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Extended abstract: *Transboundary quota enforcement with an application to the North East Arctic cod fishery*

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Many fish stocks, as well as other renewable resources, are shared between different countries. Resource management then relies on international agreements and quota enforcement. Much work has been done on whether cooperative management is feasible and how and under what conditions such outcomes can be reached. The focus of our study differs from the existing game theoretical work in that we go one step further by asking what happens once a sharing agreement has been established. Does each country in fact impose the conditions of the sharing agreement on their fishing industries by ensuring strict enough enforcement of quotas to meet international obligations? In most, if not all, commercial fisheries, illegal fishing is a serious and significant problem (Agnew, et al., 2009). This is also the case for fisheries in which sharing agreements have been reached, such as the NEA cod fishery, which is shared 50-50 between Norway and Russia.

In this paper, we conduct an empirical analysis of international quota enforcement in the NEA cod fishery. We base our analysis on our previous theoretical work of international quota enforcement (Beard & Nøstbakken, 2010), by calibrating the model developed there. In our theoretical study, we developed a model of a shared renewable resource for which there already exists an international agreement that determined each country's share of total quotas. Each government was responsible for the enforcement of their national quota. The countries could cheat on the sharing agreement by reducing enforcement efforts and thereby inducing their firms to violate quotas. We analyzed the effects of this in a differential game framework. There were two games: a Stackelberg game between the government and the firms within each country, and an enforcement game at the international level between different governments. Using this model, we characterized the long-run equilibrium and identified factors that affect the outcome. We also identified the socially optimal quota, given the reaction functions of both governments and firms. That model is used in our proposed paper as a theoretical framework for an empirical analysis of the NEA cod fishery.

The joint management of the NEA cod fishery is carried out by the Joint Norwegian-Russian Fisheries Commission that was established under the Agreement of 11 April 1975. Since that time, total allowable catches, the sharing of catches between the countries, and reciprocal access to fisheries in national economic zones have been determined by the annual meeting of the

Commission. Total allowable catches are determined based on the recommendations of the International Council for the Exploration of the Sea (ICES), where both Russian and Norwegian scientists participates. Hence, the fishery characteristics fit well into the theoretical modelling framework (Beard & Nøstbakken, 2010).

The Northeast Atlantic has the world's largest population of cod, and the North-East Arctic (NEA) cod stock is by far the largest part of this population. Over the past six decades the average annual catch has been 650 thousand metric tons. However, there has been considerable variation in annual catches as well as in the stock size. The fishery generates considerable revenues for the countries involved and the potential economic losses of poor management are large, as are the potential gains of exceeding quotas.

Over the past decades, there have been several challenges in the management of the NEA cod stock. In recent years, the biggest challenge was that considerable quantities of cod were landed illegally. Estimates suggest that illegal and unreported landings peaked in 2005, with unreported landings of between 41 (Russian estimate) and 166 (Norwegian estimate) thousand metric tons (ICES, 2009). These numbers constitute 6% and 26% of total landings, respectively. In addition, Russian officials have often argued for higher total allowable quotas than those suggested by ICES, while Norwegian officials have supported following ICES advice. In this paper, we try to explain why this happened, in addition to suggesting measures for improving the success rate of the international management of the fishery. The results are also valuable to other shared fisheries where illegal fishing is an issue.

Our paper covers all three of the important elements listed in the call for abstracts. First, our analysis focuses on a problem that has received little or no attention in the past, namely the international enforcement game where countries cheat on enforcing its quotas. Hence, it is a new economic issue related to marine resources. Second, the analysis involves applying a theoretical model to a specific fishery in order to develop new insights into the management of shared fishery. Third, our results have strong management implications, both for the NEA cod fishery and for shared fisheries in general, which is the main focus of our study.

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