International Journal of the Commons
Vol. 9, no 1 March 2015, pp. 281–305
Publisher: Uopen Journals
URL:http://www.thecommonsjournal.org
URN:NBN:NL:UI:10-1-116930

ISSN: 1875-0281

Measuring the potential for self-governance: an approach for the community-based management of the common-pool resources

Sergio Colin-Castillo
Centro de Estudios Socio Económicos (CISE) Universidad Autónoma de Coahuila, México
sergio.colin@uadec.edu.mx

Richard T. Woodward
Department of Agricultural Economics, Texas A&M University, USA
r-woodward@tamu.edu

Abstract: Self-governance can be a suitable instrument for the community-based management of a common pool resource (CPR). Under self-governance, individuals may organize themselves for the use of a CPR, a lake in our case study, to deal with problems of overexploitation and low profits that arise due to open access. Unlike most of previous research, which are ex-post in nature, this research explores the feasibility and desirability of carrying out an ex-ante assessment of the potential for self-governance to manage a CPR. Taking a set of theoretical conditions, this research proposes a way to assess the CPR users' perception on the adoption of self-governance. It represents a step toward understanding a priori whether self-governance would be feasible or not.

Keywords: Common-pool-resources, self-governance, community-based management

Acknowledgements: This work was carried out with the aid of a grant from the Latin American and Caribbean Environmental Economist Program (LACEEP), and from El Programa para el Mejoramiento del Profesorado (PROMEP) de la SEP-México. Woodward's participation was supported by Texas AgriLife Research with support from the Cooperative State Research, Education & Extension Service, Hatch Project TEX8604. We acknowledge valuable comments from the LACEEP scientific committee members, Frances Gelwick, Bruce McCarl, James

Mjelde, and three anonymous reviewers. We also want to extend our gratitude to Fernando Alonzo, Leticia Tovar and the School of Biology of University Juarez of Durango; and to all fishers of El Palmito, Las Delicias, and La Victoria.

1. Introduction

The management of *common-pool resources* (CPR) has long been discussed in economics literature. The association of CPR like fisheries with degradation and poor economic performance is well known due to excess harvests and poor management. The incentives faced by a CPR user create a dilemma. Users who limit their catch lose if others do not. And if no one limits his catch, everyone loses. Hardin's (1968) "Tragedy of the Commons" still applies in many situations today. However, contrary to Hardin, there exists evidence that common management or *self-governance*[1] can overcome these incentives. Under self-governance, user groups take control of the CPR to improve the economic viability of the resource (Ostrom 1990; Dietz et al. 2003).

The self-governance of a CPR is *successful* if the users develop solutions by themselves, aligning extraction rates with resource productivity to achieve a common benefit, and developing resource-specific rules that overcome the problems of free riders and opportunistic behavior (Ostrom 2005). CPR users, due to their daily use of the resource, have a "solid" knowledge of the situation, which is critical for successful management. In the end, by adopting self-governance the community will have the capacity to set, monitor and enforce their rules. Successful cases of self-governance have been documented around the world (see Ostrom 1990; Townsend and Sutton 2008). Study of these cases has allowed the identification of the characteristics of "successful" CPR management regimes.[2] However, our ability to predict when and where self-governance is most likely to be successful is still limited.

In this manuscript we review the theoretical framework regarding the conditions required for successful *self-governance* for the *community-based management* (CBM) of a CPR. Then we propose a method to assess the potential for self-governance based on the perceptions of the CPR users' group and their predisposition toward CBM. Finally, we test our approach in an inland small-scale fishery in the northern of Mexico, offering insights about whether or not a change in governance is feasible and desirable in the study site.

[1] Governance is the exercise of policy definition to assure rules to manage the resource. Thus, in self-governance the resource users themselves have the decision-making responsibility on defining such rules.

[2] A successful CBM can exclude external users, adapt management rules to local conditions, allow most users to participate in the decision-making process, is recognized by other authorities and have an effective monitoring, graduated sanctions, and cheap-easy mechanisms of conflict resolution (Ostrom 1990).

Knowing *ex-ante* the likelihood that CBM will succeed may save resources and direct the effort to an efficient management of the CPR. Governments and private entities spend effort and scarce resources to regulate environmental issues, and in many cases the implementation of policies is not effective. For example, fisheries have a long history of overexploitation that has reduced the ocean's capacity to provide food, preserve water quality and recover from perturbations (Worm et al. 2009). In many cases, CBM may offer an improvement over traditional regulatory approaches. An *ex-ante* assessment of the potential for self-governance would provide valuable information for policy makers seeking strategies for CPR management. We should be clear however; there are features of the resource or governmental system that might impede successful CBM even if the conditions for CBM are ideal. Here, we do not attempt to address this final question about whether CBM should be adopted. Rather, we only propose to assess ex-ante the potential for self-governance, recognizing that the management based on the community is only part of the puzzle to improve the management of CPRs.

2. Literature review

Common pool resources are facing global challenges. Taking fisheries as an example, perverse incentives, high demand for limited resources, poverty, inadequate knowledge, ineffective governance, and other environmental issues have all contributed to overexploitation and poor economic outcomes (Grafton et al. 2006; Worm et al. 2006, 2009; Andrew et al. 2007; Hilborn 2007a; Salas et al. 2007). This situation is also applicable to other resources where conventional management by governmental agencies has failed to stop resource decline (Ostrom 1990, 2005; Grafton et al. 2006, 2008; Hilborn 2007b). There is a growing recognition of the need for alternative ways to govern the CPRs. We us the term *governance* quite broadly, referring to the rules and norms (understandings) that influence the behavior of resource users (World Bank 1991; Sissenwine and Mace 2003; Stiftung 2009).

Neither the market approach nor state institutions alone have been universally successful in achieving a long-term productive use of CPRs. Although there is agreement that institutions (i.e. markets, CBM, or central government planning) are needed to solve resource problems, there is no agreement on the kind of governance structure does the best job (Acheson 2006). Many analysts recommend a mixture of private and public institutions to align the users' incentives with social targets and ecosystem health (Ostrom 1990, 2005; Degnbol et al. 2006; Grafton et al. 2006; Hilborn 2007a), while also considering endogenous institutions to achieve policy targets (Sarker and Itoh 2003; Grafton et al. 2007; Paavaloa 2007). Some have argued that community-based management is the best way to rebuild and recover such resources (Worm et al. 2009). In CBM, users themselves have the decision-making responsibility; when successful; it reduces management costs and increases the certainty and legitimacy of the users' decisions. Certainly, CBM may have some limitations and can be suitable just under some circumstances and

the successful or failure of such institution is not always predicted on the bases of the existing theory (Agrawal 2003; Acheson 2006).

Two related models have sought to describe how difficult it can be for individuals to reach collective benefits. In the first, the "tragedy of the commons," the argument is that individual's interests go in opposite direction of the group or community interests. When this happens, individual's interest will work against CBM and overexploitation will be unavoidable. Gordon (1954) and other scholars stated similar arguments describing how a diverse set of CPRs can be overexploited (Lloyd 1977; Dasgupta and Heal 1979; Clark 1980; Wilson 1985; Hanna 1995). The Prisoner's Dilemma model can be thought of as a general formalization of Hardin and Gordon; i.e. when participants are in what amounts to a non-cooperative game in which communication and cooperation are either forbidden or impossible (Dawes 1975). In such a game, as in the tragedy of the commons, the equilibrium leads to lower payoffs for both players. In short, a rational individual strategy may lead to collectively irrational outcomes (Campbell 1985; Ostrom 1990).

