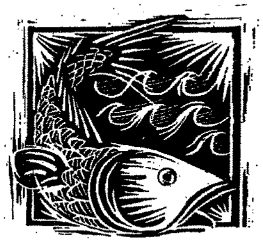

Theoretical and Practical Fishery Management

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The fishery problem

Many marine resources are extremely rich. Prudently utilized, they are capable of yielding very significant economic benefits. In some cases, the potential value of a country's marine resources is so great relative to the rest of the economy that they can provide the means for shifting the national economy onto a new and more favorable economic growth path. This has been true for Iceland in the past and it may very well also be true for Peru.

Yet there are formidable economic obstacles to realizing the potential benefits offered by ocean resources. For fisheries, there is an incompatibility between the traditional open-access, competitive structure and a sensible utilization of the fish stocks. Although open access and competition normally result in increased production and lower prices in manufacturing, they lead to reduced output and loss of economic benefits in ocean fisheries.

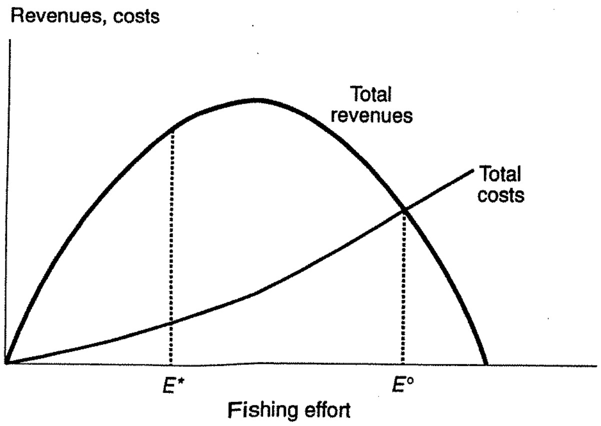
The characteristic of fisheries that gives rise to these perverse results is that fish stocks are a natural resource. This resource is not unbounded. The annual catch is limited by the reproductive capacity of the fish stocks. This natural limitation cannot be expanded by fishers. On the contrary, attempts by individual fishers to increase their catch will generally reduce the fish stock, in particular the spawning stock, to the point at which the sustainable yield of the fishery is greatly reduced. In fact, several previously large and valuable fish stocks have been depleted and the fishery destroyed by excessive fishing pressure resulting from fishers competing for catch.

The histories of most current ocean fisheries have been distressingly similar. A typical history runs as follows. Initially, when a fishery is first being developed, the resource stock is high. Therefore, catches are good and the fishers earn a high return on their investment and effort. This encourages the more enterprising fishers to expand their fishing operations. It also attracts new fishers to the fishery. Thus, fishing capacity expands and fishing effort increases. This reduces the fish stocks, and the catch per unit of effort declines. Economic returns from the fishery are correspondingly reduced. This does not put an end to the expansion in fishing capacity, however. Capacity continues to expand as long as the fishers can reasonably hope to extract a positive return from the fishery. Long before achieving a positive return ceases to be possible, however, the fish stock has normally been reduced far below the level corresponding to maximum sustainable yield, and total annual catches have actually been reduced despite the greatly increased fishing effort.

An open-access, competitive fishery will reach an equilibrium only when the expansion in fishing effort has reduced the stock to the point at which total fishing costs equal the value of the harvest. As long as harvesting revenues exceed costs there will be an incentive to invest in new capacity. At the equilibrium point, however, net returns from the fishery are zero and there is no incentive to invest in expanded capacity. Figure 2.1 illustrates these basic ideas.

In figure 2.1 aggregate fishing effort, denoted by E, is measured along the horizontal axis. Costs and revenues are measured along the vertical axis. The curve labeled total revenues represents total sustainable revenues at different levels of effort. At low lev-

Figure 2.1 The sustainable fishery model



els of fishing effort—as in the early development stages of a fishery—this curve indicates increasing revenues as higher levels of effort yield greater catches. This increase in revenues tapers off, however, and eventually they begin to fall as increased effort reduces the fish stock below the maximum sustainable yield. The curve labeled total costs represents the total costs of effort. This curve naturally rises as effort increases.

