Actual versus Optimal Fisheries Policies: An Evaluation of the Cod Fishing Policies of Denmark, Iceland and Norway

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Abstract

Many ocean fisheries are subject to a fundamental economic problem generally referred to as the common property problem. The common property problem manifests itself as excessive fishing fleets and fishing effort, depressed fish stocks and little or no profitability of the fishing activity, irrespective of the richness of the underlying marine resources. European fisheries represent some of the most dramatic examples of the common property problem.

This paper employs simple empirical models and recently developed mathematical techniques to find optimal feed-back policies to examine the economic efficiency of three European fisheries, namely the Danish, Icelandic and Norwegian cod fisheries. The optimal harvesting policies for each of these fisheries are calculated. Comparing these optimal policies with actual harvests provides a measure of the relative efficiency in these three cod fisheries.

The comparison confirms that the cod harvesting policies of these three countries have been hugely inefficient in the past. Moreover, it appears that the inefficiency has been increasing over time. Only, during the last few years of our data are there indications that this downward trend may have been halted. This comparative improvement, slight as it is, may reflect the impact of a more restrictive fisheries policy since the early 1990s.

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Introduction

Ocean fisheries have traditionally been organized as common property extraction activities. The common property arrangement, as has been abundantly established both theoretically and empirically, induces the fishing industry to invest in excessive fishing fleets and employ excessive fishing effort. The outcome is unduly depressed fish stocks, distorted ecosystems and, perhaps most distressingly, loss of the very substantial net economic benefits that could flow from these fisheries on a sustainable basis if they were properly conducted.

European fisheries are widely believed to demonstrate some of the worst excesses of common property fisheries. If true, this immediately suggests the need for a radically different management of these fisheries. However, before new policies are formulated and a revamped management system installed we must have measurements. First we need to get an idea of the magnitude of the problem. What is the actual inefficiency of the European fisheries? Is it sufficiently large to justify expense of sizable political effort and the cost of considerable social readjustment? Second, we need to identify better fisheries policies. What harvesting paths will approximately maximize economic benefits from the fisheries? How different are they from the harvesting policy we have hitherto been following?

To answer these questions two things are needed: an empirical model of the various European fisheries and a mathematical tool to calculate the economically optimal harvesting policies. Now, fisheries are very complex and modeling any one of them in detail requires substantial human and financial resources as well as years of calendar time. Given, the urgency of the problem, this approach is obviously not very practical. In addition, detailed fisheries models, even when they are available are of limited use, anyway. First, the management controls at the disposal of the authorities are broad ones and not at all capable of the “fine-tuning” suggested by detailed models. Second, fisheries are subject to a long list of ecological, biological and economic impacts with the result that the actual outcome of any control is highly uncertain. Third, the political process, crucial in the formulation of improved fisheries policies, is not well suited to deal with modeling details and really only responds to broad generalities.

Therefore, from a practical perspective, what is needed is a modeling and calculation tool that relatively quickly and easily uses widely available fisheries data to come up with estimates of the inefficiency of the fishery, the approximate optimal fisheries path and the gains to be made if that path were to be followed.

This paper reports on the development of such a tool for three European fisheries, the very important cod fisheries of Denmark, Iceland and Norway. The first nation Denmark is a member of the EU, the other two are members of the European economic area.

The Three Fisheries

The cod fisheries of Denmark, Iceland and Norway are these countries' most valuable fisheries. These nations conduct their cod fisheries employing very similar technology but in different areas; Denmark in the North and Baltic Seas, Iceland mainly around Iceland and Norway mainly in the Barents Sea.

The management context of the three cod fisheries is quite different. First, there is a difference in national control over the respective fisheries. Since the extension of her fisheries jurisdiction to 200 miles in 1976, Iceland has been in virtual sole control of her cod fishery. Norway, on the other hand, shares her cod stock, the Arctic cod, with Russia and must therefore decide on a harvesting policy jointly with Russia. Denmark is only one of several, mainly European Union, countries pursuing the North Sea cod fishery. Since the early 1980s, the European Union has set the overall total allowable catch (TAC) for this fishery of which Denmark merely receives a share. Thus, compared to Iceland and Norway, Denmark probably has the least control over her cod harvesting policy. In view of these differences in autonomy between the three countries, it is clearly of some interest to investigate whether these differences show up in their respective cod harvesting policies.