Common property regimes offer an alternative to the non-cooperative models that predict inefficient resource use. Ostrom (1990) describes the principles of self-governance and the related complications that arise when the users group manages the CPR. Based on her extensive case-study analysis, she identified eight design-principles needed to achieve "robust" or long-enduring and stable, CPR institutions: (1) Clearly defined boundaries that allow the exclusion of external users; (2) Rules for the CPR use adapted to local conditions; (3) Collective arrangements that let most users take part in the decision-making process; (4) Effective monitoring under responsibility of the local users; (5) A scale of graduated sanctions for users who violate community rules; (6) Cheap and easy mechanisms of conflict resolution; (7) Community self-determination that is recognized by higher-level authorities; and (8) A larger CPR is organized in the form of multiple layers of nested enterprises, with small local CPRs at the base level. These design principles have been used to carry out *ex-post* analysis of how robust are the local institutions managing the CPR (Gautam and Shivakoti 2005).

Beyond the eight design principles of Ostrom, perhaps the most relevant work devoted to systematize the characteristics of successful community-based efforts were done by Wade (1994) and Baland and Platteau (1999), and lately Townsend and Sutton (2008). According to Agrawal (2003), at least 36 characteristics[3] are needed to successfully manage and govern a CPR. The principal focus of these characteristics is on the users of the CPR as decision makers and the circumstances in which their decisions are made. This perspective allows us to focus on issues like technology, nature of institutions, size of the resource, size of the users group, monitoring cost and cooperation. Based on this work, researchers of the commons have proposed the Social Ecological Systems (SES)

[3] These studies share 12 common characteristics, and point out 24 non common characteristics of successful community-based efforts to manage and govern the CPR.

framework (Anderies et al. 2004; Ostrom 2007; Basurto 2008). An SES is a bio-geo-physical unit and is associated with social actors and institutions, delimited by functional boundaries surrounding particular ecosystems and their problem context (Anderies et al. 2004). SES analysis requires a trans-disciplinary research to fit an adequate problem orientation and integrative results (Hirsch-Hadorn et al. 2008). The SES framework is perhaps the state of the art approach for the analysis of CPRs, integrating many factors that may influence the management of the CPR, including the dynamics of the systems (Anderies et al. 2004), the endowment effect (Hackett et al. 1994), community characteristics for the collective action (Basurto 2005, 2008), the size of the CPR (Ostrom 1990, 2009; Berkes 2006), and transaction costs (Townsend 2010). The SES is an attractive framework because of his flexible structure; with decomposable units and relationships among them that facilitates the analyses of interactions in a systematic manner. But the most important, for our analysis, is the discussion of the factors that ex-ante influence the CBM adoption or the conditions for the self-governance.

2.1. The ex-ante assessment of the potential for self-governance

While there has been extensive and varied research on CPR management, there has been very little work to empirically evaluate whether the conditions for the adoption of self-governance are present in advance of attempts to put such a system in place. Certainly, assessing ex-ante self-governance and institutions like CBM is a difficult task because several different criteria used to measure the success (or failure), suitability and limitations to conserve natural resources like the CPR (Acheson 2006). Fortunately, the theoretical underpinnings of such analysis do exist. Ostrom proposed six conditions (Table 1, 1st column) that she believed determine the *likelihood* of users to adopt changes in the use of the CPR in favor of CBM. For identification purposes, from here to the end, we call these the Ostrom Conditions (*OC*'s).

An assessment of the six *OC*'s must account for the influence of the external political regime, because it may influence how and when the individuals use the CPR. When the pressure of political regime is essentially non-existent, Ostrom (1990) calls the situation a "zero condition." This zero condition may exist if the CPR is in a remote location or users face indifference from the political regime, such that the regime has a minimum effect on internal choices. When the de facto situation is such that the zero condition holds, the analysis is simplified since it avoids external distortions to assess the *OC*'s.

It is important to distinguish these six *OC*'s from the eight design principles mentioned above. The critical difference is that the design principles are *ex-post* in nature, so are useful to frame an evaluation of cases already in place. The six *OC*'s offer a framework for *ex-ante* analysis; they reflect the potential of CPR users to adopt changes in the rules for management of the resource.

Two other approaches may be considered for the *ex-ante* assessment of the potential for the adoption of self-governance for a CPR. First, Ostrom (1999,

Table 1: Proposed characteristics to analyze the potential for the adoption of self-governance.

Ostrom (1990)	Dietz et al. (2003)	Ostrom (2009)
(1) 'most users' conclude that they will be harmed if they do not adopt new rules (2) 'most users' conclude that they will be affected in a similar way by the new rules (3) 'most users' highly value continuing the activity (4) users share generalized norms of reciprocity and trust (5) users face low monitoring and enforcement cost (6) users are a small and stable group	(1) low monitoring cost; (2) changes in resource technology, population, and socio economic conditions take place at moderate rates (3) users have direct and frequent communications and trust each other (4) outsiders can be excluded at low cost (5) users themselves can monitor and enforce their collective agreements	(1) size of resource system (2) productivity of system (3) predictability of system dynamics (4) resource unit mobility (5) number of users (6) leadership (7) norms/social capital (8) knowledge of the SES (9) importance of resource to the users (10) collective-choice rules

2009) proposed the use of cost benefit analysis: the CPR users will favor self-governance if the expected benefits are greater than the cost. However, if the rules to be implemented are not clearly defined, such cost-benefit analysis is not a good approach. Moreover, the data to measure the benefits is hard to obtain. Second, based on the SES framework, Dietz et al. (2003) propose five characteristics (Table 1, 2nd column), while Ostrom (2009) proposed ten second-level variables (Table 1, 3rd column) to identify their positive or negative effect on the likelihood of users to engage in common governance.

There are similarities and discrepancies between the criteria used in previous research (2nd and 3rd columns in Table 1) and those proposed for this study (1st column in Table 1). First, the relevance of reciprocity and trust in these three approaches is clear, though less explicit in the third column as social capital and collective-choice rules. A second similar point is that all frameworks refer to the low cost of monitoring and enforcement, features reemphasized in the second column and not clearly identified in Ostrom (2009). Third, all three refer to the size and stability of the users group; more stable and small user groups are more likely to be successful in their adoption of self-governance. The main difference between these three frameworks is that the *OC*'s (Ostrom 1990) focuses on users' opinions as the foundation of a change in the use of the CPR, whereas Dietz et al. (2003) and Ostrom (2009) focus on the relationships among elements of the system (users, resource and institutions). Additionally, Dietz et al. (2003) do not include the predictability of the system dynamics (probable output and rules effects), neither the value of the activity-resource to the users. Alternatively, Ostrom (2009) excludes the monitoring and enforcement costs but includes other characteristics such as leadership and knowledge of the system. Certainly, the 2nd and 3rd columns of Table 1 analyze the interaction between systems rather than the users' predisposition to adopt self-governance.

While all three approaches offer distinct insights, we adopt the *OC* approach because it can be carried out based on the data gathered directly from CPR users through surveys or experiments. Hence, we feel that this approach is less likely to be based on the subjective interpretation of an analyst carrying out the assessment. Recall, our focus is in the ex-ante conditions, and such conditions would be different to the supposed 30–40 factor pointed out by Agrawal (2003), factors that affect the successful management of the CPR, but derived from ex-post analysis. In the next section we propose a general approach for the evaluation of the potential for self-governance. We then carry out such an ex-ante assessment using an example from a small-scale fishery in northern Mexico.

