to Organize The rights of users to devise their own institutions are not challenged by external governmental authorities.
For common-pool resources that are parts of larger systems: 8. Nested Enterprises Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

Source: Adapted from E. Ostrom (1990: 90).