The equilibrium point for the fishery is at effort level E°. At this point the fishery has reached maturity: total costs equal total revenues, profits are zero, and there will be no further expansion or contraction in fishing effort. But at this point there are also no net economic returns from the fishery. The figure makes it clear that significant net returns could be attained by reducing effort. In fact, net returns are maximized at fishing effort E^*, where the difference between total revenues and total costs is greatest. A reduction in fishing effort to E^* will not be supported by an open-access, competitive fishery, however. The reason is that the profits realized at this level of effort would encourage an expansion in fishing capacity until the point E° was reached again.

This simple analysis closely fits the pattern observed in open-access ocean fisheries. All over the world these fisheries are characterized by excessive fishing capital and fishing effort, depressed fish stocks, and few or no net economic returns.

This failure of open-access, competitive fisheries was recognized only relatively recently. In the mid-1950s two Canadian economists, H. S. Gordon (1954) and A. D. Scott (1955), published pioneering articles about the fishery problem. These articles, which marked the beginning of the field of fishery economics, advanced essentially the analysis outlined above.

Scott threw a slightly different light on the problem, however. He noted that a single, informed owner of a fishery would not fall into the trap of excessive exploitation of the resource. Thus, from this point of view, the fishery problem is caused by the lack of private ownership of ocean resources or, in other words, by the common property nature of ocean resources.

It is this common property nature of ocean resources that compels fishers to overexploit fish stocks, even against their own better judgment. When many fishers have access to the same fish stock, each has every reason to grasp as large a share of the potential yield as possible lest the other fishers reap all the benefits the resource can offer. Prudent harvesting by one fisher in order to maintain the stocks will, for the most part, only benefit other, more aggressive fishers without preventing the ultimate decline of the stocks. Thus, each individual fisher, acting in isolation, is powerless to alter the course of the fishery. His best course of action is to try to grasp his share as quickly as possible while the resource is large enough to yield some profits.

This is what has been called the tragedy of common property resources (see Hardin 1968). The potential benefits of a resource, no matter how great, tend to become dissipated under the onslaught of a multitude of users.

The common property problem is by no means confined to fishery resources. It is also encountered in the use of common land, wildlife, and water and air resources. In all these cases the commonly owned resources tend to become overutilized, sometimes with disastrous consequences.

Thus, the empirical evidence and the economic analysis go hand in hand. Both clearly demonstrate the need for special management of fisheries if their potential benefits are to be realized. For coastal states with rich fishery resources in their waters, the potential economic benefits of well-informed fishery management are very great indeed.

Fishery management methods

A great number of different fishery management measures have been suggested. Most can be conveniently grouped into two broad classes: biological fishery and economic fishery management. Economic fishery management measures may be further divided into direct restrictions and indirect economic management.

Biological fishery management

The most common fishery management method is to impose an upper limit on total allowable catch (TAC). This is a typical biological management measure designed to protect the fish stock. If adhered to, total allowable catch restrictions are well suited for conserving the fish stocks. But this kind of fishery management does not alter the economic dynamics of the fisheries. Thus, if the total allowable catch approach manages to enhance the fish stocks, competition among fishers for shares in the total allowable catch will result in correspondingly increased fishing effort and overcapitalization in the fishing fleet. More vessels will be brought into the fishery and fishing effort expanded until all potential rents again disappear.

The same results can be expected from all other management measures designed to improve the state of the fish stocks, including fishing stoppages during spawning seasons, closures of nursery grounds, measures for protection of juvenile fish, and restrictions on fishing gear. To the extent that such measures succeed in enhancing the fish stocks, increased fishing effort and renewed investment in fishing equipment by fishers competing for a larger share in the fishery will dissipate the potential economic benefit.

The apparent conclusion is thus that biological fishery management measures, although well suited for preserving fish stocks, are useless from an economic point of view. In fact, the outcome is typically even worse.

Setting and enforcing biological fishery restrictions is invariably costly, with actual expenditures depending on the sophistication of the measures undertaken, the extent of the underlying research, and the vigor of enforcement. Usually these costs are quite substantial. And because biological fishery management generates no economic benefits to speak of, these costs represent a net loss.