3. The method

3.1. The model

Our model is based on the six conditions identified by Ostrom (1990) as presented in Table 1. The basic proposition is that the probability of a community successfully adopting self-governance for CBM is a function of the six conditions over all the CPR users' communities. Each of the *OC*'s, however, is actually a function of the perspectives of the users that make up the community.[4] Thus, the *i*th condition (OC_i) is considered an aggregation of the form

$$OC_i = g_i(OC_i^1,\ OC_i^2,\ \ldots,\ OC_i^n) \tag{1}$$

where OC_i^j is the *i*th *OC* for the *j*th user, *j*=1,…, *n*. The challenge for *ex-ante* evaluation is that neither OC_i nor OC_i^j can be directly observed. We propose to overcome this challenge by developing a series of *m* questions, $q_{ij}^1,\ q_{ij}^2,\ \ldots,\ q_{ij}^m$, designed to be correlated with OC_i^j. These can be used to create an index $\widehat{OC_i}^j$, that is a function of the responses to the questions,

$$\widehat{OC_i}^j = h_i(q_{ij}^1,\ q_{ij}^2,\ \ldots,\ q_{ij}^m) \tag{2}$$

where q_{ij}^k represents the *j*th user's response to the *k*th question, *k*=1,…, *m,* for the *i*th *OC*. This process is repeated with different set of questions for each condition.

To arrive at a valid set of questions, each OC_i must be expressed the language of the CPR user before it can be used in a survey or experiment. This adjustment also helps us to identify the elements of each OC_i, and the answers gathered from the questions can be aggregated in a resulting index, $\widehat{OC_i}^j$.

[4] Recall, this proposed model does not have a variable related to the bio-physical condition and the variability and uncertainty of resources. The reason is because we mainly focus on users' opinions to predict a change in the use of the CPR. Hence, important elements of the CPR management problem are not captured in this framework so our assessment alone is not able to assess the probability of success of the CBM.

3.2. Empirical approach

For each OC_i, we may need three types of questions: (1) Indirect positive questions (Q_i^k), designed to be positively correlated with the corresponding OC_i; (2) indirect negative questions ($-Q_i$), designed to be negatively correlated with one of the positive questions, and (3) direct questions (DOC_i^j) designed to be a direct elicitation of the respondent's feeling about each *OC*. The language of the questions must be contextually appropriate for the resource being studied and easily understood by the individual surveyed.

By using these three types of questions we are able to assess to some extent the reliability and validity of the data. Internal validity and reliability are important because they are together at the core of what is accepted as scientific evidence. *Reliability* has to do with the quality of measurement. A measure is reliable if it would give us the same result over and over again. *Internal validity* refers to the validity of inferences (Russell 2006), and it holds if a causal relation between variables -*If X, then Y*- is properly demonstrated (Jimenez-Buedo and Miller 2009). It is more related to the cause-effect, and is analogous to accuracy while reliability is analogous to precision. If a measure is not reliable, it cannot be valid. Reliability however, is a necessary but not sufficient condition for validity (Russell 2006; Jimenez-Buedo and Miller 2009).

If the questions are designed to have a Likert scale 1–5, with 3 representing "*don't know"* or "*no change,*" such responses must be assessed carefully avoiding the central tendency bias, the acquiescence bias and the social desirability bias (Carifio and Perla 2007). On the other hand, if some questions may have different response categories (e.g. *Very good=1,..., Very bad=5* or *Increase=1, … , Decrease=5*), but if they share the characteristic that higher numbers indicate greater agreement, aggregation of the Likert answers is possible.

We can assess reliability by looking at the indirect positive and indirect negative questions. If an individual's indirect negative responses ($-q_{ij}^k$) are positively correlated with the indirect positive response (q_{ij}^k) , then reliability fails. Such situation indicates that the respondent is not giving consistent responses, and to improve reliability, you may drop the observations from individuals who gave consistently unreliable responses.

Before assessing reliability, the responses to q_{ij}^k we need to create an index, $\widehat{OC_i^j}$, that aggregates the individual's responses into a single index measuring his or her coherence with each *OC*. For exploratory purposes, in this paper we use principal component analysis (PCA).[5] The first principal component captures the maximum variation in the respondents' answers to OC_i, this first component can

[5] Principal component analysis is a technique involving an orthogonal linear transformation of a data set, yielding a smaller set of components, say $y_1,\ldots, y_n$, such that as much of the variation as possible is captured by the components used. We refer readers to Johnson and Wichern (2002) for the matrix algebra presentation of PCA.

be used as a weighted sum for the k questions associated with that OC_i, and then define the index according to equation (3):

$$\widehat{OC}_i^j = \sum_{k=1}^{m} \delta_i^k \cdot q_{ij}^k, \tag{3}$$

where the δ_i^k obtained from the PCA algorithm are normalized so that $\sum_{k=1}^{m} |\delta|_i^k = 1$, and it is a weighted measure for OC_i index. PCA has several attractive features. First, it allows us to group a set of probably correlated answers in a way that captures as much variation as possible. Second, by normalizing we may retain a similar scale for all of the *OC*'s. Third, the indices can take on continuous values; this change permits, with caution, the use of the mean and standard deviation, making flexible the interpretation of the Likert values and serve as an intermediate step in a more complex analysis (Johnson and Wichern 2002; Jolliffe 2002). Clearly, we must observe the PCA assumptions, it means to check for the existence of missing values, outliers and truncated data; otherwise these affect the reliable correlations and get a bias result. As well, normally distributed variables are desirable but not necessary if we are using the analysis in a purely descriptive manner (Jolliffe 2002).

Once we obtain the indices, the last step is to assess internal validity by looking for positive correlation between the $\widehat{OC}_i^j$ and the direct questions DOC_i^j, which were essentially a rewording of the each *OC* as presented in Table 1. An absence of strong positive correlation would cause us to question the validity of the indices.

4. Empirical application

4.1. Study site

We studied the potential for self-governance at a fishery in the Lázaro Cárdenas Reservoir (LCR), a reservoir located in a poor and arid region at the upper watershed of the Nazas River, best known as "La Laguna", in Durango, Mexico. LCR has a storage capacity of 3336 million m^3 of water on 15,000 hectares (INEGI 2005). Three fishing communities are situated on the banks of the reservoir: El Palmito, Las Delicias, and La Victoria. The fishers are not the legal owners of the reservoir, but they enjoy unlimited access. The communities are largely dependent on fishing, supplemented by minimal agriculture-livestock activities and remittances from emigrants. Recreational fishing is infrequent, but increasing, although this provides little benefits to commercial fishers.[6] As well, it has been detected a very small number of independent fishers, not members of the cooperatives, composed mainly by girls, fisher's wife, and occasional foreign fishers that arrive mainly on the weekends or vacation times. Throughout our lengthy visits to the region

[6] Development of recreational activities requires the coordination of fishers. By reasons of competing technologies (hand lines vs. nets), recreational and commercial fishing cannot operate simultaneously.

and conversation with leaders and fishers in the communities, we did not detect the existence of independent permit holders in the region. The harvested species are *Micropterus salmoides* (lobina or largemouth bass), *Ictalurus punctatus* (bagre or channel catfish), *Cyprinus carpio* (common carp), *Oreochromis aureus* (blue tilapia) and *Pomoxis annularis* (robaleta or white crappie) and *Lepomis macrochirus* (mojarra or bluegill).

Based on informal agreements, each cooperative has an area to fish and every fisher is knowledgeable of these limits. Some level of cooperation is evident in the region; the fishers help each other with actions like sharing their boats and some fishing equipment, and they informally monitor the lake to prevent the entrance of fishers from outside the communities. But probably the most significant cooperation is in the commercialization of the fish; the fishers have a cooperatively managed storage facility with staff that keeps the records of each fisher's production and sales. Such cooperation in commercializing their production may help in their sales, but we found no evidence that the cooperative's activities extended to the management of harvests from the lake.

The LCR fishing fleet is composed of small fiberglass boats with outboard motors, although a few fishers row their boats (Tovar et al. 2009). Most of the boats and engines are old, and most of the fishers use gill nets, but a few use angling gear (hook and line). Some fishers share boats to split the operation costs. The fishers are exclusively men, mostly between 40 and 50 years old, with elementary school education, and living in a family of 4 individuals or more (see Table A1 of Appendix).