Second, during the latter part of the period studied in this paper, the fisheries management systems of the three countries have been quite different. Stated very briefly, Iceland has since 1990 operated a more or less complete ITQ-system in her cod fishery. Norway has for about the same period managed her cod fishery on the basis of quasi-permanent individual quotas. In Denmark, however, the fishery has for the past decade essentially been managed on the basis of a licence limitation program supplemented with very short term (down to two months) non-permanent, non-transferable vessel quotas that become invalid in case the fishery is closed. Thus, it is clear that the quality of the harvesting rights held by individual companies in these three cod fisheries has differed greatly in recent years. It is often suggested that differences in the fisheries management regime, especially the quality of individual harvesting rights, may influence harvesting strategies. Therefore, it is of interest to find out whether there is empirical evidence supporting this.

The modeling and calculation tool

In our study we take it that the objective of the fisheries policy is to maximize the present value of the flow of economic benefits from the fishery from the present time onwards. We refer to the fisheries policy that attains this as "optimal". Since fish stocks constitute a renewable resource, the optimal fisheries policy normally implies a sustainable fishery.

Our tool to derive optimal fisheries policies for fisheries consists of two parts. There is an empirical part describing the fisheries in question, and there is a mathematical part to derive the optimal fisheries policy.

The empirical part is based on a simple aggregative model of the fisheries in question. This model is aggregative in the sense that it describes the fishery in terms of biomass and the fishery in terms of a single homogeneous fishing fleet. On this basis, a biomass growth function, a fishery profit function and a fish price function are estimated by econometric methods using time series data on biomass and harvests and time series-cross section data on fish prices, fishing costs and fishing effort. Note that these data are usually relatively easily available for most fisheries.

The mathematical part of the tool is designed to derive optimal feed-back harvesting policies. An optimal feed-back harvesting policy is a rule or function that relates the optimal harvest at each point of time to the state of the resource and exogenous variables such as prices. Thus, once the optimal feed-back function has been identified, finding the appropriate optimal harvest level at each point of time is the relatively simple matter of plugging the state of the system into this function and observing the outcome.

Optimal feed-back rules have great advantages over the traditional approach where optimal paths for harvests as a function of time are found. Such open-loop policies (i.e. time paths) are of limited practical use because in reality the path of stocks (and other variables) always deviates (usually quite substantially) from what was predicted when the optimal open loop policy was formulated. Therefore, following the open loop policy blindly is usually disastrous. As a result the open loop policy has to be recalculated — usually a formidable undertaking — whenever conditions change. Thus, not only will the feed-back policy be much more robust with respect to actually identifying the optimal fisheries policy, it will also save a lot of calculation and recalculation effort. The drawback is that feed-back policies are mathematically more difficult to derive.

In our research we have managed to develop mathematical techniques that allow us to derive, comparatively easily, optimal feed-back policies for our class of fisheries models. We refer to our technique as the "Optimal Feed-back Policy Generator" and we believe that our approach belongs to "adaptive management" (Hilborn and Walters 1992). This tool is simple enough to be run on ordinary desktop computers given the appropriate software that we have developed.

Efficiency

Having completed our description of the basic modeling and calculation tool, we are now in a position to assess the efficiency of the cod harvesting policies followed by the three countries in the past. For this purpose we employ two main criteria; (i) the "economic health" of the cod stock and (ii) the "appropriateness" of the annual harvest. The former is measured by the actual stock size relative to the optimal steady state level. The latter is measured by the actual annual harvest relative to the optimal one given the existing stock level.

Consider first the "economic health" of the cod stock in each country. This is illustrated in figures 1–3. In these figures, the actual biomass relative to the optimal one is presented. The optimal equilibrium biomass stock equals unity. Numbers less than unity represent an overexploited stock and vice versa. Thus, the graphs in figures 1-3 trace out the actual development of the cod stock relative to the optimal one. In addition, two horizontal reference lines are drawn in these figures. One corresponds to the optimal steady state stock level. The other corresponds to the fishing moratorium stock level, i.e. the stock level for which it is optimal to halt fishing temporarily.

As illustrated in figures 1-3, the cod stock biomass for these three countries has been far below the economic optimal level for most of the period for which we have data. Moreover, all three cod stocks exhibit a clear downward trend relative to the optimal level over time. Thus, our model confirms the general view that the at least these three European cod stocks have been overexploited and the overexploitation is getting worse. Only towards the very end of the period, in the 1990s, do we see signs that this trend is leveling off.