Thus, we must conclude that fishery management based exclusively on biological conservation measures will generally generate a negative economic return. Such measures are therefore to be recommended only if the alternative is the biological destruction of the fish stocks.

Economic fishery management: Direct restrictions

The most frequently employed direct fishery management methods are restrictions on fishing effort, restrictions on the use of various fishing inputs, and limits on investment in fishing capital. These methods are designed to limit fishing effort and capital to optimal levels and thus to realize the potential economic benefits of the fishery. But because they do not change the basic common property nature of the fisheries, they encounter serious problems in achieving that objective.

Restrictions on fishing effort have been tried in many fisheries. The restrictions take various forms, including limitations on days at sea, fishing time, engine size, and the holding capacity of vessels. But irrespective of the precise nature of the constraints on fishing effort, their outcome is generally the same. Fishing effort is a composite of many variables. To maximize their returns from a fishery, competing fishers always expand fishing effort variables that are not subject to restrictions. If the number of fishing days is limited, fishers generally invest in larger and more powerful vessels. If there is a restriction on the holding capacity of vessels, fishers will add vessels and use faster ones. If there are simultaneous restrictions on the number of vessels, fishing days, and engine capacity, fishers will invest in fish-finding equipment, fishing gear, and similar variables. Competing fishers will always find ways to invest in effort variables that are not controlled. And this investment will not come to a halt until all potential economic rents from the fishery have been dissipated.

Restrictions on the use of certain fishing inputs and on investment in fishing capital lead to similar results. Imposing such restrictions will simply lead to substitution away from the restricted inputs to unrestricted ones. As long as there are any economic rents in a fishery, there will be an incentive to find ways to bypass the restrictions. Experience shows that it would be unwise to underestimate the ingenuity of fishers in finding such ways.

The conclusion therefore must be that direct fishery management methods are unlikely to generate significant economic benefits. This holds especially for single measures. A combination of direct management measures—such as access restrictions supplemented by restrictions on investment and effort—may be capable of sustaining some economic rents. But because maintaining and enforcing such measures is usually quite costly, the net benefits generated may easily turn out to be negative.

Economic fishery management: Indirect measures

The most prominent indirect economic fishery management methods are corrective taxes and such rights-based instruments as access licenses and individual transferable quotas. Both taxes and individual transferable quotas are theoretically capable of achieving economic efficiency in fisheries. But taxes involve substantial sociopolitical problems as well as some practical ones as a fishery management tool. In any case, taxes have not been used as the main fishery management tool in any significant ocean fishery. Individual transferable quotas, however, have been used in several fisheries. They have been fairly successful and are rapidly spreading to other fisheries.

Corrective taxes. The purpose of using taxes as a fishery management tool is to alter the economic conditions of the fishing firms so as to induce them to behave in a socially optimal fashion. The many different types of corrective taxes that could be used for this purpose can be broadly classified as taxes on fishery inputs or taxes on catch.

Taxes on fishery inputs do not appear very promising. Such taxes will generally lead to a substitution away from taxed inputs to inputs that are not taxed. But, to the extent that technical input substitution possibilities are not perfect, this method will generally generate some economic rents in the form of collected taxes.

Taxing catch is a much more effective way to realize the potential economic benefits of a fishery. After all, apart from cheating, there is no way for fishers to avoid this kind of a tax. The immediate effect of a tax on catch is to make a fishery less profitable. Thus, by squeezing out the least efficient fishers, a tax on catch forces a reduction in aggregate fishing effort. Depending on the tax rate, the effort level in a fishery can in principle be brought down to the economically most rewarding level.

Rights-based approaches. Rights-based approaches to fishery management attempt to eliminate the common property problem by establishing private property rights over the fish stocks. Because the source of the economic problems in fisheries is the absence of property rights, this approach should in principle secure the full economic benefits of a fishery.

Broadly speaking, two quite different rights-based approaches have been used in fisheries: access licenses and individual catch quotas.