There are some data for the fishery from 1983 to 1992, when fish production was about 1000 tons/year (71 kg/ha/yr), with a maximum yield of 1200 tons/year (FAO 1996). According to leaders and fishers, the number of fishers using the LCR varied from 204 in 1992 to 134 in 2007. At the time of the survey (summer of 2010), 148 fishers were found registered in the three cooperatives, but only about 100 were active at the time. The decline in the number of fishers may be due to increasing emigration of the young people, but also could be attributed to diminished promotion of the fishery activities by the central government. From 1981 to 1992 there was a ministry for the fisheries; a ministry that disappeared when it was integrated into the Ministry of Environment, with a consequent reduction in the enforcement.

Based on discussions with fishermen and scientists studying the fishery, it was detected that the fishery is in a critical condition and the regulation is weak. The municipal government and CONAPESCA, the federal fisheries agency, provide little regulatory oversight due to a lack of personnel and budgetary resources. As a result, there is very limited monitoring and enforcement of existing regulations. As a result, a number of problems arise. For example, government rules allow fishers to use a gill net with mesh openings of 4 inches; however the use of smaller mesh sizes is common. Agency decisions regarding seasonal closures, fish stocking, and gear restrictions are made without scientific support (Tovar et al. 2009). This situation is not unique to LCR; it is representative of most of the inland fisheries of

Table 2: Indirect and direct questions related to Ostrom conditions 1 to 6 ($OC_{1, 2, 3, 4, 5, 6}$).

OC[a]	Type[b]	Question or Working Statement	Answer type[c]
1	W	"Most fishers" conclude they will lose harvest if they maintain the current rules	
1	D	Fishing will decrease if strict fishing rules are not adopted?	L(1-5)
1	I+	If the current rules remain for the next year, my catch will (&)	L(E)
1	I+	Do you favor the adoption of strict management rules (e.g. stop fishing bass)	L(1-5)
1	I-	During the last 5 years, my fishing catches…	L(F)
2	W	"Most fishers" agree with rules that affect all fishers similarly	
2	D	*How much do you agree with a fishing rule that equally affect all fishers?	L(1-5)
2	I+	Most cooperative agreements equally affect all fishers	L(1-5)
2	I+	A good set of rules imply hard work of all fishers	L(1-5)
2	I+	A good set of rules imply sacrifice from all fishers	L(1-5)
2	I+	The cooperation among all fishers is not important.	L(1-5)
2	I–	Most of the cooperative agreements are made for only few fishers	L(1-5)
3	W	"Most fishers" highly value the benefits derived from the fishing, hence they want to continue	
3	D	*If someone in your family decides to be a fisher, the value for you will be…	L(A)
3	I+	*All things considered, how satisfied are you working as a fisher?	L(G)
3	I+	I want my sons and grandsons to be fishers.	L(1-5)
3	I+	I teach my son (will teach if I have one) how to fish.	L(1-5)
3	I+	I am very proud of being a fisher.	L(1-5)
3	I–	I would like to stop fishing if I find a job with the same salary	L(1-5)
4	W	Fishers share norms of cooperation and trust	
4	D	*The trust among the fishers is…	L(B)
4	I+	Very often, you do favors for other fishers.	L(1-5)
4	I+	Most fishers share experiences & knowledge with you.	L(1-5)
4	I+	You trust your community neighbors and fishers.	L(1-5)
4	I+	You trust the fishers of other communities.	L(1-5)
4	I–	Doing a favor among fishers is something very rare to see.	L(1-5)
5	W	Fishers face low cost getting information to monitor and enforce the rules	
5	D	*Monitoring if fishers follow the fishing rules is?	L(C)

(*Table 2: continued*)

OC[a]	Type[b]	Question or Working Statement	Answer type[c]
5	I+	If you violate a rule, you have fear of being punished.	L(1-5)
5	I+	You can easily see how other fishers harvest.	L(1-5)
5	I+	In a cooperative agreement (e.g. no fishing bass). It's easy to see if fishers obey the agreement	L(1-5)
5	I+	It is easy to detect if outsider fishers are fishing.	L(1-5)
5	I–	If a fisher harvests a lot, the other fishers hardly know it?	L(1-5)
6	W	Fishers group in LCR have been small and stable in the last 5 years	
6	D	*In last 5 years, the number of fishers has…	L(D)
6	I+	Five years ago, the reservoir had more fishers than it has today.	L(1-5)
6	I–	The lake never had so many fishers as it has today.	L(1-5)

Unless marked with a *, questions are of the form, "How much do you agree or disagree with the following statement…?

Notes:

The survey was administered in Spanish and this table presents a translation of those questions. The authors will make available the original survey instrument in Spanish upon request.

[&]The scale was reversed (i.e. 2 was converted to 4, and 1 to 5) to have an equivalent direction on the responses

[a]The Ostrom Conditions (OC_1-OC_6) are stated in Table 1

[b]W: Working statement of the OCfrom Table 1; D: Direct question regarding the OC; I+: Indirect question regarding the OC with standard coding; I-: Indirect question regarding the OC with reverse coding;

[c]Answer types, all on a 1-5 scale as follows:

L(1-5): It is the most typical answer on our Likert scale: 1.Strongly disagree, 2.Disagree, 3.Don't know, 4. Agree, 5.Strongly agree

L(A): 1.Very low, 2.Low, 3.Don't know, 4.High, 5.Very high

L(B): 1.There is no trust at all, 2.Not good, 3.Don't know, 4.Good, 5.Very good

L(C): 1.Very expensive, 2.Expensive, 3.Don't know, 4.Cheap, 5.Very cheap

L(D): 1.Increased a lot, 2.Increased, 3.No change, 4.Decreased, 5.Decreased a lot

L(E): 1.Increase, 2.May be increase, 3. No change, 4.May be decrease, 5.Decrease

L(F): 1.Decreased a lot, 2. Decreased, 3. No change, 4. Increased, 5. Increased a lot

L(G): 1.Not at all satisfied, 2.Not satisfied, 3.Don't know, 4.Satisfied, 5.Very satisfied

Mexico and, based on Salas et al. (2007) and Andrew et al. (2007) the LCR case may be representative of other inland small-scale fisheries of other developing countries. As a result of this weak regulation and overfishing, the fishers reported declining harvest both in numbers and size and low profits (Tovar et al. 2009).

4.2. Data: a survey

Our survey was administered in the summer of 2010. The survey instrument was pretested in two focus groups, one with students of Universidad Juarez of Durango and another with fishers of Francisco Zarco, another lake in the region. A group of biology students were hired as enumerators to conduct most of the surveys. To increase the response rate, each fisher received a compensation of 50 Mexican pesos (about 4 US dollars), and a prize from a random drawing at the end of the survey. As described above, a series of questions measure each respondent's perceptions with regard to each of the six *OC*'s. In addition, the survey captures the socioeconomic data presented in Table A1 of the Appendix.

From a total of 148 fishers registered in the three cooperatives, only about 100 were active at the time of the survey. We interviewed 111 individuals, and then our survey is basically a census. The questions used to calculate the *OC* indices are presented in Table 2.

As seen in Table 2, we add a working statement for every OC_i. This is an adaptation of each of the original *OC*'s, in contextually appropriate language that can be easily understood by the fishers surveyed. We also should point out that OC_6 is a factual point that ideally would be obtained based on data rather than perceptions. Unfortunately, no reliable records were available, so we had no choice but to ask for the fishers' perceptions. For this OC_6 we used only one indirect question.

