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Heterogeneity and the fragility of the first best: Putting the "micro" in bioeconomic models of recreational resources☆

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ABSTRACT

We bridge the non-market microeconomic recreational demand and bioeconomic modeling literatures by constructing a dynamic model to guide optimal management of recreational fisheries. Our model incorporates multiple forms of angler heterogeneity and directly models feedbacks between policy instruments and angler behavior rather than dictating behavior as a social planner. This approach highlights the importance of distinct forms of heterogeneity for price and technology based management. We show that management with a price instrument charged per unit fish mortality or a differentiated charge per trip, an input to fish mortality, fully internalizes the dynamic stock externality when the manager observes agent heterogeneity in stock impacts, but is naïve to heterogeneity in preferences. Unobserved heterogeneity in stock impacts leads to welfare loss that increases with the variance of unobserved stock impacts. When the manager uses technology constraints to manage the fishery, understanding heterogeneity in preference, price, and stock impacts leads to greater social welfare, and understanding all sources of heterogeneity is necessary to optimally manage the resource. Nevertheless,

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technology based management can never replicate the first best. Explicit incorporation of heterogeneity and behavior enables us to show exactly where welfare is lost.

1. Introduction

The foundational theory of the optimal intertemporal management of resources is rooted in commercial examples. The economic literature has placed less emphasis on *recreationally* exploited stocks and their optimal management, despite increasing recognition of recreational users' important role in many systems. This is particularly notable for fisheries. Recreational fisheries can offer significant economic surplus and serve as a locally important source of employment and income despite their small share of most nations' national product (Cisneros-Montemayor and Sumaila, 2010). Recreational catch is often treated as a secondary causal factor in the depletion of many marine fisheries stocks (Cooke and Cowx, 2006; Post et al., 2002). Yet recreational fishing often constitutes a large portion of total fish mortality and may contribute significantly to overall depletion (Coleman et al., 2004; Cooke and Cowx, 2004). Cooke and Cowx (2004) estimate that recreational harvest accounts for 12% of global fisheries harvest. Within the US, 23% of the landings of "populations of concern" – those that are either overfished or experiencing overfishing – are accounted for by recreational harvest (Coleman et al., 2004). This proportion rises to 64% for the US Gulf of Mexico. Recreational harvest is also a major mortality source for many freshwater species (Post et al., 2002).

Diffuseness, heterogeneity, and imperfect observability of users are distinguishing characteristics of many recreational resource systems. These characteristics make the direct pricing of intertemporal stock externalities, prescribed by first best solutions, difficult or infeasible. In this context, extending capital theoretic approaches to consider the optimal "tuning" of imperfectly targeted, but achievable, second best policy instruments can enhance the policy relevance of bioeconomic models.[3]

The nature and extent of agent heterogeneity critically influences the relative efficiency of second best incentive mechanisms. We construct a dynamic single-site bioeconomic model of a recreational fishery with heterogeneous anglers to investigate the interactions between agent heterogeneity, behavior, and policy targeting in a dynamic setting. This model is grounded in a structural model of angler behavior drawn from the recreation demand literature. Our treatment of heterogeneity is general, encompassing variation in the preferences, income, prices and ecological impacts of agents. We thereby contribute to the bioeconomic literature on recreational resource management (Abbott and Wilen, 2009; Anderson, 1993; Homans and Ruliffson, 1997; Mcconnell and Sutinen, 1979; Swallow, 1994; Woodward and Griffin, 2003), which has devoted limited attention to the problem of managing heterogeneous anglers.

Our bioeconomic model makes several methodological contributions. We aggregate the welfare and behavior of heterogeneous agents directly from an underlying structural model of utility maximization. This directly accommodates a wide range of first and second best policy instruments as control variables in a single consistent modeling framework. This method contrasts with the standard approach in bioeconomics and public economics where optimal policy instruments are derived obliquely by resolving the first order conditions of the unregulated model with those of a social planner. While instructive in first best settings, the "standard" approach does not transfer easily to second best instruments and hampers comparisons across various instruments.

We embed a structural model of agent behavior and explicitly incorporate *unobserved* preference heterogeneity to bridge the void between the bioeconomic resource management and recreation

[3] The term "second best" has a long but imprecise history of usage in economics. In general, it refers to the optimal setting of a policy instrument in the presence of preexisting market distortions (Lipsey and Lancaster, 1956). In our partial equilibrium setting, we employ the term to indicate cases where policy or information constraints prevent the achievement of a first-best outcome yet social welfare is nevertheless maximized given these constraints.