Global Environmental Change 48 (2018) 151–157

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Local response to global uncertainty: Insights from experimental economics in small-scale fisheries

E.M. Finkbeiner[a,e,*], F. Micheli[a,e], A. Saenz-Arroyo[b], L. Vazquez-Vera[c], C.A. Perafan[b], J.C. Cárdenas[d]

[a] Stanford University Hopkins Marine Station, 120 Ocean View Boulevard, Pacific Grove, CA 93950, USA
[b] Departamento de Conservación de la Biodiversidad, El Colegio de la Frontera Sur (ECOSUR), Carretera Panamericana y Periferico Sur S/N, Barrio Maria Auxiliadora, CP 29290, San Cristóbal de las Casas, Chiapas, Mexico
[c] Comunidad y Biodiversidad A.C., Francisco I. Madero No. 2050 Col. Centro, CP 23000, La Paz, Baja California Sur, Mexico
[d] Universidad de los Andes Facultad de Economía, Calle 19A No. 1-37 Este, Bloque W (W-803), Bogotá, Colombia
[e] Center for Ocean Solutions, 99 Pacific Street, Suite 555E, Monterey, CA 93940, USA

ARTICLE INFO

Keywords:
Experimental economics
Uncertainty
Common-pool resources
Small-scale fisheries
Global change

ABSTRACT

Global change has systematically increased uncertainty for people balancing short-term needs with long-term resource sustainability. Here, we aim to understand how uncertainty drives changes in human behavior and the underlying mechanisms mediating use of behavioral strategies. We utilize a novel behavioral approach – dynamic common-pool resource economic experiments in the field – and apply it to small-scale fisheries as a system that is particularly vulnerable to global change. Contrary to previous research, we find that when faced with higher uncertainty, resource users are choosing to reduce harvest to compensate for potential future declines. Correlates of this behavior include the capacity for social learning, previous exposure to uncertainty, and strong local institutions. These findings have important implications for any local system facing increased uncertainty from global change. Given adequate access to resources and rights, local communities can be active agents of change, capable of addressing and mitigating impacts of processes generated by higher scales.

1. Introduction

1.1. Global change and common-pool resources

In an era of global change, local systems are becoming increasingly connected across scales, at times creating opportunities, other times exacerbating vulnerabilities (Adger, 2006). This phenomenon has systematically increased uncertainty for people balancing short-term needs with long-term resource sustainability. Small-scale fisheries are exemplar of local systems quickly becoming connected across scales vis-à-vis climate change, global markets, distant water fleets, migration, and international conservation and development policies (Adger et al., 2005; Armitage and Johnson, 2006; Berkes et al., 2006; Perry et al., 2011). Employing the vast majority of the world's fishers, and contributing roughly half of global fisheries production, healthy small-scale fisheries are critical for food security, livelihoods, and sustainability of marine systems (Berkes et al., 2001).

The ease of exhausting marine resources given technological advances, coupled with the difficulty in preventing others from harvesting what is left behind, make fisheries a text-book example of a common-pool resource. As such, resource users in fisheries face the same common-pool resource dilemma as in forests, pastures, and groundwater systems – how to balance the short-term, *individual* benefits of harvesting with the long-term, *shared* costs of overharvesting (Bromley et al., 1992; Ostrom, 1990; Ostrom et al., 2002).

Assuming that resource users are motivated by maximizing personal short-term profit, Garrett Hardin (Hardin, 1968) famously hypothesized that all common-pool resources will inevitably face their destiny as a tragedy of the commons. This seminal theory suggests that resource users, and fishers in particular (Gordon, 1954), are not capable of environmental or resource stewardship alone, and thus require some sort of external intervention. Decades later, empirical evidence has shown that this is not always the case, and collective action, cooperation, and stewardship behavior among resource users can emerge in the absence of external intervention (Bromley et al., 1992; Ostrom, 1990; Ostrom et al., 2002). However, as fishers and other resource users are now confronted with an increasing rate of change in environmental and socio-economic conditions, the fundamental unanswered question becomes, how does uncertainty and unpredictability change behavior?

* Corresponding author.
E-mail address: elenamf@stanford.edu (E.M. Finkbeiner).

https://doi.org/10.1016/j.gloenvcha.2017.11.010
Received 26 May 2017; Received in revised form 25 October 2017; Accepted 23 November 2017
0959-3780/

1.2. Behavioral change under high uncertainty

Early work suggests that when environmental uncertainty increases, harvesting pressure also increases, resulting in higher probabilities of resource depletion and poor collective outcomes (Budescu et al., 1995, 1992; Rapoport et al., 1993, 1992). Subsequent work suggests that the relationship between cooperation and uncertainty remains inconclusive (van Dijk et al., 1999). Individuals do not act similarly and as uncertainty increases, decisions are mediated by social value orientations (Roch and Samuelson, 1997). For example, non-cooperators are more likely to overharvest under conditions of uncertainty; but the reverse is true for cooperators – uncertainty will foster cooperation (Biel and Garlinc, 1995; Roch and Samuelson, 1997). In addition to social value orientation, behavior is also contingent on the type of uncertainty (i.e. environmental versus social) (Kocher et al., 2015; van Dijk et al., 1999; Wit and Wilke, 1998), and the degree of temporal discounting (i.e. intra- versus inter-generational) (Jacquet et al., 2013).