Access licenses give the holders the right to participate in a fishery. They thus constitute a property right and, to the extent that they are transferable, will command a market price. Access licenses do not, however, eliminate the common property problem in a fishery. The fishery is still the common property of all holders of access licenses, and they will act accordingly. To improve or even maintain their share in the fishery, fishers will be forced to invest in fishing capital and increase their fishing effort. This process continues until all attainable rents have been dissipated and the fishery finds an equilibrium.

A system of access licenses may alleviate the common property problem somewhat, however. This may occur, for example, if the number of license holders is small and, more important, there are restrictions on capacity expansion.

Access licenses have been used in many important fisheries in recent years. In British Columbia's valuable salmon fishery, for example, access licenses have been in effect for a number of years and have achieved some economic success.

Individual catch quotas are a much more promising approach to the fishery problem. The allocation of catch quotas to individual fishers in effect gives them property rights in a fishery. And because the fishers' catch is secured by their quota holdings, the common property nature of the fishery is eliminated. Thus, a vessel quota system, by freeing fishers from competing with the other fishers for catch from a limited resource, allows them to concentrate on minimizing the cost of harvesting their catch quota and maximizing its value by improving its quality.

Transferable and perfectly divisible catch quotas are usually referred to as individual transferable quotas or ITQs. If the ITQs are also permanent, they constitute a complete property right, just like a right to a building or to a piece of land. In that case, standard economic theory should apply and, barring market imperfections, the fishery should automatically reach full efficiency.

This important point should be explained in a little more detail. First, if catch quotas are transferable, a market for the quotas will emerge. With the help of this market the quotas will tend to go to the most efficient fishing firms. The more efficient the quota market, the more pronounced this tendency will be. In this manner, an ITQ fishery management system will tend to guarantee that the TAC is always caught by the most efficient fishing firms.

Second, if the catch quotas are also permanent, the fishing firms will find it to their advantage to adjust the capacity of the fishing fleet to the socially optimal level. After all, the transferability of the quotas will ensure that only the most efficient firms do the harvesting. These firms will not hold excessive fishing capital; if they did they would not be fully efficient and would lose out in the market for quotas. For the other firms—those holding no catch quotas—there is of course no point in maintaining unutilized fishing capital. Therefore, aggregate fishing capital will tend toward the socially optimal level.

The most promising fishery management systems

Of all the fishery management systems considered, only the individual transferable quota system and the tax on catch seem capable of delivering the full potential economic benefits of fisheries. A consensus has emerged among fishery economists that the ITQ system, because it essentially eliminates the basic common property problem of fisheries, offers the most promising general approach to managing ocean fisheries. That does not mean that ITQs are necessarily the best management system for all fisheries, however. For example, for this method to work requires that the individual quota constraints be enforceable. If that is not possible in a fishery, another management method may be preferable.

Minimum information fishery management

The ITQ fishery management system, besides being generally best suited for realizing the potential economic benefits of fisheries, minimizes the need for centralized management. Under the ITQ system, the role of the fishery manager is reduced to determining the annual total allowable catch (TAC). If the quotas are transferable, the fishery manager does not have to concern himself with the allocation of the quotas,[1] but can depend on market forces to move quotas from the less efficient fishing vessels to the more efficient ones.

Calculating the optimal total allowable catch is no easy task, however. The optimal TAC depends on the detailed economics of the fishing fleet and the state of the fish stock at each point in time. Therefore, to determine the optimal total allowable catch, the fishing authority needs perfect knowledge of every variable in the fishery. This includes complete knowledge of the harvesting and cost functions of each vessel, the development of the fish stocks, their migratory pattern both generally and regionally, and the market conditions for landed catch. Clearly, these informational requirements greatly exceed the capacity of any fishery manager.

These informational difficulties do not mean that an ITQ system will yield no benefits. On the contrary, only an exceptionally inept fishery manager would set a TAC that would not generate a significant fraction of the attainable benefits of a fishery. After all, any TAC will be taken in the most efficient way. But it appears that the informational problems in an ITQ fishery management system would prevent it from generating a fishery's full potential rents. The ITQ system, in other words, appears to be a second-best management system.