The first step in the analysis is to assess the reliability of each respondent's answers by looking for consistency between the indirect positive and indirect negative questions. The correlation between $-q_{ij}$ and q_{ij}^k for each condition *i*th, is presented in Table 3. Looking at the raw data (n=111), most of the correlation values are negative, yet some are close to zero and correlation in OC_6 is actually positive, indicating the need for a close check of reliability. Each fisher had a maximum of six chances to give a contradictory answer, and on average each fisher was inconsistent in 1.95 times. If a fisher gave more than two contradictory answers, we interpreted this as an indication that the respondent was either not understanding the questions or not seriously attempting to answer honestly. In order to minimize the effect of non-reliable observations, therefore, such observations were dropped from the analysis.[7] Following this rule, we eliminated

[7] In a sort of sensitivity analysis, another option was to use 3 inconsistent answers. That is, if a fisher contradicts in more than three *OCs*, the number of observation dropped is 12 reducing the data to 99 observations.

Table 3: Correlation on answers to indirect positive and indirect negative $(-q_i^k)$ *questions, before (n =111) and after (n =74), reliability improvement.*

	q_1	q_2	q_3	q_4	q_5	q_6
Complete data set (n=111): q_i^k	–0.03	–0.18	–0.11	–0.10	–0.01	0.06
Reliable data set (n=74): q_i^k	–0.20	–0.51	–0.30	–0.21	–0.21	–0.12

Table 4: Correlation between answers to direct Ostrom condition (DOC_i) *questions and the Ostrom condition indices of* OC_i^j *using a simple sum of* q_{ij}^k *and with PCA.*

	DOC_1	DOC_2	DOC_3	DOC_4	DOC_5	DOC_6
(n=111) $\widehat{OC_i}^j$ as a simple sum	0.270	0.080	0.270	0.110	0.060	0.380
(n=74) $\widehat{OC_i}^j$ as a simple sum	0.309	0.068	0.441	0.260	0.146	0.461
(n=74) $\widehat{OC_i}^j$ with PCA	0.310	0.069	0.420	0.219	0.130	0.501

37 respondents leaving us with 74 observations. The second row of Table 3, presents the correlations for the revised smaller data set.

The next step is to assess the validity of indices found by aggregating the indirect questions in Table 2. In Table 4 we look at the correlation between the DOC_i^j, and indices found using the responses to the indirect questions, q_{ij}^k.[8]

The first two rows of Table 4 are found by simply summing up the responses for each *OC*, first for the full sample and then for 74 observations that were found to be reliable. In the third row of the table, we present the correlation for indices created using the first principal component as discussed above.[9] As can be seen, with the exception of OC_2, which has a very low level of correlation, this measure of validity improves when only the 74 observations deemed reliable are used. Interestingly, the correlation with the *DOC*'s changes very little when an index created using a simple sum of the responses is used in place of the indices calculated using PCA.

5. Results

Using the responses of 74 of the LCR fishers, we evaluate the predisposition of the LCR fishers toward self-governance based on the six *OC*'s. We use the 19 questions listed in Table 2, dropping 2.6% of the responses that were either missing or gave answers of 3 ("don't know"), a recommended procedure in the Likert analysis (Trochim 2006). The remaining data were handled in

[8] A similar positive correlation was also found using the full data set (n=111).

[9] In our application, the first principal component was found using the pca command in Stata

Table 5: Descriptive statistics of Ostrom condition indices (OC_i) in percentage values.

OC_i indexes	1–5 scale*	1–4 scale	Std dev	Median	Mode	Min	Max
OC_1	74%	72%	15%	67%	67%	44%	100%
OC_2	82%	79%	16%	75%	75%	68%	100%
OC_3	70%	68%	33%	77%	75%	63%	100%
OC_4	75%	71%	14%	75%	75%	45%	95%
OC_5	78%	75%	15%	75%	75%	63%	100%
OC_6	51%	53%	31%	50%	75%	25%	100%
OC_iAvg	72%	71%	10%	74%	74%	48%	95%

*Note: *For comparison purposes we keep the original scale 1–5, second column, presented in percentage values. All remaining analysis uses results from the 1–4 rescaling.*

two ways: using the original scale (1–5), and rescaling the remaining Likert answers from 1 to 4.[10]

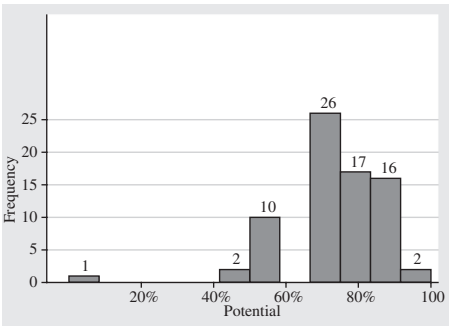
The descriptive statistics for the six conditions are presented in Table 5 and histograms of the data are presented in Figure 1. With exception of OC_6, all of the histograms indicate a high predisposition towards self-governance. The results obtained using the 1–5 or 1–4 scaling are qualitatively quite similar with none of the average indices shifting by more than seven percentage points. In the rest of the manuscript we use the 1–4 scaling with all results presented in percentage terms.

Statistics on the resulting $\widehat{OC}_i$ index are presented in Figures 1 and 2 and in Table 5. There are several features to discuss. First, all of the *OC*'s suggests that on average fishermen at the LCR are predisposed toward self-governance. Based on $\widehat{OC}_1$, commercial fishers in LCR tend to favor the adoption of stricter fishing management rules, agreeing that they will be harmed if they do not adopt such alternative rules. Nonetheless, the median and mode for $\widehat{OC}_1$ are among the lowest for the *OC*'s with a value of 67%.

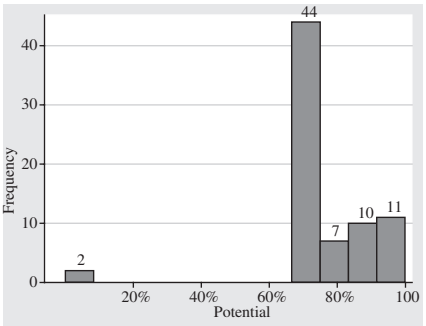
With regard to OC_2, the average index for $\widehat{OC}_2$ is 79%, indicating general agreement that fishers should be affected in similar ways by any alternative rule to be adopted in LCR. As seen in the histogram of OC_2 in Figure 1, the distribution is skewed to the left, showing that the vast majority of the respondents are strongly in agreement with this *OC*.

The $\widehat{OC}_3$ index has an average value of 68%, suggesting that fishers tend to value the fishing activity – most are satisfied and proud to be fishermen – but support for this condition is not as strong as for most of the other *OC*'s. We also see that the standard deviation is the highest among all the measured *OC's* since

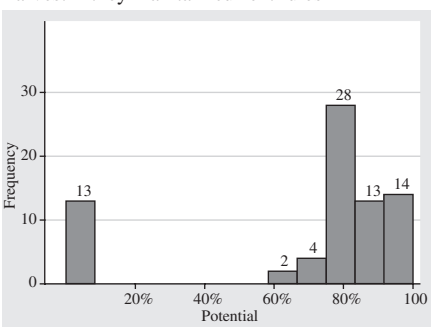
[10] Here is important to observe that indirect positive question one that form the OC_1 index, is the only with an option 3= No change, different to "I don't know". Therefore the first outputs handled for OC_1 index uses the scale (1–5) and the second is rescaled 1–4.5.