Figure 1. Denmark: Stock relative to optimal steady state

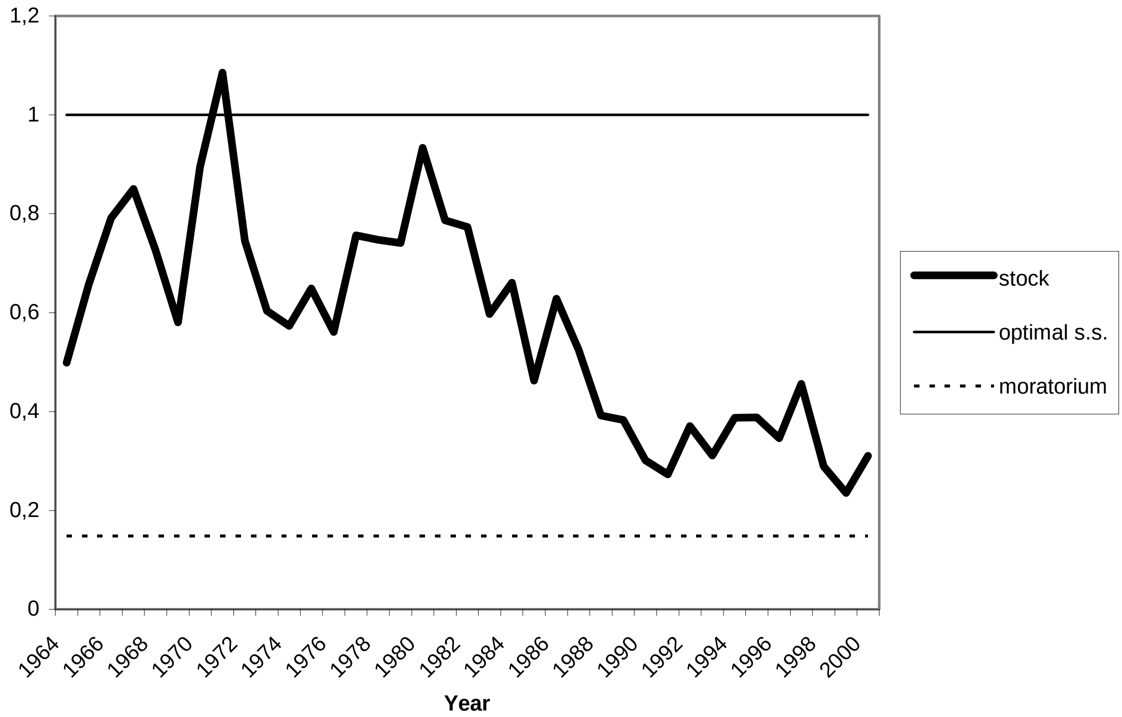
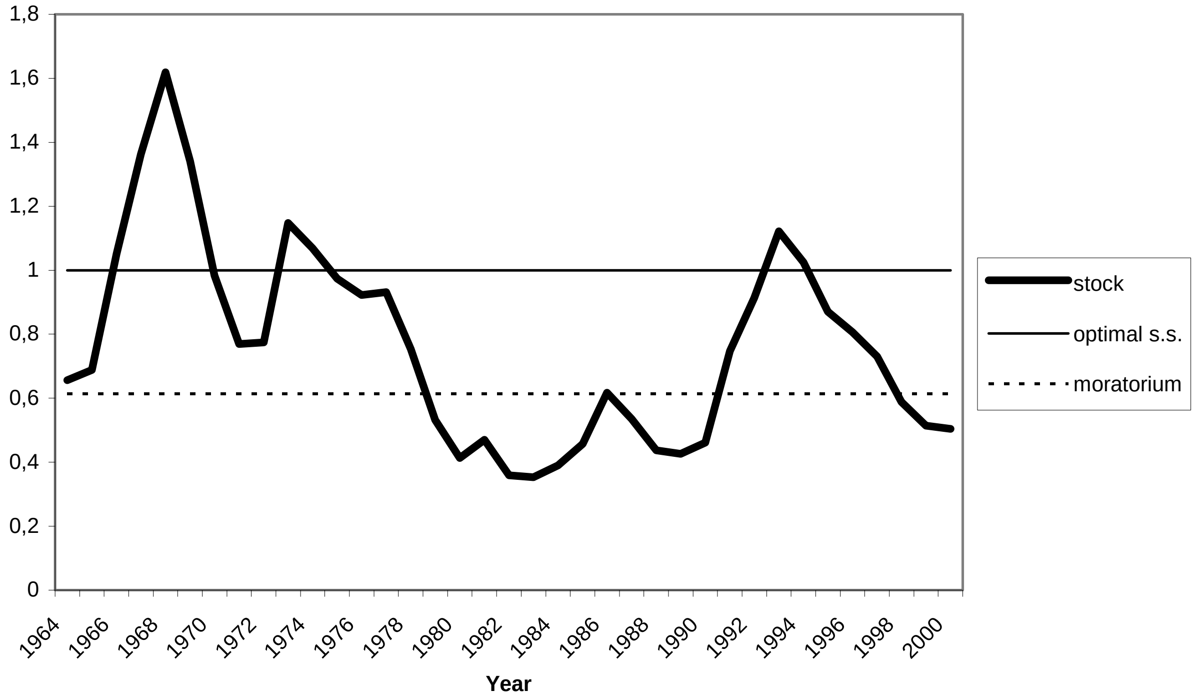