Fortunately, however, the information needed to determine the optimal total catch for a fishery already exists in that fishery. The fishers have the most complete information available about their harvesting economics and catch prices and they command detailed knowledge about the state of the fish stocks. In addition, conducting successful market transactions in quotas requires sound knowledge of the overall state and development of the fish stocks. Thus, the quota market, provided it works reasonably well, will induce traders to gather the optimal amount of information about the fishery.

The workings of the quota market suggest the solution to the information problem. Given an efficient quota market, all information about the future course of the fishery, the state of the fish stocks, the market price for landed fish, harvesting costs, and so on, will be embodied in the market value of the quotas, which will be roughly equal to their expected return in use. The total value of outstanding quotas is thus a good measure of the total expected rents in a fishery.

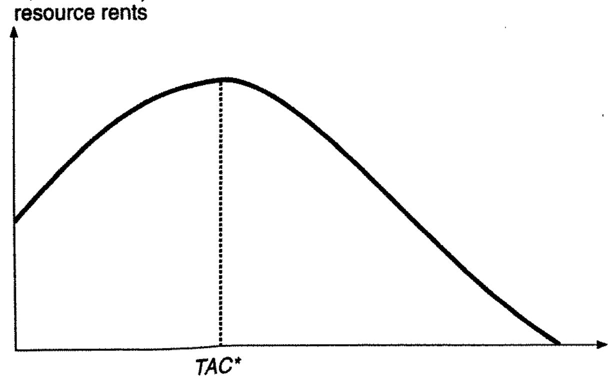
It follows that to determine the optimal total quota, the fishing authority has only to adjust the total allowable catch until the value of the outstanding quotas is maximized. This effectively exploits all the available information on the fishery.[2]

Figure 2.2 draws quota values or, alternatively, resource rents as a function of the TAC. It illustrates the proposition that the ITQ system will generally yield substantial economic rents for a wide range of TACs. More important, the figure shows that the manager of a fishery can locate its optimal TAC by simply adjusting the TAC until the market value of outstanding quotas is maximized.

This is clearly an exceptionally simple fishery management system. Under this system the fishery manager does not have to collect any information about the fishery. All the manager must do is keep a sharp eye on quota prices and adjust total allowable catch to maximize the value of outstanding quotas. For this reason, the system has been referred to as the minimum information management system (see Arnason 1990).

Putting this system into practice requires an appropriately designed ITQ system, however. First, the catch quotas must be shares in the total allowable catch. Second, the quotas must be perfectly divisible and easily transferable. Third, the market for quotas must function smoothly. The fishery manager should therefore encourage the development of the quota market and be ready to participate in it if necessary.

Figure 2.2 Resource rents and total allowable catch



The fishery manager would locate the maximum quota value by adjusting the total allowable catch and observing the resulting movement in quota prices. If total quota values go up when the total allowable catch is increased, the total quota has moved in the right direction—and vice versa. These manipulations of the total allowable catch may sound fairly complicated but they are in fact quite straightforward. Any respectable stockbroker should be able to perform these duties with little trouble.

Minimum information fishery management is a relatively recent idea that has not yet been put into practice in any ITQ fishery. Although it should be beneficial in all fisheries, it appears particularly attractive for fisheries in which there is little centralized knowledge and data processing capabilities are low.

It should be kept in mind that minimum information fishery management relies heavily on individual fishing firms behaving in an economically rational way. If the fishing firms are not rational, the minimum information management method is not likely to yield good results—but neither is any other decentralized fishery management system. Thus, even when the fishing firms are less than rational, the best management strategy may still be the minimum information management scheme.

The fishery management regime

The installation of a sound fishery management system, such as the ITQ system, is not by itself sufficient to successfully manage fisheries. To achieve that objective, a fishery management system must be supported by an effective monitoring and enforcement function backed by an efficient judicial process. Without these supporting functions, an otherwise excellent fishery management system will accomplish little.

Let us refer to the overall institutional framework within which the fisheries operate as the fishery management regime. In most industrial fishing nations, the regime is quite complicated, involving several institutes and activities. Logically, it must contain three main components—a fishery management system, a monitoring, control, and surveillance component, and a fishery judicial system (figure 2.3).

