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Fisheries management and operations research ☆

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Abstract

Fisheries are subject to a deep-rooted problem of economic inefficiency, often referred to as the fisheries problem. The fisheries problem derives fundamentally from inappropriate social institutions controlling the fishing activity, the foremost of which is the common property arrangement. Fisheries management consists of replacing these institutions with more appropriate ones. Which institutions are most appropriate depends on the social objectives of the fisheries. There are strong economic arguments for the view that there should be only a single objective, namely to maximize the present value of the flow of benefits from the fisheries. In reality, different interest groups often push for several, often conflicting, objectives. In that case a multi-objective programming approach may be appropriate.

A set of institutions to manage fisheries is referred to as the fisheries management regime. The fisheries management regime consists of a (i) fisheries management system, (ii) fisheries enforcement system and (iii) fisheries judicial system. Each one of these has to be appropriately designed and implemented. The efficacy of the overall fisheries management regime cannot be greater than that of its weakest link. At the same time it is of the greatest importance to keep an eye on the cost of fisheries management. Global evidence suggests that the cost of fisheries management often constitutes a substantial fraction of the value of the harvest. The problem, thus, is to strike the right balance between the efficacy of the fisheries management regime and its cost of design, implementation and operation.

The problem of fisheries management is by its nature multidisciplinary. It involves marine ecology and biology, mathematics, economics, game theory, political science and anthropology to name a few. The problem is, moreover, typically quite complex, requiring powerful modelling and calculation techniques. In many respects this is the kind of problem operations research techniques are designed to deal with.

Keywords: Fisheries management; Operations research; Fisheries management regimes; Operation research in natural resources

1. Introduction

Fisheries worldwide are subject to economic mismanagement of major proportions.[1] Although most commercial fish stocks are capable of yielding high net profits (rents), only a relatively few fisheries actually manage to be profitable. In fact, seen as a whole, the world's fishing industry is heavily subsidized (Milazzo, 1998). Rough estimates suggest that on a global scale, the loss of economic rents (profits) due to mismanagement of fisheries may easily amount to 50% or more of the global landed value of some 100 billion USD annually.[2] This loss, approximately 50 billion USD, is similar in magnitude to the total annual development assistance from industrialized nations to the underdeveloped nations of the world.

While mismanagement characterizes the global fishery as a whole, it is important to realize that there are fisheries,

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[1] A global overview of the current state of fish stock exploitation can be found in FAO (2004). A well researched example of global fisheries mismanagement is North Atlantic cod, see e.g. Hannesson (1996).

[2] Global landings from ocean fisheries have in recent years been in the neighbourhood of 84 million metric tones. Average landed value may be close to USD 1.20 per kg. Various empirical studies of fisheries around the world typically suggest loss of potential profits of some 50% of the value of landings.

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sometimes quite sizeable fisheries, that do not adhere to this general pattern and are both biologically sustainable and highly profitable. These fisheries, which comprise such diverse marine conditions as those of New Zealand, Falkland Islands and Iceland, are in no way different from the other fisheries which exhibit declining stocks and negative profits. The only thing they have in common is good management. Generally, this management is based on high quality and well enforced property rights.

Ocean fish stocks have traditionally been arranged as common property resources. This means that anyone, at least anyone belonging to a certain group (often a complete nation), is entitled to harvest from these resources. Thirty years ago the common property arrangement was virtually universal. Today, at the beginning of the 21st Century, it is still the most common arrangement of ocean fisheries.

Since the work of Gordon (1954) it has been known that common property resources are subject to fundamental economic problems of over-exploitation and economic waste. In fisheries, the common property problem manifests itself in:

(1) Excessive fishing fleets and effort,
(2) Overexploited fish stocks.
(3) Little or no profitability and unnecessarily low personal incomes.
(4) Unnecessarily low contribution of the fishing industry to the GDP.
(5) A threat to the sustainability of the fishery.
(6) A threat to the sustainability of human habitation.

The essence of the fundamental problem is captured by the diagram in Fig. 1.

