

available at [www.sciencedirect.com](http://www.sciencedirect.com)[www.elsevier.com/locate/ecolecon](http://www.elsevier.com/locate/ecolecon)

## ANALYSIS

# Increasing marginal returns and the danger of collapse of commercially valuable fish stocks<sup>☆</sup>

Jose M. Maroto<sup>a</sup>, Manuel Moran<sup>b,\*</sup>

<sup>a</sup>Department of Estadística e Investigación Operativa II, Spain

<sup>b</sup>Department of Fundamentos del Análisis Económico I. Both at Universidad Complutense, 28223 (Madrid), Spain

## ARTICLE INFO

## Article history:

Received 18 October 2007

Received in revised form

23 February 2008

Accepted 21 April 2008

Available online 29 May 2008

## Keywords:

Dynamic programming

Precautionary Approach

Bioeconomic modelling

Stock collapse

Lipschitz continuity

Increasing marginal returns

## ABSTRACT

On the basis of data from the North Sea herring fishery, we discuss the consequences of increasing marginal returns on the exploitation of renewable resources. We show that high, but still reasonable, discount rates can cause extinction to be optimal even in the ideal case of a sole owner and a resource with a high growth rate. In the case of lower discount rates, optimal cyclical policies can periodically drive the resource to levels approaching Safe Minimum Standards. We discuss the sustainability, intergenerational equity, social risk aversion, and theoretical issues raised by increasing marginal returns.

© 2008 Elsevier B.V. All rights reserved.

## 1. Introduction

There is increasing empirical evidence of the severe worldwide depletion of commercially valuable fish stocks. According to the FAO (2004), 75% of all commercially valuable fish stocks are exploited. Moreover, Myers and Worm (2003) show that all commercially important fisheries in the world are heavily overexploited (see also Sterner and Svedäng, 2005).

Internationally, the significance of stock collapse is well understood and has led to widespread endorsement of the Precautionary Approach, which attempts to manage fish stocks within safe biological limits established by the International Council for the Exploration of the Sea (ICES). The term “collapse” is used to signify that the stock has reached a level

where it suffers from severely reduced productivity (ICES, 2005a). Important marine fisheries that have already reached this situation are, among others, Atlantic cod, Pacific sardine, haddock, Bering wolffish, and Atlantic halibut (Hutchings, 2000). In these cases, recovery is likely to be slow and will depend on effective conservation measures. Hutchings (2000) stresses that many fisheries which have suffered dramatic population reductions have experienced little, if any, recovery. According to this author, worldwide overfishing has raised concerns that the risk of extraordinary collapse in abundance may significantly increase due to the complex interlinking of ecological systems and the extinction probability of both targeted and incidentally harvested marine fishes. This means that if a stock is in danger of collapse, biological extinction

<sup>☆</sup> This research has been supported by the Spanish Ministry of Science and Technology, research project MTM2006-02372/.

\* Corresponding author. Tel.: +34913942407; fax: +34913942561.

E-mail addresses: [maroto@ccee.ucm.es](mailto:maroto@ccee.ucm.es) (J.M. Maroto), [mmoranca@ccee.ucm.es](mailto:mmoranca@ccee.ucm.es) (M. Moran).