INTRODUCTION TO
NATURAL RESOURCE ECONOMICS

Lecture 5

Renewable resource exploitation: fishery regulation

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1 Introduction

We have seen that efficient, sustainable, exploitation of a renewable natural resource, such as a wild fish stock, requires that the marginal profit from harvesting is equated with the *shadow price* of the resource, i.e.,

$$\pi_q = \lambda.$$

The shadow price reflects the value of the marginal unit of stock in terms of its contribution to future profits, taking into account both the growth of the stock and the implications of a larger stock for harvesting costs. A sole owner or social planner, it was argued, would observe this rule, but an individual competitive firm in an open access fishery would (almost certainly) not. One way of looking at the open access (or *free* access) problem is in terms of correct pricing. Because the resource is not priced, fishing firms do not take account of the resource cost in their production (harvesting) decisions. This is exactly analogous to other externality problems, such as industrial pollution, and is an example of *market failure*.

The absence of a correct resource price results in excessive harvest and the dissipation of resource rent through excessive use of inputs. The stock may also become depleted to the extent that physical yields are reduced and the risk of stock collapse is increased. The term "overfishing" encompasses some combination of these outcomes. Note that, in economic terms, there is excessive fishing effort if resource rents are dissipated, even if the fishery is sustainable. In order to prevent overfishing, some form of regulation or *management* of the fishery is required.

An open access fishery is sometimes referred to as a "common property" fishery, but some object to this description on the grounds that it confuses unregulated fisheries with those where true common ownership results in the emergence of effective institutions for resource management.

2 Economic management instruments

A variety of approaches have been used in order to manage fisheries so as to avoid the problems of overfishing. We begin by looking at two management *instruments* which are designed to impose a direct *user cost* for the resource, in effect substituting for the shadow price.

2.1 A harvest/landings tax

Assume that each fishing firm has a profit function that can be written in terms of harvest as

$$\pi(q) \equiv pq - c(q).$$

In the absence of regulation, profits for the firm are maximised where $p - c'(q) = 0$. If we impose a tax on the harvest (catch) at a rate τ, the profit function becomes

$$\pi(q) \equiv [p - \tau] q - c(q)$$

and now the firm will maximise its profits by choosing a level of catch where $p - c'(q) = \tau$. Clearly, the tax can (in theory) be set at a rate approximating to the shadow price of the resource, so that the firm chooses a socially optimal level of catch.

Since each firm in the fishery equates price minus marginal cost with the tax rate, marginal costs are equated across all firms and hence total production (catch) is allocated *efficiently*.

In practice there are problems, however. Firstly, it is actually very difficult to observe catches and therefore a tax would, in practice, have to be imposed on landings of fish at the quayside, meaning that the regulator cannot control the quantity of fish that is *discarded* at sea because it is of poor quality or low market value. Secondly, setting the tax at the correct rate requires that the regulator possesses an enormous amount of information about both the dynamics of the stock and the cost structure of the industry over time. Nevertheless, *any* tax should reduce landings (and hence catches) and the "right" tax rate could be achieved by a process of trial and error. The main reason why landings taxes are not used in practice appears to be political.

2.2 Tradeable quotas

Tradeable fish quotas, often referred to as "individual transferable quotas" or ITQs, are analogous to tradeable pollution permits. The regulator issues a total quota, corresponding to a "total allowable catch" (TAC) for the fishery, usually on an annual basis. If quota can be freely traded between fishing firms then a market equilibrium quota price will be established which individual firms will take into account in their production decisions. If we assume that firms purchase enough quota for the amount of fish they catch and sell (i.e., that they do not cheat), we can write the firm's profit function as

$$\pi(q) \equiv [p - s]\, q - c(q)\,,$$

where s is the (rental) price of quota. Since firms now maximise profits where $p - c'(q) = s$, we can see that taxes and quotas are equivalent in economic terms. The important difference is that with ITQs, the regulator only has to determine the TAC; the user cost, in the form of the quota price s, is determined by the market.

Setting a socially optimal level of TAC for the fishery still requires a huge amount of information on the part of the regulator, but in practice a TAC can be chosen that will maintain the stock at a biologically "safe" level. Allowing quota trading should then ensure that the TAC is used in an economically efficient manner. This pragmatic (second-best) approach is the one that is adopted in the ITQ systems which are now in operation in a number of important fishing nations, including Australia, New Zealand, Iceland and Canada.

As with a tax, in practice it is generally too difficult (costly) to ensure quota compliance at sea and therefore quotas really only apply to landings rather than catches. The incentive for firms to discard less valuable fish at sea can then be a problem for the regulator.

2.3 Rent distribution

In the case of a landings tax, the regulator collects revenues directly which approximate to the resource rent. In the case of ITQs, however, the resource rent is reflected in the price of quota and the distribution of rent depends upon how the quotas are allocated to the fishing industry.

