CHAPTER 4

ECONOMIC PRINCIPLES: AN ECONOMIC PERSPECTIVE ON FISHING

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Contents

1. AN ECONOMIC APPROACH TO FISHERIES

Fishing is an economic activity based on available fish stock resources. Biological resource properties and market characteristics determine the economic performance of the fishery. The aim of fishing may be to obtain food for one's own consumption, to bring fish products to a market or to gain recreational value. Fishing can be unrestricted, but is now more often regulated. Modern fisheries regulation focuses resource conservation and sustaining exploitable fish stocks but aquatic ecosystems are dynamic and the state of a system is hard to measure and forecast. The economic activity of fishing interacts directly with the natural resources and previous fishing activity is one of several factors influencing future stock situations.

Open access to common-pool stock resources is known to involve severe market failures causing overcapacity of fishing effort and loss of resource rent (the concept of resource rent is explained later). The core idea of introducing fisheries management is to control fishing activity to increase the probability of achieving desirable future stock development and to promote a sustainable fishery. Essentially the management problem is to reduce or control growth of fishing effort. The choices of proper management means and levels of fishing effort are however not trivial problems. Fish stock resources as well as fishing fleets are highly dynamic, non-transparent systems.

Old-established fisheries regulation systems were aiming to solve social and economic problems caused by the unregulated fishing; such as the Norwegian Lofoten Act of 1816, targeting the problem of gear collisions due to high fleet densities on local fishing grounds in the Norwegian cod fishery. Other regulations with a long-standing tradition focus on market and trade issues, controlling landings and production facilities.

When classical economics emerged as a discipline in the 18th century, it was on the basis of studies on the use of scarce natural resources versus the seemingly exponential growth of the human population. Adam Smith, professor in moral philosophy at the time, was studying such problems and became one of the founders of modern economics. The following quote from his main work, '*Wealth of Nations*' (Smith, 1904), demonstrates a profound understanding of the role of natural resources in different markets, pointing at management challenges yet to come:

> "Hunting and fishing, the most important employments of mankind in the rude state of society, become in its advanced state their most agreeable amusements, and they pursue for pleasure what they once followed from necessity. In the advanced state of society, therefore, they are all very poor people who follow as a trade, what other people pursue as a pastime. Fishermen have been so since the time of Theocritus. A poacher is everywhere a very poor man in Great Britain. In countries where the rigour of the law suffers no poachers, the licensed hunter is not in a much better condition. The natural taste for those employments makes more people follow them than can live comfortably by them, and the produce of their labour, in proportion to its quantity, comes always too cheap to market to afford anything but the most scanty subsistence to the labourers."
> *Adam Smith (1776), An Inquiry into the Nature and Causes of the Wealth of Nations. Book I, Ch.10 (I.10.6): Of Wages and Profit in the Different Employments of Labour and Stock in paragraph.*

1.1 Different components of a fishery

As pointed out above, fishing is an economic activity where the dynamics of the economy interact with the dynamics of an ecosystem. The resource base (the ecosystem) is of course the essential part of any fishery. The fishing activity may target different trophic levels of the ecosystem, ranging from the lowest level prey species to the top predators. The fishery may target several species at the same time, including species from different trophic levels (multispecies fishery) or specifically one species or one specific part of this species. Species which could possibly be targeted by fisheries are determined by ecosystem properties, available technology and market conditions. Fishing technologies (vessel and fishing gear) typically have different properties of selecting between and within species, reflected in different catch compositions of different gears utilised in the same fishing area (see Chapter 7).

Fisheries are normally classified by a set of criteria:

- Economic category (industrial, artisanal, subsistence)
- Spatial dimension (freshwater: lake, river; marine: coastal, oceanic, foreign waters)
- Seasonal profile (may involve dynamic adaptations to natural variations)
- Home port (the origin of the vessel)
- Landing port (from which the fleet operate)
- Fishing gears (alternating seasons)
- Vessel size (vessel length, tonnage, engine size)
- Targeted species (multispecies fisheries, alternating seasons)
- Product types (fresh, frozen, preserved, salted, etc.)
- Markets (auction, traders, vertical integration, sales organisations, processing industries, etc.)

