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Economic behavior of fishers under climate-related uncertainty: Results from field experiments in Mexico and Colombia

José Santiago Arroyo Mina[a], Daniel A. Revollo Fernández[b,*], Alonso Aguilar Ibarra[c], Nikolaos Georgantzis[d]

[a] Grupo de Investigación Desarrollo Económico y Economía Internacional, Centro de Estudios e Investigaciones en Desarrollo Regional (CEIDER), Universidad Santiago de Cali, Cali, Colombia
[b] Instituto de Investigaciones Económicas, UNAM, CONACYT-Universidad Autónoma Metropolitana, Unidad Azcapotzalco, Av. San Pablo No. 180, Col. Reynosa Tamaulipas, Del. Azcapotzalco, Ciudad de México, México, CP 02200
[c] Instituto de Investigaciones Economicas, UNAM, Circuito Mario de la Cueva s/n, Ciudad Universitaria, México, DF, C.P. 04510
[d] LEE-Economics Department, Universitat Jaume I & School of Agriculture, Policy and Development, University of Reading, Whiteknights, PO Box 237, Reading, RG6 6AR, UK

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ABSTRACT

This paper presents the results of economic experiments run among fishermen from the Mexican and Colombian Pacific. The experimental design aims at studying behavior under uncertainty concerning the possible effects of climate change on fisheries. We find that subjects' risk-aversion diminishes the level of catches and changes fishing practices (e.g. adopting marine reserves), provided that fishermen have *ex ante* information on possible climatic consequences. Furthermore, social preferences (e.g. for cooperation and reciprocity) also play an important role regarding extraction from common-pool resources. Other factors, such as income, gender and religion are also found to have some influence. These results have important implications for adaptation actions and the management of coastal fisheries.

1. Introduction

The livelihoods and regional development of millions of people in developing countries depend to a large extent on the fishing sector. For example, several Asian and Latin American countries are among the major fishing nations in the world and their populations receive up to 20% of their protein intake from fish products (FAO, 2012). Furthermore fisheries and aquaculture secure the livelihoods of 10–12 percent of the world's population (FAO, 2014). Nevertheless, although global fish catch has stabilized during the last decades, fish stocks have been depleted in a number of regions worldwide (Worm et al., 2006). A direct consequence of this situation is the risk on food security in a number of regions in the developing world (Srinivasan et al., 2010; Smith et al., 2011).

A changing climate is an additional factor of risk for a number of fisheries, especially for livelihoods in poorer regions (Badjeck et al., 2010). Furthermore, it is well acknowledged that the vulnerability of fishing livelihoods toward climate change impacts will be enhanced by poor fishery management (Brander, 2007; Allison et al., 2009; McIlgorm et al., 2010).

Thus, understanding stakeholders' decisions under these risky scenarios is of paramount importance for adaptation to climate change (Gowdy, 2008). Experimental economics provides a powerful tool for analyzing stakeholders behavior when dealing with common-pool resources (Cárdenas and Ostrom, 2004) and with risky and uncertain situations in general (Sabater-Grande and Georgantzis, 2002; McAllister et al., 2011; Hasson et al., 2012).

Decisions in a fishery, such as the level of catches or whether or not to comply with regulations, depend on a number of factors such as resource availability, rigor in enforcing regulations by the authority, prices and costs of the activity, fishermen's preferences, among other factors. Among the preferences which are relevant in fishing decisions, fishermen's attitudes toward risks entailed in climate hazards play a major role in their actual behavior (Smith and

* Corresponding author.
E-mail addresses: jarroyo@usc.edu.co (J.S. Arroyo Mina), darevollof@conacyt.mx (D.A. Revollo Fernández), aaibarra@unam.mx (A. Aguilar Ibarra), n.georgantzis@reading.ac.uk (N. Georgantzis).

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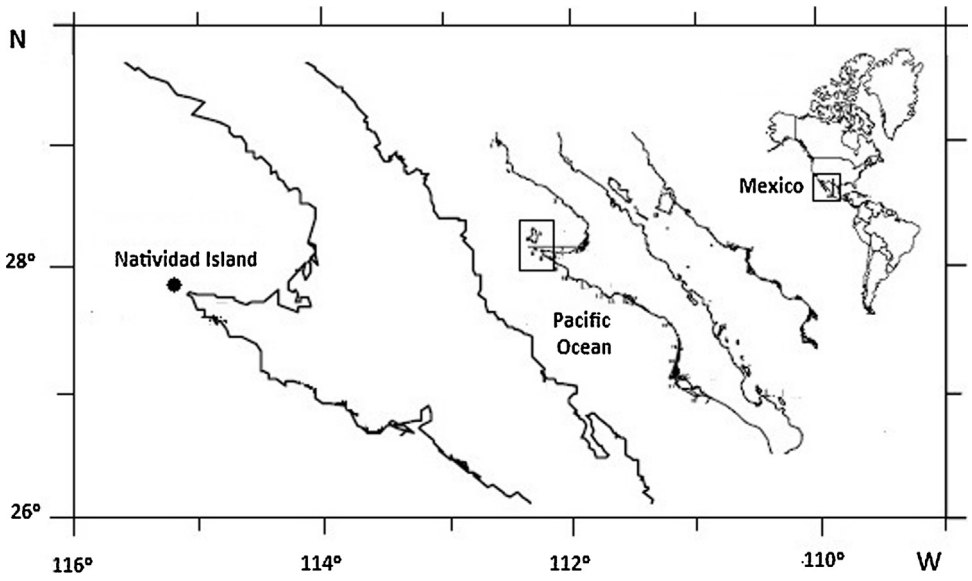