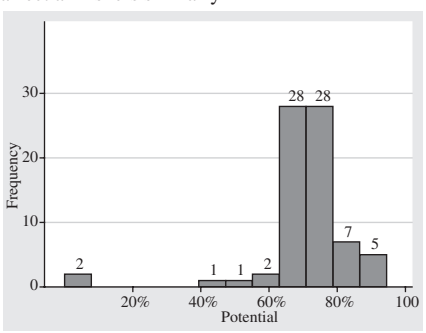
OC$_1$ "Most fishers" conclude they will lose harvest if they maintain current rules



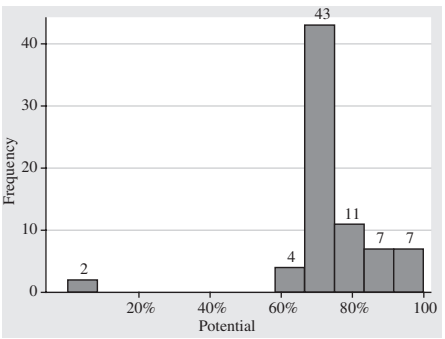
OC$_2$ "Most fishers" agree with rules that affect all fishers similarly



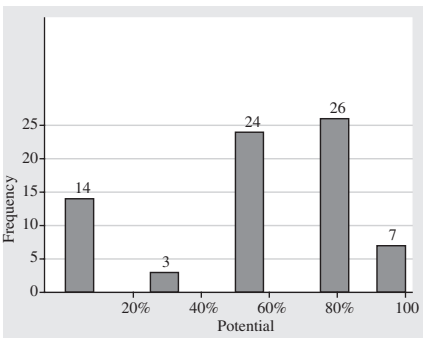
OC$_3$ "Most fishers" highly value the benefits from the fishing and they want to continuo



OC$_4$ Fishers share norms of cooperation and trust



OC$_5$ Fishers face low cost getting info to monitor and enforce the rules



OC$_6$ Fishers group in LCR have been small and stable

Figure 1: Frequencies of the six OC indices.

13 fishers that express a low percentage value on the graph *OC*$_3$ of Figure 1. This dissatisfaction might be attributable to the fact that the fishers are not happy with the low incomes they obtain from fishing since most of them do not have another activity that brings a better profit or salary.

The index $\widehat{OC}_4$ has an average value of 71%, suggesting agreement that there is an environment of reciprocity and trust among the fishers. We found in the community strong evidence of this within each community, but not necessarily among the fishers from one community to another, as it was recorded in the survey. This may be the reason for the relatively dispersed distribution seen in Figure 1. Informal arrangements may play an important role in achieving shared norms of cooperation and trust. For example, each cooperative has an area to fish and fishers help each other, sharing boats and other implements. Nonetheless, cooperation may be highest in the commercialization of their harvest. We suspect that the fishers' experience with cooperative efforts may be important in creating a favorable predisposition towards CBM among the fishers.

The average index for $\widehat{OC}_5$ is 75%. The fishers tend to agree that monitoring and enforcement of the rules would not be costly. As described above, fishers have experience with informally monitoring the fishery to prevent the entrance to external fishers, and many of them have first-hand knowledge that enforcement of rules is possible based in community informal agreements. As a part of informal agreements, some fishers have received punishment, social condemnation or disapproval because they fished during the closed season. According to community leaders and the presidents of the fishing cooperatives, sanctions such as exclusion from the fishing cooperative are only rarely used and are decided on a case-by-case basis. Nonetheless, such non-monetary punishment seems to deter the prohibited actions.

The last of the *OC*'s, whether the fishers group has been small and stable during the last 5 years, had the lowest index, only 53% on average. Among, the several factors that may have led to variation in the fisher population over time, based on visits to the community and conversations with leaders, two seem most likely to be important. First, fishers can easily rotate from one activity to another, especially if livestock and agricultural activities offer the opportunity of alternative income. Second, most of the young people emigrate to study in the nearby cities or to work in the USA. Such emigrants can easily return to the region to work as fishers. Hence, it is not surprising that many respondents did not know about stability of LCR fishery.

Pulling together the six conditions, we have a general assessment of the potential for self-governance in LCR. Averaging the means yields a global mean of 71%;[11] it means that fishers tend to favor the self-governance. A composite view of the six conditions is offered in Figure 2, where a polygon close to the borderline indicates a high inclination of the fishers toward the adoption of CBM. Among the three communities, Las Delicias has the largest index, but the differences among the three communities are small and not statistically significant. All they have an average mean and median around 70 to 71%, a high value that favors the likelihood for CBM adoption.

[11] The mode was 74% and the median 70%.

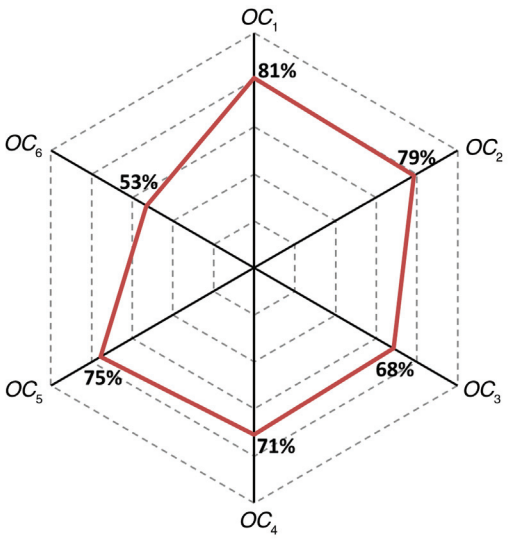


Figure 2: A joint representation of the six Ostrom conditions indexes.

Although the data seem to indicate support for CBM, there are a number of areas of concern. It seems possible that a lack of trust, even by a small minority of the fishers, could significantly diminish the prospects for CBM. We also suspect that OC_3 reveals some uncertainty regarding the extent to which CBM may garner support in the community; even if the majority of the fishers value highly fishing as a vocation, 13% of the fishers were at the opposite end of the spectrum. Is this because of the low profits of the fishery? Or it is because the current high rates of emigration by the communities' youths? These questions would be important areas for future explorations if CBM were to be pursued.

Unfortunately, we are not able to conclude with any certainty whether these measures indicate a sufficiently strong foundation for a successful CBM. Is an average of 71% high enough? How problematic is it that the index for OC_6 is only 53%? Are the population means the most important statistic or is it more important to focus on the upper or lower tail of the distributions? These are important questions that we cannot answer. What we can conclude is that it appears to us that there is sufficiently strong support for LCR fishers and fisheries agency officials to explore the potential support among the fishers for a stronger management regime. Further, the statistics indicate areas of stronger and weaker support. This could be used to prioritize educational and organizational activities that would benefit the fishers.

A last interesting question is whether there is a correlation between income and predisposition toward self-governance for a CBM. In Figure 3 we present the

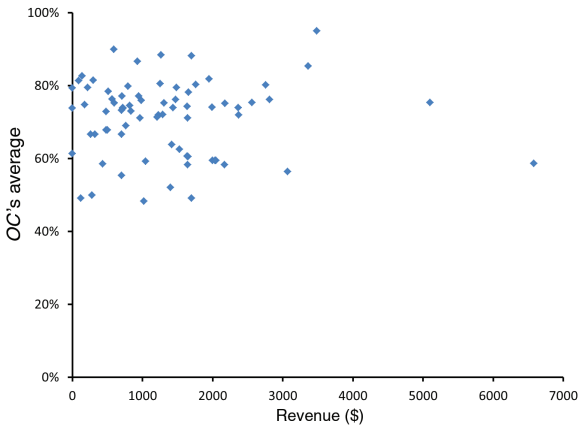


Figure 3: Relationship between potential for self-governance (OC's average) and fisher's revenue at Lázaro Cárdenas reservoir.

relationship between the fishers' average index and their reported revenue from fishing. The correlation is –0.00031, statistically significant, but very small.[12] While the fishers' revenue increases, the likelihood of adopt self-governance virtually stay constant. Hence, it appears that there is no economically important relationship between a fisher's income and his predisposition toward CBM.

6. Conclusions and limitations

This research offers a way to assess *ex-ante* the potential for self-governance towards the CBM. Based on six critical conditions for self-governance success proposed by Ostrom (1990), our approach offers insights about whether the conditions necessary for success are present before the process for developing a self-governance is begun. The method is based on attitudes of the CPR users, an approach that could be replicated in other settings.