Several of the criteria are interrelated and the list demonstrates the multidimensional environment in which a single decision maker in fisheries is operating. Some of the criteria are the result of decisions made in the short run, while others are determined by long term investments. Several of the criteria are targets of management decisions, effectively reducing the fisher's multidimensional space of possible decisions.

Within the multidimensional space the fisher is expected to make decisions aiming to maximise the profit earned from the fishing activity. As the constraints vary by natural fluctuations, the activity of other fishers and changes in management decisions, the fisher faces uncertainty at many levels. Attitude towards risk, ability of adapting to changes, market information, assets, skills and experience, constitute the background of the decisions by the fisher. The manager faces the same types of uncertainty, including the uncertainty related to the future decisions by the fisher. The introduction of the precautionary approach (cf. chapters 12 and 13) and ecosystem approach to fisheries management (EAF, see Garcia and Cochrane, 2005) opens the way for procedures capable of handling uncertainty at different levels.

The fisher's choice of vessel type relates to the choice of fishing gear. Some vessels may have the capacity to operate several different gears, making it possible to participate in different fisheries over the year (adapting to seasonal variations). Other vessels are more specialised in respect of fishing gears and targeted species. Fishing may also take place without any vessel (e.g.

beach seining) and in some cases also without any specific fishing gear (e.g. diving for mussels). Catch production is discussed further in point 1.6 below.

For the profit maximising fisher, choice of which fishing gear to use involves a number of considerations, including: knowledge on market price on fish products (market information), capacity to operate and utilise the potential of different gears (skills to handle equipment), the cost of gears and gear operations (investments and running costs), and knowledge of the stock situation and prospects (stock estimates and future expectations).

For the manager, the fishers' choice on which gear to use is equally important, as different gears have different impacts on the ecosystem (see chapter 7 for details). It is also important for the manager to have knowledge on fleet economy and technological and economic differences between vessel groups. If a management system is put in place the fishers may be obliged to provide governmental institutions with such information as a part of the legal system of allocating fishing rights (e.g. licensing agreement).

Elements of the fleet economics are reflected in markets where fish products are landed and traded. Quantities and prices are important factors to monitor, firstly as a part of the ordinary catch monitoring and control, but also, when separated on different markets, for identifying market mechanisms. Some fish products are traded in local markets where the fishers may have some degree of market power (influencing the prices), while other products are priced according to world market prices, not providing the single fisher with any market power (as they are price takers). By monitoring catch quantities and market prices over time in different markets, information on the relation between quantity and price may be obtained. This information could prove to be useful in predicting the impacts of changes in catch quantities on fishers' revenues.

Essential cost information is however not equally easy to monitor. If management measures have less impact on fleet dynamics, some rough cost information may be found by utilising bioeconomic reasoning as explained in subsection 2.1, while more accurate information has to be based on sampling economic data. The quality of collected data may however also be tested against bioeconomic theory, as some development patterns over time may be more likely than others. Increasing stock size (reflected in e.g. increased catch per unit of effort) is for example more likely to be the consequence of decreased fishing effort over time, than the opposite. If information provided by the fishing fleet is inconsistent with what is expected from a theoretical point of view, further investigations may be needed to confirm the data.

Cost data can be separated into three cost components:

- Fixed costs (long term investments and costs not related to level of activity, in principle including opportunity costs)
- Effort dependent costs (running costs directly related to the amount of fishing effort produced)
- Costs varying with catch quantities (costs of handling, transporting and preserving catch)

Opportunity costs represent a theoretical concept which is discussed further in subsection 1.2 below. Operational costs are easier to identify, given that annual accounts are accessible. Separating variable costs into different types of costs (as the second and third bullet point above) makes it possible to make a cost prognosis on the basis of different levels of effort and catch, as well as calculating possible effects of changes in costs, for example by different taxation levels.