The regulator could collect the rent directly if annual quotas were sold each year to the industry (perhaps through a fixed price, by tender or some sort of auction). In most ITQ systems, however, quotas are initially distributed free of charge to the industry as *permanent* entitlements to an annual quota (which varies according to the annual TAC). Typically, both asset and lease (rental) markets for quota develop, with asset prices, i.e., prices for permanent quota entitlements, being essentially a capitalisation of lease prices. If the regulator does not intervene in these markets, all rents accrue to the industry. In principle, fiscal measures could then be introduced in order to collect part or all of the rent for the benefit of society as a whole, but to date it appears that no country with an ITQ system has pursued such a policy.

2.4 Pricing effort

In theory, it would be possible to tax fishing *effort* instead of landings, or to have a system of tradeable effort quotas, so indirectly imposing a resource user cost. The term "effort", however, is just a convenient way of describing a bundle of inputs used in fishing. Depending on the particular context, effort can mean numbers of fishing boats, or the size and power of fishing boats, or the number of days spent fishing, or the number of tows of a trawl net, and so on. Introducing an additional cost to effort begs the question of which component of effort should be targeted, in effect as a proxy for all the (variable) inputs used in catching fish. The correct charge would then depend on the relationship between the particular input and catch - a relationship that is likely to change over time through technological advances. Although it is difficult to argue for pricing effort in this way rather than harvest, fishery regulations which attempt to exert some control over fishing effort are very common (see below).

Nevertheless, from the simple static (Gordon-Schaefer) model of the fishery, we can see that, in principle, a tax or charge on (long run) effort, in effect an access charge, could be used to increase firms' total costs and hence reduce effort at the open access equilibrium. In the process, the regulator could collect a resource rent. There are examples of fisheries where licence charges are used to raise revenue, although usually other measures are also used in order to regulate harvests.

3 Other forms of management

Most fishery regulations are not economic, in the sense that they are not designed to achieve economic efficiency. In many countries, fishery regulations are primarily designed to control the level of harvest in order to prevent (further) stock depletion. Such "non-economic" management instruments commonly include

- vessel licences or permits to restrict entry to the fishery,
- restrictions on vessel "capacity" such as size (tonnage) or engine power,
- restrictions on "days-at-sea",
- non-transferable annual catch quotas or weekly/monthly catch limits.

Effort controls, of which the first three are examples, tend to be popular with fishery managers because they are relatively easy to implement and enforce. The main problem with effort controls is that they introduce inefficiency. Since they only control harvest indirectly, they can also become less effective as fishermen try to compensate for restrictions on some inputs by expanding their use of other inputs. Technological progress will also tend to reduce the effectiveness of effort controls over time.

In general, economic management instruments which regulate catch are to be preferred, since fishermen are then able to use efficient combinations of inputs.

Fisheries management in practice is often relatively ineffective, particularly in exerting control over levels of catches and hence protecting fish stocks from depletion. For this reason, many countries have periodically attempted to intervene directly to reduce the size (capacity) of their fishing fleets by compensating firms for exiting the industry (through decommissioning or "buy-back" schemes).

Fisheries are usually also subject to many regulations which are not designed to exert control over levels of harvest *per se*, but rather to reduce the adverse stock/environmental impacts of fishing. Examples include

- minimum mesh sizes and minimum landing sizes to restrict catches of juvenile fish,
- closed areas and closed seasons to protect stocks during spawning,
- various restrictions on fishing designed to protect other species or aspects of the marine environment (such as seabirds, dolphins, cold-water corals, etc.).

4 Enforcement

All fishery regulations need to be *enforced* if they are to be effective. This requires systems for monitoring landings of fish as well as compliance with various effort controls, together with a process for imposing sanctions on offenders who are detected.

Monitoring and control activities may include aerial patrols, at-sea inspections of catches and fishing gear, quayside inspections of landings and inspections in fish markets and wholesalers, backed up with "paper trails" and electronic recording systems. Under the EU's Common Fisheries Policy (CFP), all fishing vessels over a certain size are also required to carry equipment for satellite positioning so that vessel activity can be continuously recorded.

5 The benefits and costs of management

The social benefits of (effective) management are the realisation of an economic surplus in the form of resource rent and, if sustainable harvests increase in the long run, an increase in consumers' and producers' surplus. Fisheries management is costly, however, and hence the social costs of management need to be deducted from the social benefits. In theory, the optimal "amount" of costly management effort is given where the marginal benefits of management just equal the marginal costs.

6 Further reading

Look at HSW, pp.288-291 and Conrad, pp.49-57.

To see examples of fisheries policies and management approaches relevant to the UK, look at

http://ec.europa.eu/fisheries/index_en.htm

http://www.defra.gov.uk/marine/index.htm

http://www.scotland.gov.uk/Topics/Fisheries/Sea-Fisheries

You could also look at the website of the New Zealand Ministry of Fisheries, which operates a very well-developed ITQ system:

http://www.fish.govt.nz/en-nz/Commercial/default.htm