In our empirical application, we find a predisposition of the LCR fishers toward self-governance for a CBM. The strongest measure was that indicating the extent to which users believe that rules affect all fishers similarly. The weakest indicator was regarding the size stability of the fishers' group. Overall, our measures were consistent with the additional interviews and opinions of leaders and stakeholders of the three LCR fishing communities.

There are several limitations in our general approach and the specific application that should be emphasized. The most significant limitation is the lack of a true validity measure. We do not observe ex-post whether CBM was pursued or successful – that experiment has not yet played itself out. Therefore,

[12] T-value 10.02, significant at 95% level.

we do not have strong evidence that answering *OC*'s favor self-governance or not. Furthermore, although Ostrom and others scholars have studied the idea of predicting outcomes for the management of CPR, we are unaware of any attempt to make a systematic *ex-ante* assessment based on Ostrom's six conditions. Hence, there has not been an opportunity to compare a measure of a community's predisposition toward self-governance for CBM to the outcome over time, which is what would be needed to establish the true validity of such an ex-ante measure.

Because of our inability to test the validity of our measures, our approach does not yield clear guidance for policy. We find that fishers' perspectives might lead to a favorable environment for CBM, but it does not indicate they will adopt self-governance. Certainly, policies may fail because the prospects are not well designed or because the policies are imposed without considering the interests of the stakeholders. Moreover, CBM may not lead to successful management of the LCR or any other CPR, even when there is a strong predisposition in favor of self-governance. The bio-physical condition and the variability and uncertainty of resources play important roles. Hence, our focus on the propensity of a community to adopt self-governance provides information about only part of the puzzle to improve the management of the CPR.

Two additional points should be noted. First, as expected in *ex-ante* analysis, at the time of the survey we did not have specific rules to show fishers the form that CBM might take in the fishery. This increases the level of uncertainty and may affect the responses of the fishers to the survey. Finally, in our LCR application we had a weak measure of condition six, assessed through one question to the fishermen. As we note, it would have been better to have reliable statistics indicating whether the population of fishers is stable or not.

Despite these caveats, we do feel that this approach could prove valuable. Ex-ante assessment of the potential for self-governance could certainly be useful. In some cases CPR users have received help from the government officials by giving technical inputs and/or speeding and control the early stages of the process (Townsend and Sutton 2008). In other cases CPR users and government share the management. In either case, having an indication of whether the policy is likely to work and the dimensions that might require the most attention could save time and money, valuable inputs in the policy making process. We see a growing need for such analysis; Agrawal (2003) notes that more than 50 countries now involve communities as in environmental decision-making.

The approach that we propose and implement is built on the solid foundation of Ostrom' work, which distills the experiences in a large set CPRs around the globe. Ostrom (1990) highlighted the first five conditions as the most important. The literature explains the relevance of cooperation and trust but also emphasizes the low cost of monitoring and enforcement for a successful self-governance (Basurto 2008; Ostrom 2009). Ex-ante assessment as we propose would not only help communities and policy makers in each application, but as the approach is replicated in more systems, it will provide valuable baseline data that can greatly help in our understanding of the relationship between ex-ante conditions and

ex-post success, thus contributing greatly to our understanding the management of common-pool resources.

Appendix

Table A1: Descriptive statistics of fishing activity in Lázaro Cárdenas Reservoir: n=89.

Variable description	Unit	Avg.	Var	Std dev	Min	Max	Delicias	Palmito	Victoria
Community	# fishers						39	35	15
Age	Years	44.6	259.7	16.1	16	90	42.6	45.8	47.1
Family size	Number	4.4	5.5	2.3	1	15	4.3	4.4	4.5
People <15 years old	Number	1.1	1.9	1.4	–	6	1.0	0.9	1.7
Years of school	Years	6.0	6.3	2.5	–	12	6.0	5.6	6.7
Fisher experience	Years	23.9	223.8	15.0	1	60	20.7	27.4	24.4
Labor	Hr/week	26.7	194.2	13.9	–	63	20.3	36.1	22.0
Catch Jan (p/week)	Kg	153.1	46,371	215.3	–	1150	151.3	170.0	119.7
Revenue Jan (p/week)	$000*	2.9	12,436	3.5	–	19	2.7	3.0	3.2
Catch last week	Kg	92.3	19,759	140.6	–	920	61.1	137.9	69.7
Revenue last week	$000*	1.4	1855	1.4	–	8	1.1	1.9	1.0
Nets used last week	# nets	6.6	13.6	3.7	–	15	6.5	7.4	4.9
Days fishing	# days	5.7	3.0	1.7	–	7	5.4	6.0	6.1
Gas cost	($ week)*	275.8	69,542	263.7	–	1400	242.3	324.7	251.6
Boat length	Mt	4.3	0.6	0.8	3	6	4.2	4.4	4.2
Engine power	HP	20.0	50.0	7.1	5	48	20.0	21.9	14.1
Age of the boat	Years	14.9	87.0	9.3	1	50	14.0	16.3	14.2
Age of motor	Years	11.4	84.1	9.2	0	35	11.0	11.0	13.7
Fixed cost	$ (000)*	16.0	180,517	13.4	–	64	13.4	19.9	14.0
Nets cost	$ (000)*	1.2	573	0.8	–	3	1.2	1.5	0.8
Maintenance cost	$ (000)*	0.9	1933	1.4	–	7	0.8	1.3	0.5
Number of dependents	# people	3.1	3.4	1.8	–	9	3.0	3.2	2.9
Income from fishing	$000*	0.5–0.6	0.8–1.0	0.2–0.3	<0.2	>1.5	0.3–0.4	0.6–0.7	0.4–0.5
Total income last week	$000*	1–2	<1	<1	<1	6–7	<1	1–2	1–2

**All monetary values are in Mexican pesos.*

Literature cited

Acheson, J. M. 2006. Institutional Failure in Resource Management. *Annual Review of Anthropology* 35(1):117–134.

Agrawal, A. 2003. Sustainable Governance of Common-Pool Resources: Context, Methods, and Politics. *Annual Review of Anthropology* 32(1):243–262.

Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. A Framework to Analyze the Robustness of Social-Ecological Systems from an Institutional Perspective. *Ecology and Society* 9(1):18.

Andrew, N. L., C. Bene, S. J. Hall, E. H. Allison, S. Heck, and B. D. Ratner. 2007. Diagnosis and Management of Small-Scale Fisheries in Developing Countries. *Fish and Fisheries* 8(3):227–240.

Baland, J. M. and J. P. Platteau. 1999. The Ambiguous Impact of Inequality on Local Resource Management. *World Development* 27(5):773–788.

Basurto, X. 2005. How Locally Designed Access and Use Controls Can Prevent the Tragedy of the Commons in a Mexican Small-Scale Fishing Community. *Society and Natural Resources* 18(7):643–659.

Basurto, X. 2008. Biological and Ecological Mechanisms Supporting Marine Self-Governance: The Seri Callo-de-Hacha Fishery in Mexico. *Ecology and Society* 13(2):20.

Berkes, F. 2006. From Community-Based Resource Management to Complex Systems: The Scale Issue and Marine Commons. *Ecology and Society* 11(1):45.

Campbell, R. 1985. Background for the Uninitiated. In *Paradoxes of Rationality and Cooperation: Prisoner's dilemma and Newcomb's problem*, eds. R. Campbell and L. Sowden, 3–44. Vancouver: University of British Columbia Press.

Carifio, C. and R. J. Perla. 2007. Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Likert Scales and Likert Response Formats and their Antidotes. *Journal of Social Sciences* 3(3):106–116.

Clark, C. W. 1980. Restricted Access to Common Property Fishery Resources: A Game Theory Analysis. In *Dynamics Optimization and Mathematical Economics,* 117–130. New York: Springer.

Dasgupta, P. S. and G. M. Heal. 1979. *Economic Theory and Exhaustible Resources*. Cambridge, UK: Cambridge University Press.