Fish products may pass through several markets before being consumed. As the primary target of management decisions is the fishing fleet and its activity, the manager should place most emphasis on landed value when predicting immediate effects of management decisions. Vertically integrated companies, operating through several markets between fisher and consumer, may represent a problem for the manager regarding obtaining accurate information in this respect, since obtained price on landings may include market imperfections.

Market regulations may be appropriate and required at all levels, but in this context we only consider the primary market, trading between fisher and fish buyer, reflecting landed value. Value landed gives income for the fisher and within the framework given by the authorities, one of the core inputs in the decision-making by the fisher regarding his future fishing activities.

Some fish products go directly to the consumer market, from fisher to consumer. Given price negotiation between the two is not distorted by market imperfections, the fisher – and monitoring manager – gets information immediately through the negotiated price that reflects the social benefits of the fishery. In principle, this is the same also for fish products passing though several markets before final consumption. If all markets in the market chain were perfect, effective regulation (reducing fishing effort from the open access level) should, in principle, provide the fisher with all the resource rent that could be obtained from the fishing activity, unless the management includes means of effectively increasing costs of fishing (e.g. taxation, prohibiting effective gear use, etc.).

1.2 What are opportunity costs of fishing?

Cost of fishing is the value spent on the two input factors, labour and capital, to produce fishing effort and catch handling. The costs include investments (sunk costs) and running (variable) costs, as described in subsection 1.4. The opportunities forgone by not utilising this labour and capital elsewhere also represent a cost, known as the opportunity cost. Opportunity costs are therefore normally not found by examining annual accounts.

The opportunity cost of labour is the highest return which could be obtained by utilising the labour resource elsewhere. This cost may be estimated on the basis of average ordinary salaries of similar labour groups within the region, assuming this to reflect the best alternative salaries for the fishers.

Similarly the opportunity cost of capital is the highest return which could be obtained by investing the capital elsewhere. If this is higher than the return earned in fisheries, in the long run, capital is expected to move from fisheries to be invested where it gives higher return. In the opposite case, capital is expected to move from other sources into fisheries. Therefore, in a perfect market, the return on capital should be levelled between all possible placements and this return defines the ***normal profit*** on capital investments, in the long run. This applies to all input factors in production, not only capital. Normal profit is the profit needed to cover all opportunity costs of production, basically the opportunity costs of labour and capital. If the profit exceeds the normal level (abnormal profit), economists characterise the additional profit as ***economic rent***. Before discussing economic rent further let us look more on the role of opportunity costs.

Opportunity costs are not constant. As the economy develops, opportunity costs change and even though markets may be imperfect, in the long run changes in profitability within one sector influence other sectors within the same economy. The following example may illustrate the impact that economic development has on all sectors, including fisheries:

Assume the opportunity cost of labour to be close to zero in a fishing village where virtually the whole population depend on fishing activities as food supply and no labour is demanded by labour markets outside the fishing sector. Assume further that a labour-intensive industry is to be established in the village. The industry offers low salaries, but still more than zero. This new demand for labour affects fishing activities. Fishers will look at the new industry for jobs which offer higher salaries than those received from fishing. It the supply of labour exceeds the number of jobs offered by the industry, the latter may reduce salaries, substituting capital by labour until the salary of an industrial worker equals (or corresponds to) the income of a fisher. The reduction in number of fishers available affects the profitability in the fishery and hence the return to labour employed in fishing. The increased total income in the community affect the price setting on fish products (increased price on fish is expected) and the reduced number of fishers may have an immediate positive effect on the stock (increasing availability) and thereby reducing unit cost of harvest. This effects on the fishing may attract industrial workers back to the fisheries until labour market equilibrium is reached when the industry salaries equal the return to labour in the fishery, at a level which is higher than the initial return per fisher (before the new industry developed). The unit cost of effort has therefore increased as a consequence of the installation of the new industry. The unit cost of harvest may be less than before if the impact of reduced effort on the stock more than compensates for the increase in unit cost of effort. The economic development described may later result in additional increases in the market price of fish products, causing the fishing effort to increase, possibly also beyond the initial level[1].