Figure 2. Iceland: Stock relative to optimal steady state

Figure 3. Norway: Stock relative to optimal steady state



Measures for the average stock health are presented in Table 1. For our complete data set, i.e. 1964-2000, the average stock as a fraction of the optimal equilibrium stock is lowest for Denmark or about 0.57. For Iceland it is about 0.68 and for Norway it is about 0.77. It should be noticed, however, that in all three cases the stocks, as a fraction of the optimal, are declining over time so that toward the end of the period, this fraction is down to 0.34 for Denmark, 0.44 for Iceland and 0.67 for Norway of the optimal level.

Table 1. Cod biomass relative to the optimal

	Average for the period 1964-2000	Average for the period 1995-2000
Denmark	0.57	0.34
Iceland	0.68	0.44
Norway	0.77	0.67

Let us now turn our attention to the "appropriateness" of the cod harvest policies in each of the three countries. This is illustrated in figures 4-6 below where the optimal harvest according to the calculated optimal feed-back policy is represented by the solid curve and the actual harvest levels by the dots. In these diagrams harvest above and to the left of the optimal feed-back curves are economically excessive while harvests below or to the right of these curves are economically too little. From the diagrams it is evident that the harvesting policies for all three cod stocks have generally been severely excessive. For any given biomass level most of the actual harvest points are much higher than would have been optimal at those biomass levels. Moreover, although this is not apparent from these diagrams, the level of overexploitation has been increasing over time for all three cod stocks. It is only towards the end of the period, in the late 1990s that there are signs of some improvement in the harvesting policies especially in Norway and Iceland.