Dawes, R. M. 1975. Formal Models of Dilemmas in Social Decision Making. In *Human Judgment and Decision Process: Formal and mathematical approaches*, eds. M. F. Kaplan and S. Schwartz, 87–117. New York: Academic Press.

Degnbol, P., H. Gislason, S. Hanna, S. Jentoft, N. J. Raakjær, S. Sverdrup-Jensen, and D. C. Wilson. 2006. Painting the Floor with a Hammer: Technical Fixes in Fisheries Management. *Marine Policy* 30(5):534–543.

Dietz, T., E. Ostrom, and P. C. Stern. 2003. The Struggle to Govern the Commons. *Science* 302(5652):1907–1912.

FAO. 1996. *Informe de Pesca 552*: Informe de la consulta técnica de la copescal sobre el manejo de la pesca en embalses de América Latina.

La Habana, Cuba: Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO).

Gautam, A. P. and G. P. Shivakoti. 2005. Conditions for Successful Local Collective Action in Forestry: Some Evidence from the Hills of Nepal. *Society and Natural Resources* 18(2):153–171.

Gordon, H. S. 1954. The Economic Theory of a Common-Property Resource: The Fishery. *The Journal of Political Economy* 62(2):124–142.

Grafton, R. Q., J. E. Kirkley, T. Kompas, and D. Squires. 2006. *Economics for Fisheries Management*. Hampshire, England: Ashgate Publishing Limited.

Grafton, R. Q., R. Hilborn, L. Ridgeway, D. Squires, M. Williams, S. Garcia, T. Groves, J. Joseph, K. Kelleher, T. Kompas, G. Libecap, C. G. Lundin, M. Makino, T. Matthiasson, R. McLoughlin, A. Parma, G. San Martin, B. Satia, C.-C. Schmidt, M. Tait, and L. X. Zhang. 2008. Positing Fisheries in a Changing World. *Marine Policy* 32(4):630–634.

Grafton, R. Q., T. Kompas, R. McLoughlin, and N. Rayns. 2007. Benchmarking for Fisheries Governance. *Marine Policy* 31(4):470–479.

Hackett, S., E. Schlager, and J. Walker. 1994. The Role of Communications in Resolving Common Dilemmas. Experimental Evidence with Heterogeneous Appropriators. *Journal of Environmental Economics and Management* 27(2): 99–126.

Hanna, S. 1995. Efficiencies of User Participation in Natural Resource Management. In *Property Rights and the Environment: Social and Ecological Issues,* eds. S. Hanna and M. Munasinghe. Washington, DC: The Beijer International Institute of Ecological Economics and World Bank.

Hardin, G. 1968. The Tragedy of the Commons. *Science* 162(3859):1243–1248.

Hilborn, R. 2007a. Moving to Sustainability by Learning from Successful Fisheries. *Ambio* 36(4):296–303.

Hilborn. R. 2007b. Reinterpreting the State of Fisheries and their Management. *Ecosystems* 10(8):1362–1369.

Hirsch-Hadorn, G., H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, and E. Zemp, eds. 2008. *Handbook of Transdisciplinary Research*. Switzerland: Springer.

INEGI. 2005. XII Censo General de Población y Vivienda. México, México City: Instituto Nacional de Estadística, Geografía e Informática (INEGI).

Jimenez-Buedo, M. and L. M. Miller. 2009. Experiments in the Social Sciences: The Relationship between External and Internal Validity. Paper Presented at the SPSP: Society for Philosophy of Science in Practice Workshop. Minn. Minnesota, June 18–20, 2009.

Johnson, R. A. and D. W. Wichern. 2002. *Applied Multivariate Statistical Analysis*. Cambridge, MA: MIT Press.

Jolliffe, I. T. 2002. *Principal Component Analysis*. Springer series in statistics, 2nd ed. New York: Springer.

Lloyd, W. F. 1977. On the Checks to Population. In *Managing the Commons*, eds. G. Hardin and J. Baden. San Francisco: Freeman.

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

Ostrom, E. 1999. Self Governance and Forest Resources. Center for International Forestry Research. Plenary Presentation, International CBNRM Workshop. Washington DC, USA, 10–14 May 1998.

Ostrom, E. 2005. *Understanding Institutional Diversity.* Princeton, New Jersey: Princeton University Press.

Ostrom, E. 2007. A Diagnostic Approach for Going Beyond Panaceas. *Proceedings of the National Academy of Sciences (PNAS)* 104(39):15181–15187.

Ostrom, E. 2009. A General Framework for Analyzing Sustainability of Social Ecological Systems. *Science* 325(5939):419–422.

Paavaloa, J. 2007. Institutions and Environmental Governance: A Reconceptualization. *Ecological Economics* 63(1):93–103.

Russell, B. H. 2006. *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. Lanham, Maryland: Rowman AltaMira Press.

Salas, S., R. Chuenpagdee, J. C. Seijo, and A. Charles. 2007. Challenges in the Assessment and Management of Small-Scale Fisheries in Latin America and the Caribbean. *Fisheries Research* 87(2007):5–16.

Sarker, A. and T. Itoh. 2003. The Nature of the Governance of Japanese Irrigation Common-Pool Resources. *Society and Natural Resources* 16(2):159–172.

Sissenwine, M. P. and P. M. Mace. 2003. Governance for Responsible Fisheries: An Ecosystem Approach. Paper Presented at the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem. Reykjavik, Iceland, 1–4 October 2001.

Stiftung, B. 2009. *Sustainable Governance Indicators 2009*: Policy Performance and Executive Capacity in the OECD. USA – Indiana: Bertelsmann Stiftung – University of Indiana Press.

Tovar, C. L., F. P. Gelwick, and F. A. Rojo. 2009. *Diagnóstico de la actividad pesquera en la presa Lázaro Cárdenas del Municipio de Inde, Durango*. Special Publication No 29, 30 Sept. INIFAP-Conacyt-SAGARPA.

Townsend, R. E. 2010. Transactions Costs as an Obstacle to Fisheries Self-Governance in New Zealand. *Australian Journal of Agricultural and Resource Economics* 54(3):301–320.

Townsend, R. E. and R. Sutton. 2008. Fisheries Self-Governance: New Directions in Fisheries Management. Food and Agriculture Organization of the United Nations (*FAO*) *Fisheries Technical Paper* 504:1.

Trochim, W. M. 2006. *The Research Methods Knowledge Base*, (2nd ed). Internet WWW page, at URL: <http://www.socialresearchmethods.net/kb/> (version current as of October 20, 2006).

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

Wilson, R. K. 1985. Constraint on Social Dilemmas: An Institutional Approach. *Annals of Operations Research* 2(1):183–200.

World Bank. 1991. *Managing Development: The Governance Dimension*. Discussion Paper No 34899. Paper prepared by a Task Force with participation from the Operations; Policy, Research and External Affairs; Legal; Corporate Planning and Budget; and Finance Complex: Washington, DC.

Worm, B., E. B. Barbier, N. Beaumont, J. E. Duffy, C. Folke, B. S. Halpern, J. B. C. Jackson, H. K. Lotze, F. Micheli, S. R. Palumbi, E. Sala, K. A. Selkoe, J. J. Stachowicz, and R. Watson. 2006. Impacts of Biodiversity Loss on Ocean Ecosystem Services. *Science* 314(5800):787–790.

Worm, B., R. Hilborn, J. K. Baum, T. A. Branch, J. S. Collie, C. Costello, M. J. Fogarty, E. A. Fulton, J. A. Hutchings, S. Jennings, O. P. Jensen, H. K. Lotze, P. M. Mace, T. R. McClanahan, C. Minto, S. R. Palumbi, A. M. Parma, D. Ricard, A. A. Rosenberg, R. Watson, D. Zelle. 2009. Rebuilding Global Fisheries. *Science* 325(5940):578–585.