Fig. 1. Natividad Island, Baja Peninsula, Mexico.

Wilen 2005; Eggert and Lokina 2007; Nguyen and Leung 2009; Brick et al., 2011). Furthermore, fisheries is a typical extraction activity of a shared resource, also known as common-pool resource. In such a context, fishers face the dilemma of individual against collective benefits. Experimental economics has proven to be a useful tool to analyze decision-makers' risk attitudes and other-regarding preferences in the laboratory or in the field. Then, attitudes elicited in an experiment reflect the individual behavior and values which have been developed during a subject's social or professional interaction experiences. Therefore, experimental methods can be used to capture attitudes and preferences which both affect and are affected by the subject's real world activity. In this sense, the experiments with populations of fishermen will capture how this specific subject pool will behave in a simulated context resembling their real-life decision-making environment and, consequently, real-world fishery management (Moreno-Sanchez and Maldonado, 2009; Revollo and Ibarra, 2014; Revollo Fernández et al., 2016).

In spite of the regional importance of the fisheries sector in Latin America (Thorpe and Bennett, 2001), few studies in Latin America have used experimental economics for analyzing fishers' behavior in controlled economic environments (for more detail see Table I). Even fewer experimental studies have been carried out on adaptation to climate change (e.g. Hasson et al., 2010; Hasson et al., 2012). In the case of Latin America, Bernal-Escobar et al. (2013) analyzed the adaptation strategies of farmers when confronted to water scarcity due to climate change. Although game theory has been used for studying fisheries and climate change (Bailey et al., 2010), as far as we know, no studies have been published on fisheries' adaptation to climate change using experimental methodology. The aim of this paper is to report results from field experiments on behavior toward climate change among fishermen. We present two studies in Latin America: one deals with the artisanal fisheries of Tribugá Gulf, Colombia; and the other deals with the abalone fishery, off Baja Peninsula, Mexico. We present both cases in detail in the next two sections. In both experiments, real monetary rewards were used to incentivize the decisions made by subjects in a controlled economic environment. In both experiments, the decision-making context involves extraction decisions from a common-pool resource under scenarios of external environmental change, framed as a risk affecting the returns of the extraction process. This paper is divided into five sections: the introduction is followed by materials and methods, results, discussion, and conclusions.

2. Methods

2.1. Local context and study areas

2.1.1. The abalone fishery off Natividad Island, Baja Peninsula, Mexico

In terms of total volume and value, shrimp is the most important species in Mexico, despite the much higher prices of lobster and abalone (10.5 US$ per kilo, vs. 3.5 US$ per kilo of shrimp) (CONAPESCA, 2013). While abalone in Mexico is mostly an export commodity, it indirectly contributes to domestic welfare and food security, since earned money is used to buy local food. It is exploited by 22 fishing cooperatives and generates about 20,000 jobs (both direct and indirect). Abalone catches have diminished to about 10% of the average volume harvested during the 1950s (Revollo and Saenz-Arroyo, 2012). Possible explanations for this sharp decrease are: over-exploitation, environmental change, illegal harvesting, or combinations of these. The fact is that global climatic change is expected to have more impact on vulnerable fisheries. Indeed, ocean acidification will directly affect species with calcium carbonate skeletons (Perry, 2011), such as abalone. Furthermore, there is evidence that an increasing temperature and decreasing dissolved oxygen (i.e. hypoxia) in coastal ecosystems, due to carbon dioxide absorbed by marine waters (Roessig et al., 2004), provokes higher mortality rates in marine invertebrates such as abalones (e.g. Guzmán del Proo et al., 2003).

We present the case of the fishing cooperative that operates in Natividad Island (27°51′09″N/115°10′09″O), located in mid-Baja Peninsula (Fig. 1). Both the fishing cooperative and the NGO Comunidad y Biodiversidad (COBI A.C.) has implemented a pilot program of marine reserves around Natividad Island (Micheli et al., 2012). Under this context, we designed a field experiment with the inhabitants of Natividad Island in order to study the determinants of their behavior in a harvesting experiment, framed as a common-pool resource in the presence of a changing climate.

2.1.2. The tribugá gulf fishery, Colombia

The Tribugá Gulf is located in the northernmost Colombian Pacific, Province of Chocó (N5°30′06″/W77°16′09″), dominated by