How fishers and other resource users anticipate and deal with change and uncertainty (termed adaptive capacity) (Smit and Wandel, 2006) involves difficult trade-offs and has direct implications for their immediate and long-term well-being and the ecological resilience of the environments they depend on (Cinner et al., 2011). Fishing less is an example of an adaptive strategy potentially dampening resource decline, while fishing more in response to uncertainty or perceived declines is an adaptive strategy capable of amplifying destructive feedbacks, and undermining long-term resilience (Cinner et al., 2011). Importantly, adaptive strategies are contingent on available opportunities and resources (Adger, 2006; Finkbeiner, 2015; Leach et al., 1999); not all fishers can afford to fish less and incur short-term costs when future declines are anticipated. The main objectives in this study are to understand how uncertainty drives changes in harvesting behavior of a common pool resource, and what mechanisms foster or constrain use of alternative adaptive strategies.

2. Methods

2.1. Field experimental economics

To test behavioral responses to uncertainty, we used a field experimental economics approach (Smith, 1982), and evaluated individual choices under a variety of circumstances and conditions (Cardenas and Carpenter, 2005). Relative to purely observational techniques, using an experimental approach in behavioral research reduces confounding effects, and allows for replication and direct comparison among different groups (Cardenas and Carpenter, 2005; Poteete et al., 2010). Experimental economics has recently been brought from the laboratory to the field, engaging actual stakeholders (Cardenas, 2000; Cardenas and Carpenter, 2005; Cárdenas, 2009), and thus increasing external validity of results (Gelcich et al., 2013). Used in conjunction with other techniques, such as surveys and interviews, experimental economics can address *why* behavior changes, in addition to *how* (Castillo et al., 2011).

2.2. Study system

The small-scale fisheries along the Pacific coast of the Baja Peninsula in Mexico (Fig. 1) were selected as a model system for this research due to the critical importance of fisheries and highly dynamic and uncertain conditions small-scale fishers in the region face (Brusca et al., 2004; Lluch-Cota et al., 2007). This system supports the production and harvest of highly lucrative fisheries products such as abalone (*Haliotis* spp.) and lobster (*Panulirus* spp.), exported directly to international markets. At the same time, seasonal and inter-annual upwelling-driven changes in nearshore physical and biological conditions result in high local exposure to change and disturbance (Collins et al., 2002; Pérez-Brunius et al., 2006). In recent years, high variability in oceanographic conditions, including high temperatures and hypoxia, has resulted in mass mortalities of abalone and other invertebrates, reducing local fished species' abundance by up to 75% (Micheli et al., 2012). Fishers in this region are generally organized into cooperatives at the community level with varying degrees of organization, collective action, and capacities of adapting to change (Finkbeiner and Basurto, 2015; McCay et al., 2014).

2.3. Experimental design

To understand how uncertainty drives changes in fishing behavior we used a dynamic common-pool resource game with realistic biological and economic parameters and real monetary incentives (Janssen, 2010) to simulate decisions fishers make in their abalone fishery, based on long-term oceanographic, biological, and socio-economic research in the region. We conducted 36 distinct sessions of economic games with a total of 180 fishers from six cooperatives (Fig. 1), testing the effects of six different treatments on fishing behavior (Table 1). In groups of five, fishers decided how many abalone they wished to individually harvest from a dynamic common-pool stock over the course of 15 rounds. For each abalone harvested, fishers would receive $15 Mexican Pesos, and could potentially make the equivalent of a normal day of fishing over the course of the game. The initial stock of the resource was 100 units. Each round was representative of a fishing season; as such, the stock grew 10% of its remaining population size in between each round. Fishers did not know how much other individual players were harvesting; only the total group capture was disclosed in each round. Individual fishers could never harvest over five abalone per round. Thus, no more than 25 abalone could be taken collectively in each round. Even so, if all fishers extracted the maximum allowable catch, the stock could be depleted by the fifth round effectively ending the game and the potential to make more money for the remaining 10 rounds.

As the game proceeded and the abalone stock declined, the total number of abalone each individual could harvest decreased (Supplemental material), just as catch per unit effort would decrease during resource scarcity in real fishery dynamics. Each game included two treatments with fifteen rounds of decision-making each. Participating fishers also completed a post-experiment survey to collect demographic information and to ascertain perceptions on different sources of uncertainty and risk they experience in real life (Supplemental material). The economic games concluded with an open discussion among all participants about their reactions and thoughts on the games and reflections about how this approximates decision-making in a fishery in real life.

2.4. Experimental treatments

The above dynamics describe the baseline treatment (Table 1, Treatment A1). During the subsequent treatment (communication) (Table 1, Treatment A2), participants were given permission to have face-to-face communication for three minutes in between each round. During this time, participants could talk about anything related to the game.

In the environmental uncertainty treatment (Table 1, Treatment B1), participants were told there was a 1/10 probability of a mass mortality event affecting 50% of the remaining abalone stock. To operationalize this, a ten-sided dice was thrown in between each round visible to all the participants. If the dice landed on a five, then 50% of the remaining abalone would be removed from the stock. If the dice landed on any other number, the next round would commence as usual. In the subsequent treatment (environmental uncertainty with communication) (Table 1, Treatment B2), the same rules apply as in the environmental uncertainty treatment – there is a 1/10 probability that a mass mortality will reduce the remaining stock by half in each round – however, participants are also allowed to communicate (the same rules as in the communication treatment apply).