Journal of Environmental Economics and Management 62 (2011) 386–401

Contents lists available at ScienceDirect

Journal of Environmental Economics and Management

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

Dissecting the tragedy: A spatial model of behavior in the commons

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ARTICLE INFO

Article history:
Received 21 August 2009
Available online 27 July 2011

Keywords:
Common property
Cooperation
Spatial modeling
Bycatch
Random utility model

ABSTRACT

Much of the discussion of the tragedy of the commons focuses on aggregate impacts, often in data-poor developing country settings. Few non-experimental empirical studies shed light on contextual circumstances driving the extent of rent dissipation and overexploitation. We utilize a high-resolution data set to estimate a behavioral model of fishermen's spatial choices. A unique policy setting allows us to measure the degree to which individual fishermen's choices appear aimed at mitigating the tragedy of the commons in a small numbers setting. We find evidence of partial mitigation in excess of what we would expect under pure self-interest but short of what would occur under group-maximizing behavior. We also examine how contextual factors in the fishery shape the degree of cooperation within the fishing season and find evidence that competition for the common pool resource distorts fishermen's implicit cost of distance—creating a form of "common property inertia".

1. Introduction

Our understanding of the nature of exploitation of common property resources has evolved considerably since early work [7,24] that gave rise to the characterization of the "tragedy of the commons". A major contribution of economists has been to point out that biological overexploitation and rent dissipation are symptoms of the more fundamental cause of the tragedy, namely lack of secure rights to resource access [21]. Creating secure rights thus has been one policy avenue for fixing the problem, such as the creation of individual tradable quotas (IFQs) in fisheries that guarantee rights to a share of total allowable catch (TAC).

Observation has revealed that the most egregious instances of the tragedy of the commons occur under pure open access [12]. However, when access is confined to a restricted groups of users (by law, coercion or isolation), the tragedy may be partially if not fully mitigated [35,39–41]. The extent to which mitigation occurs seems to depend importantly on the size of the group of users [9,39]. Small group sizes mitigate overuse in two ways. First, small group sizes lower transaction costs of spontaneous cooperative self-governance [38]. Second, they may foster non-cooperative mitigation if individuals recognize that their own impacts have a significant impact on the resource [1]. Theoretical and experimental research often predicts a gradation of behavior from rent maximizing (with one participant), to partial rent dissipation with small numbers, finally to complete dissipation with large numbers of atomistic participants. Importantly, what constitutes "large" or "small" numbers is dependent upon various contextual factors [53] and complete dissipation may occur for a very small number of participants.

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doi:10.1016/j.jeem.2011.07.001

Existing empirical work on common property resource exploitation often focuses on common use in developing nation and artisanal contexts where data are often sparse or of poor quality, either cross-sectional survey data, or short-duration time series. These limitations preclude robust modeling of individual behavior and rigorous testing of fundamental predictions of theories of commons use. In this paper we exploit an unusually detailed and high quality data set covering a unique policy setting from a developed country setting. Our data capture repeated choices of fishing location by a relatively small and stable group of fishermen in the multi-species groundfish fishery of the Eastern Bering Sea. The fishery has limited access and hence does not face the prospects of open access rent dissipation. Decision makers do not have secure *individual* rights to resource access but rather face common TAC constraints on their targeted catch. What is uniquely important about our setting is that fishermen also face a common-pool limit on their catch of a regulated *bycatch* species. Fishermen may not retain bycatch species for sale, but collective bycatch is monitored and if the bycatch TAC is reached before the target species TAC, the fishery is shut down regardless of remaining uncaught target species' TAC.