Figure 4. Denmark: Optimal feed-back harvesting vs. the actual harvest

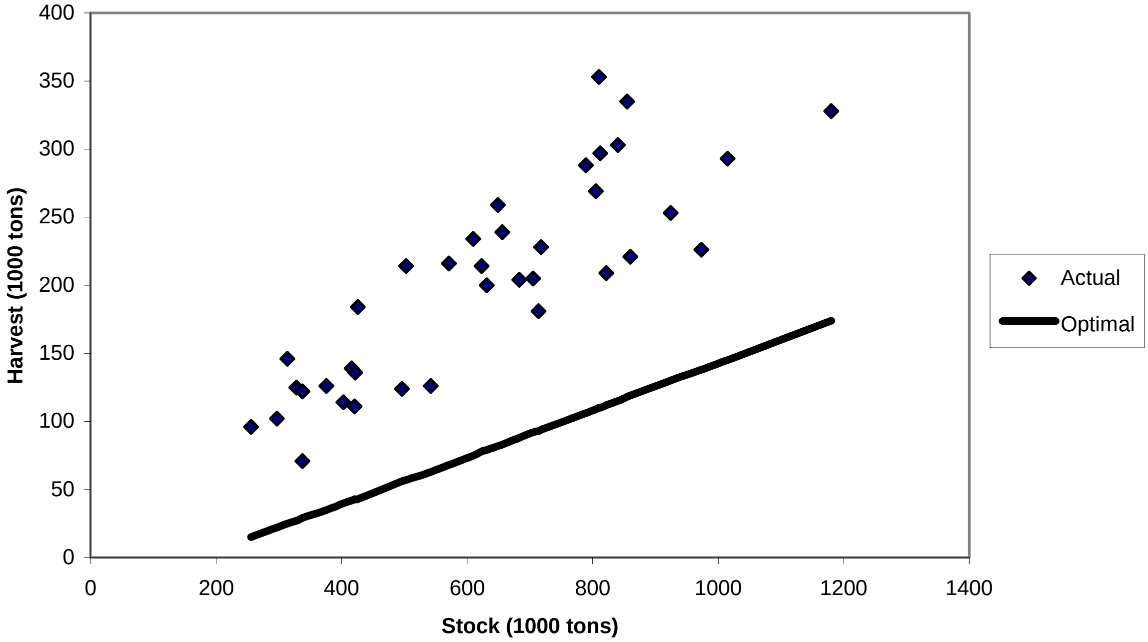


Figure 5. Iceland: Optimal feed-back harvesting policy vs. the actual harvest

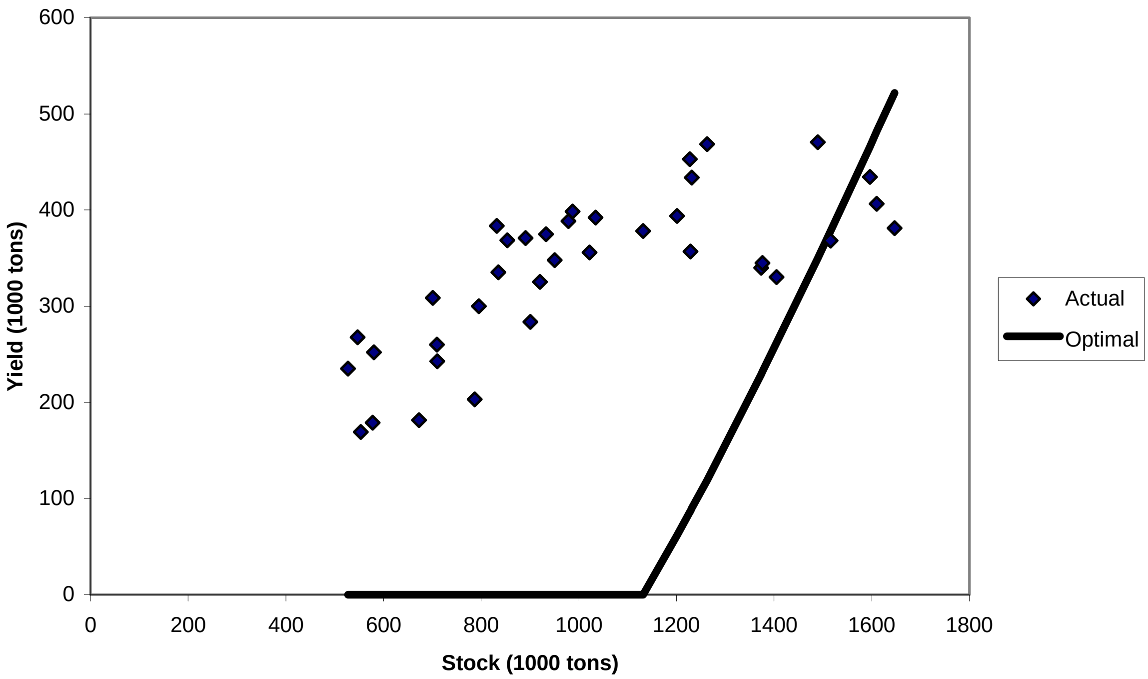
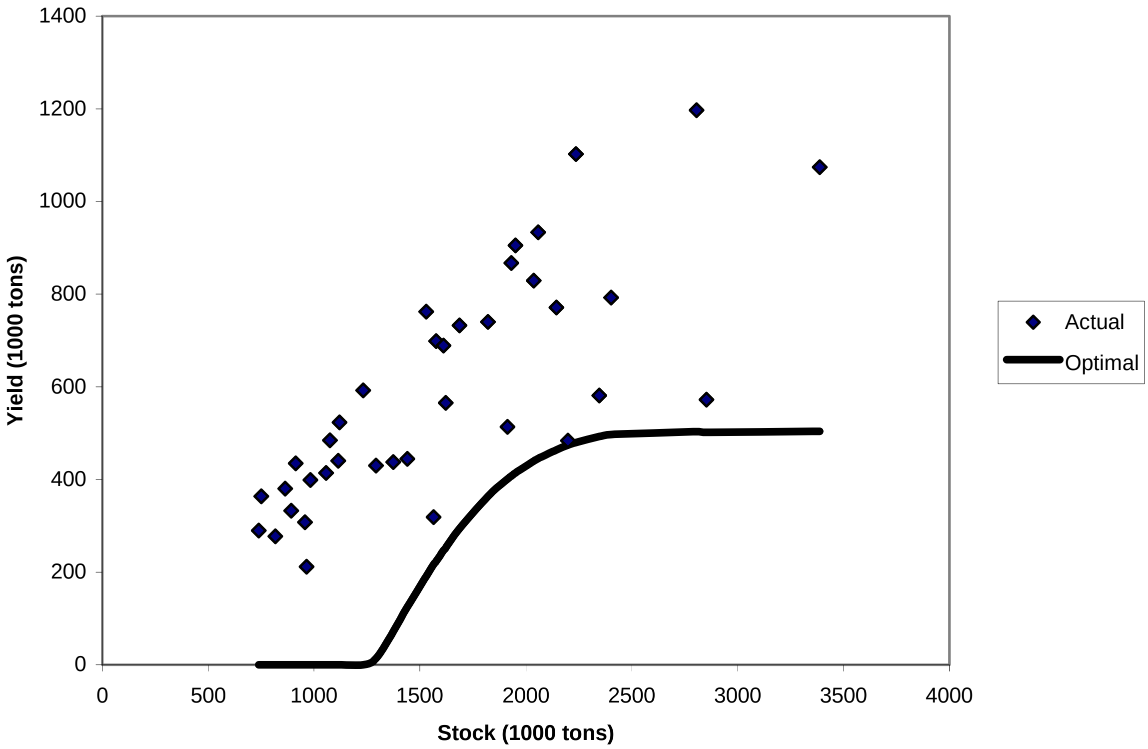