The *fishery management system* specifies the regulatory framework for fishing. It encompasses both basic fishery management rules—such as requirements concerning fishing licenses and catch quotas—and less crucial ones—such as gear and area restrictions. In most countries fishery regulations are based on legislation that aims to promote the generation of social benefits from the fisheries.

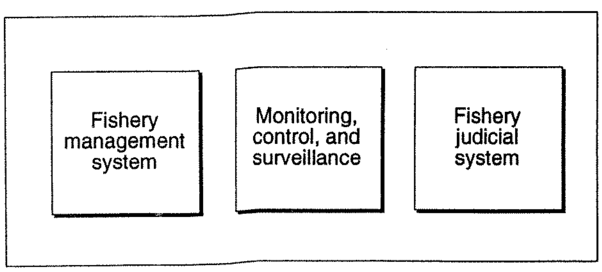
The primary task of the *monitoring, control, and surveillance* function is to enforce the management system that has been adopted. Its secondary—but nevertheless very important—task is to generate data that can be used to improve both the fishery management and judicial systems and the monitoring, control, and surveillance activity itself.

The *fishery judicial system* is usually a part of the general judicial system. It issues sanctions to those alleged to have violated fishery regulations and thus complements the monitoring, control, and surveillance activity.

The three components of the fishery management regime are strongly interdependent. For example, the fishing rules specified by the fishery management system define the scope of the monitoring, control, and surveillance activity and the focus of the fishery judicial system. The monitoring, control, and surveillance activity places demands on the fishery judicial system, and both activities in turn suggest modifications of the fishery management system.

Each of the three components of the fishery management regime is crucial to its success. To attain full economic benefits from the fishery, all three components must be appropriately designed, well coordinated, and fully functional. This point cannot be overemphasized. Any one or two of the components of the regime, however well designed and managed, will generate limited social benefits unless integrated with and supported by the other two components.

Figure 2.3 The components of the fishery management regime



These observations suggest that the design and implementation of effective fishery management requires full attention to all three components of the fishery management regime. They also suggest the importance of a single entity overseeing the regime as a whole and coordinating its components. Without a strong guiding hand of this nature, the social benefits generated by a fishery management regime are likely to be significantly reduced. In industrial fishing nations this guiding hand is usually provided by a special ministry or department of fisheries.

Establishing a successful fishery management regime

Establishing a successful fishery management regime is basically an exercise in social engineering. It involves not just technical, biological, and economic aspects, but a range of social and political considerations. For optimal results, it is very important to pay attention to as many of the sociopolitical aspects of the situation as possible. These include public attitudes, regional conditions, power relations, interest groups, and traditional social values and methods of production. Some of these aspects may justify important modifications of the components of the management regime. Others, if not attended to in time, may develop into serious obstacles to the implementation and the eventual success of the regime.

There are, of course, a great many ways to develop and implement an effective fishery management regime. Nevertheless, a few general guidelines apply:

1. Study the fisheries and the social situation carefully.

2. Avoid the wholesale import of a ready-made fishery management regime from other fisheries.

3. Design the fishery management regime with local conditions in mind. This applies to all its components—the fishery management system, monitoring, control, and surveillance, and, not least, the fishery judicial system.

4. In designing and implementing the regime and its components, work as closely as possible with the social groups most affected. Most important among these are the participants in the fishing industry and their organizations.

5. Study the most likely incidence of the fishery management regime and make provisions for flexibility in the system and for compensation to those unfavorably and unjustly affected. Compensation should always be possible because, if the system is socially beneficial, the fishery will yield monetary rents that exceed the necessary compensations.

These guidelines are intended to increase the probability that the reorganization of a fishery management regime will succeed. The first three are crucial for the effectiveness of the system, and the last two for generating the necessary social acceptance and support for the system. Without a relatively high degree of social acceptance and support, any fishery management regime will be either largely ineffective or prohibitively expensive to maintain.

Notes

1. Although the allocation of quotas may constitute a political problem.

2. This general theory is expounded in Arnason (1990).

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