Fig. 1 illustrates the revenue, biomass and cost curves of a typical fishery as a function of fishing effort. Fishing effort here may be regarded as the application of the fishing fleet to fishing. The revenue and biomass curves are sustainable in the sense that these are the revenues and biomass that would apply on average in the long run, if fishing effort was kept fixed and, of course the exogenous variables such as prices and technology remained constant.

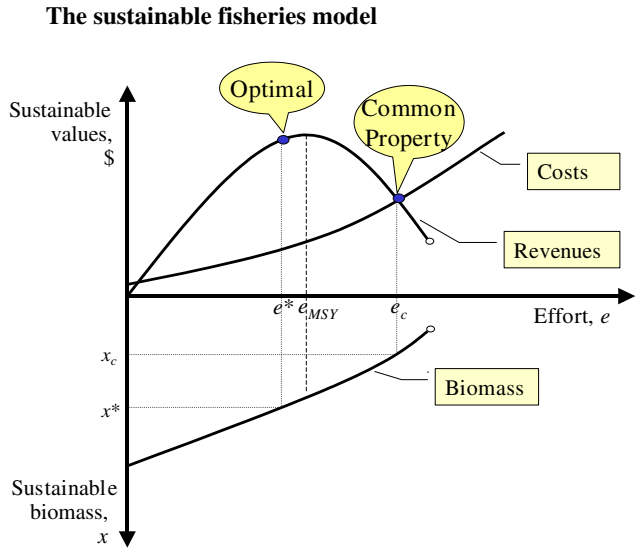

Fig. 1. The sustainable fisheries model.

The upper part of Fig. 1, is the well-known sustainable fisheries model initially forwarded by Gordon (1954). As illustrated, sustainable revenues initially increase with fishing effort but at a declining rate as the biomass is reduced. At a certain level of fishing effort, sustainable revenues are maximized. If fishing effort is increased beyond this point, sustainable revenues decline as the biomass level is reduced still further. Finally, at a certain level of fishing effort, the fishery is no longer sustainable. The stock collapses and there will be no sustainable revenues. As drawn in Fig. 1, costs, on the other hand, increase monotonically with fishing effort.

The lower part of Fig. 1 describes what happens to sustainable biomass as fishing effort is increased. Note that the level of biomass is measured in a downward direction so that the further down in the diagram the higher the biomass. The relationship between biomass and fishing effort, drawn in the diagram, shows that sustainable biomass is monotonically decreasing as fishing effort is increased. If, as illustrated in the diagram, fishing effort exceeds a certain level, the stock size becomes insufficient for regeneration – the fishery is no longer sustainable at that effort level – and the stock collapses.

Looking at Fig. 1, quickly reveals that the profit maximizing level of the fishery occurs at fishing effort level e^*. At this level of fishing effort, profits and consequently the contribution of the fisheries to GDP is maximized.[3] Notice that the profit maximizing fishing effort e^* is less than the one corresponding to the maximum sustainable yield, e_{MSY}. Consequently, the profit maximizing sustainable stock level, x^*, is comparatively high as can be read from the lower part of Fig. 1. The profit maximizing fisheries policy, consequently, is biologically conservative. Indeed the risk of a serious stock decline is generally very low under the profit maximizing sustainable fisheries policy.

Under the common property arrangement, the fishing industry will find an equilibrium at fishing effort level, e_c. At this level of fishing effort, costs equal revenues and there are no profits or rents in the industry. If, at the same time fishing labour is paid its reservation wage the net contribution of the fishery to the GDP is approximately zero.[4] In other words the competitive fishery contributes little or no net benefits to the economy. Notice that this is the equi-

[3] This assumes that all the relevant prices correctly reflect economic values.

[4] The assumption that labour receives its reservation wage is, in the market economy, equivalent to assuming that the labour market is in equilibrium, including no involuntary unemployment. In a situation of unemployment, i.e., excess supply of labour in the fishing industry or generally, even a common property fishery will generate some contribution to the GDP.