This policy setting provides a unique way to identify common property overuse behavior in a small numbers setting. Theory suggests that if the bycatch quota is sufficiently scarce, a large number of fishermen in such a setting will engage in a "race to bycatch" that prematurely closes the target fishery [1,11]. With a large number of fishermen, each decision maker sees himself as atomistically insignificant and pursues the target species without regard to the joint take of bycatch and its effect on impending closures. However, if numbers are small enough, theory suggests individual skippers may avoid bycatch by foregoing areas with high joint catch of target species and bycatch species in favor of areas with lower expected bycatch rates. The extent to which fishermen behave as if there is a shadow cost of bycatch is thus a novel test of the behavior of users of a common property resource. If numbers are small enough, we should observe individual avoidance behavior that, at minimum, reflects decision maker's awareness that another pound of bycatch brings him closer to a premature bycatch-induced closure. More generally, a small group would be expected to behave in ways that reflect recognition of the interdependence of individual decisions in causing premature closures. Mitigation behavior could either be non-cooperative or cooperative, with outcomes ranging from zero avoidance behavior to behavior closer to sole-owner, optimized avoidance.

We utilize a spatial random utility model (RUM) that specifies the attractiveness of a site as a function of not only its expected revenues and costs, but also its expected bycatch. By careful specification of the shadow cost of bycatch we are able to rigorously test for significant individual conservation of the common pool bycatch quota. The rich panel data allow us to model contextual factors that drive the evolution of bycatch avoidance over a season while also facilitating the incorporation of some new methods of treating expectations formation and heterogeneity across decision makers. These modeling innovations expand the frontiers of spatial modeling of micro-behavior as well as offering new insights about behavior.

Our results suggest that, in this setting of 19 skippers piloting vessels owned by 9 firms, there is apparent individual cognizance of the cost of premature closure associated with bycatch. Fishing location choices reveal positive shadow prices for halibut bycatch, signifying a willingness to avoid bycatch at some sacrifice to immediate profits. This willingness to avoid bycatch peaks near the end of the season. The size of the bycatch avoidance effect is larger (about 4 times larger) than would be expected based on an individual's calculus of the average "own" effect of postponing the season closure by a marginal amount. However, it is not large enough to be consistent with cooperative, group profit-maximizing behavior. Our results square with skipper interviews that describe a mix of individually motivated non-cooperative avoidance melded with group enforced norms and occasional cajoling and shaming of high bycatch vessels.

2. The North Pacific groundfish fleet: history and management

The subjects of this study are a group of 19 catcher–processor vessels (owned by 9 companies) plying the federal waters of the Bering Sea and Aleutian Islands. They utilize bottom trawl nets to catch a range of species that are minimally processed (i.e. "head and gut") and frozen for export. These vessels are fairly homogeneous in design, with lengths from 110 to 230 ft. The primary targets in the Bering Sea are yellowfin sole and rock sole with other species such as Pacific cod and rockfish playing an important supplementary role.

Size and processing capabilities enable the vessels to stay at sea for several weeks prior to making port. Broad oceanographic and climatic trends influence the movements of target and bycatch species over the grounds and hence play a key role in the spatial decision making of vessel captains. Species exhibit differing degrees of movement on varying spatial and temporal scales, leading to opportunities to target or avoid particular species over the course of the season.

While the natural environment is critical in shaping skipper choice, the constraints embodied in the regulatory system are equally fundamental. Regulatory constraints include: limited entry, time and area closures and common pool quotas on both target and bycatch species. The existence of common pool quotas for both targeted and regulatory bycatch species is the most important feature of the fishery for the purposes of this research. Prior to the beginning of each season, the North Pacific Fishery Management Council (NPFMC) establishes a biologically determined TAC limit for each targeted species. Catch is monitored in-season using data from onboard observers and weekly production reports. If regulators anticipate that a TAC will be met in the near future, they close the fishery to "directed fishing", a status that allows the species to be retained, but in greatly reduced proportions. These closures remove the incentive for targeting of the species in question while allowing the harvest of other species.

Similarly to target species, fishermen also face common quotas on "prohibited species catch" (PSC), named because regulations require the groundfish fleet to discard 100% of the catch of these species. This discourages fishermen from pursing the targets of other non-trawl fisheries administered by entities besides the NPFMC. For our purposes, the quota