Figure 6. Norway: Optimal feed-back harvesting policy vs. the actual harvest



Compared to the other two countries, Denmark has operated the most stable harvesting policy relative to the optimal, but, unfortunately, it has been stable overexploitation. By contrast, Iceland's cod harvesting policy relative to the optimal is the most volatile. It features some years of close to optimal harvesting and even underharvesting especially in the early period, but also has the most severe cases of excessive harvesting relative to the optimal, i.e. when a harvesting moratorium should have been imposed as can be read from figure 5. It should be noted, however, that due to the shape of the estimated Icelandic harvesting cost function, this moratorium occurs at very much higher stock level (80% of the optimal stock) than for either Denmark or Norway. Norway's cod harvesting policies fall somewhere in between those of Denmark and Iceland.

Conclusions

This study demonstrates that it is possible on the basis of relatively simple empirical models and fairly standard applied mathematical techniques to identify approximately optimal feed-back harvesting policies and, on that basis, obtain estimates of the inefficiency of current policies. Both can contribute usefully to the design and implementation of more beneficial fisheries policies.

Our comparative study of the three cod fisheries is perhaps more striking in terms of the similarities it uncovers rather than the differences. For all three countries the efficiency of their cod fisheries, measured as the ratio between actual and optimal stock and harvest levels, appears to have been quite low. Moreover, for all three countries this efficiency shows a declining trend since the 1960s. This is, of course, in broad accordance with the prediction of fisheries economics for open access fisheries. What is mildly surprising, however, is that in spite of much greater national control over the cod fisheries since the 1970s, at least in Iceland and Norway, there are very few signs of a reversal in this trend of declining efficiency.

During the last decade or so of our data set, the cod fisheries in the three countries have been subject to somewhat different fisheries management systems. As discussed above, the Danish cod fishery is basically managed on the basis of TAC-restrictions with some limited short term quota rights. The Norwegian cod fishery is based on individual quotas with uncertain permanence. The Icelandic cod fishery on the other hand has since 1990 been managed on the basis of a fully fledged individual transferable quota system with fairly secure permanent quota rights. The differential effects of these management systems, if any, do not show up in our efficiency measures. Admittedly, these measures are restricted to aggregate harvest rates and biomass levels. As such the results do not exclude different economic returns in the fisheries predicted by the theory on individual quotas. Nevertheless, it is interesting to note that, at the end of our data period, the theoretical superiority of individual quota systems does not seem to show up in the buildup of cod biomass towards the optimal level, neither in Iceland nor Norway. It may of course be the case that this impact of the individual quota systems in Iceland and Norway — really only in effect since about 1990 — has yet to emerge.

Further readings

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