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The triple bottom line: Meeting ecological, economic and social goals with individual transferable quotas

J.-C. Péreau [a,*], L. Doyen [b], L.R. Little [c], O. Thébaud [d]

[a] CNRS-GRETHA (UMR 5113), Groupe de Recherche en Economie Théorique et Appliquée, Université de Bordeaux, Av Leon Duguit, 33608 Pessac, France
[b] CNRS-MNHN (UMR 7204), Dpt Ecologie et Gestion de la Biodiversité, 55 rue Buffon, 75005 Paris Cedex, France
[c] CSIRO Marine and Atmospheric Research, GPO Box 1538, Hobart Tasmania 7001, Australia
[d] CSIRO Marine and Atmospheric Research, 233 Middle St., Cleveland, Queensland 4163, Australia

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ABSTRACT

This paper deals with the sustainable management of a renewable resource based on individual and transferable quotas (ITQs) when agents differ in terms of harvesting costs or catch capability. In a dynamic bio-economic model, we determine the feasibility conditions under which a fishery manager can achieve sustainability objectives which simultaneously account for stock conservation, economic efficiency and maintenance of fishing activity for the agents along time. We show how the viability of quota management strategies based on ITQ depends on the degree of heterogeneity of users in the fishery, the current status and the dynamics of the stock together with the selection of TAC schedules. In particular for a given stock, we compute the *maximin* effort for a given set of agents and we derive the maximal number of active agents for a given guaranteed effort. An application to the nephrops fishery in the Bay of Biscay illustrates the results.

1. Introduction

Numerous renewable resources are under extreme pressure worldwide, particularly in marine fisheries [26]. A key reason for this is the common pool status which creates incentives for fishing firms to invest in fishing capacity beyond collectively efficient levels [27,36,37]. This has led to the recognition that access regulations are important in guiding resource use on sustainable paths that respect the ecological, economic and social goals of the triple bottom line [24].

Restricting access to fisheries and allocating shares of a Total Allowable Catch (TAC) as secure harvesting privileges to fishers has been proposed as a promising way forward in this domain [9,28,7]. With costs and fishing abilities varying among fishers, the addition of transferability of individual quotas (ITQs) allows fishers to choose between continuing to fish or transferring (by sale or lease) their quota holdings to other, more efficient, fishers. ITQs thus offer a decentralized method of allocating catch possibilities within fisheries which should promote efficient resource use [10,29]. Recent reviews of the experience with ITQs in fisheries show that they are increasingly being adopted, and that this has been associated with improved status of fish stocks and levels of catches (see e.g. [48,14,8,23]).

* Corresponding author.
E-mail addresses: jean-christophe.pereau@u-bordeaux4.fr (J.-C. Péreau), lucdoyen@mnhn.fr (L. Doyen), Rich.Little@csiro.au (L.R. Little), Olivier.Thebaud@csiro.au (O. Thébaud).

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In contexts where excess capacity in the fishery exists, introducing ITQs should lead to a decrease in fishing capacity as catch privileges are transferred to the more efficient fishers [38]. Indeed, an immediate consequence of allowing individual quotas to be transferred has in many cases been a rapid reduction in fishing capacity, as measured by, the number of registered vessels, or the number of active fishers and firms. Although this is an impact that could be expected, and to some extent desired, it has turned out to be one of the key points of debate on the opportunity and effectiveness of introducing ITQs as a management instrument in fisheries [49]. This is due in particular to the resulting concentration of fishing privileges in the hands of smaller groups, and to the reduced nominal size of fishing activities in coastal areas [13,48,32]. The social consequences of these reductions have in some cases been considered important enough that they may outweigh the expected ecological and economic benefits of the regulations, leading to question their acceptability and feasibility, as was illustrated during the EU consultation on "rights-based" fisheries management that preceded the revision of the Common Fisheries Policy [1].

In this paper, we aim to address the tradeoffs that arise between conservation and the drive for economic efficiency and social objectives in an ITQ managed fishery. We develop a dynamic bio-economic model of a fishery composed of heterogeneous participants and including an explicit representation of the quota market. There have been various approaches to modeling ITQs in fisheries, ranging from analytical models [5,35,6,33,11], linear programming approaches [39], through to models that use numerical simulation [21,30,31,41]. Despite the importance granted to social considerations in debates on ITQs, these have only rarely been explicitly included as an objective or a constraint in bio-economic models of fisheries. Heaps [35] examined how a change in the biomass of the fish stock affects the number of participants in a fishery managed with a TAC and ITQs. [6] analyzed the distributional issues of the ITQ system and showed that it can improve the welfare of some agents (the fishing captains and the consumers) at the expense of other agents (the input suppliers). Fulton et al. [25] have also drawn attention to the role of social networks in the operation of fisheries quota markets. However, little work has been done on the possible interactions between the social, economic and biological objectives which a policy maker may pursue with ITQs in a dynamic setting.

The analysis of our bioeconomic model relies on the weak invariance [12] or viable control method [2]. This approach focuses on identifying inter-temporal feasible paths within a set of desirable objectives or biological, social and economic constraints [4,22,16,3,46]. This framework has been applied to renewable resources management and especially to the regulation of fisheries (see, e.g. [4,45,17,19]), as well as to broader (eco)-system dynamics [15,20]. Our approach departs from these previous studies in that it explicitly represents heterogeneous operators and considers a set of controls that includes total fishing output, as well as a social objective which is expressed in terms of maintaining a level of activity in the fishery. While such a social objective was considered in Martinet et al. [45], it was with a focus on how it could effect the rate at which a fishery may recover from an initial state of crisis, using input-controls. Moreover, none of the existing applications of the viability method to fisheries to date have included an explicit representation of a quota market.

The major contribution of this paper is to show that the ITQ management system is viable in a triple bottom line sense only under very specific conditions. In particular, it is pointed out how the success of such a management depends on the degree of heterogeneity of agents operating in the fishery, the current status and the dynamics of the stock together with the design of TAC.

The paper is structured as follows. Section 2 is devoted to the description of the dynamic bio-economic model and the ecological, economic and social objectives which a manager may wish to observe. Section 3 characterizes the feasible stock states and quota policies and examines the role of heterogeneity between users. Then the maximum number of active fishers and the maximum guaranteed fishing effort are computed. An application to the nephrops fishery in the Bay of Biscay illustrates the results in Section 4. The last section concludes.

2. The bio-economic model

2.1. The resource dynamics

A renewable resource is described by its state (e.g. biomass or density) $x(t) \in \mathbb{R}$ at time t. If the amount removed $Q(t)$ is caught at the beginning of each time step, the dynamics of the exploited resource $x(\cdot)$ is given by the escapement function

$$x(t+1) = f(x(t) - Q(t)), \tag{1}$$

where f is assumed continuous, increasing and zero at the origin. Since the amount caught cannot exceed the resource stock, a scarcity constraint holds

$$0 \le Q(t) \le x(t). \tag{2}$$

2.2. The ITQ market

At the beginning of each period t, a regulator allocates a total allowable catch (TAC) among the n agents (vessels). The supply of quota is

$$Q(t) = \sum_{i=1}^{n} Q_i^-(t), \tag{3}$$