This theoretical example also describes the dynamics of an economic system interacting with a natural resource. In the example, perfect markets are assumed, and the profits earned at all levels are normal profits. Profits exceeding normal levels (abnormal profits) could only be obtained when the markets are not perfect. The economic rent obtained is often categorised according to its origin. ***Monopoly rent*** originates from a market distortion caused by the hold on market power by sellers or buyers in a market, while ***intra-marginal rent*** originates from differences in technology or unit cost of effort among the producers. ***Resource rent*** is yet another type of economic rent, originating from the properties of the exploited biological resource. If not paid for (as in the case of free access to a common-pool resource) the economic value of the resource (reflected in the primary market) constitutes a rent, which is a profit beyond the normal level defined by the opportunity costs.

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[1] This example does not include the effect of external markets. External markets interfere with the local factor markets (labour and capital) as well as with the local fish product market. Increased product quality may open high price markets outside the community, while increased fuel price (within the capital factor market) is an external factor changing the substitution rate of labour and capital, normally reducing the overall fishing effort.

The following subsection provides an explanation on why resource rent may occur in fisheries. It may be reflected (at least in the short run) in the payment to input factors in fishing. Labour costs reflected in wages and salaries paid to fishers may be regarded as shares of profits for the fishers, rather than payment of input factors in production (Turvey, 1964). This distinction clarifies the reason why resource rent also may be found in wages. The labour market is affected as fishing becomes more attractive and other employers have to pay more to keep their labours. In the long run the picture may however be the opposite, as the resource rent may be lost and both labour markets pay a lower price the initial.

1.3 Basic market failures in fisheries

Economists often argue that the market should take care of efficient allocation of goods and commodities, since social welfare is efficiently maximised in perfect markets according to standard economic theory ("*the invisible hand*" of Adam Smith). Market imperfections always exist to some extent but, normally, markets show amazing ability to find solutions close to social optimums. There are however some markets that systematically fail to reflect true social values, because of severe market failures. Free access to the exploitation of common-pool fish stock resources are such cases.

From an economic point of view, management is motivated by the political wish to impose market failures where, before, there was more or less a perfect market situation (e.g. licensing taxi drivers) or to resolve existing market failures (e.g. in the case of public goods which are not produced by market mechanisms). Political reasons may therefore exist for both introducing and eliminating barriers to free market, creating or removing market failures. Exploitation of common-pool stock resources normally includes market failures which need to be corrected through management measures.

In short market failures in fishing have two causes:

1. The discrepancy between real value (reflecting relative scarcity) and zero payment from the resource users (in case of free access to the resource).
2. The long-term interrelation between the two essential input factors fish harvest production; fishing effort and stock biomass.

According to standard textbook production theory, efficient production is obtained by using less fishing effort and more fish stock biomass since access to stock biomass is free while effort production is costly. However, the stock biomass is either given (in the short term) or partly determined by biological growth and previous fishing efforts (in the long term). As a consequence, the basic conditions for normal substitution are not met and the presence of the free factor (stock biomass) leads to increasing use of the other factor (fishing effort). The opposite should be expected if both factors were independent of each other.

Together the two points mentioned above constitute the situation referred to as the market failure of open access fishery; the first of them originates from a value not reflected in the market (the economic aspect) and the other originates from the stock response to harvest, simply the fact that the natural level of equilibrium of the stock declines as mortality increases (the biological aspect).

The first market failure (the economic aspect) underscores the potential for gaining economic rent (resource rent), while the second (the biological aspect) is the reason why the rent is wasted. Management is needed if the market failures are to be corrected and resource rent collected. The resource value increases as the resource becomes scarcer, making potential gain by proper management even greater. Fisheries management therefore is not equally relevant in all fisheries at all times.

Hardin titled his famous Science paper in 1968 "*The tragedy of the commons*"[2], referring to how open access to common-pool resources leads to over-exploitation (Hardin, 1968). Fisheries are often used as a case illustrating Hardin's point. Similar reasoning was presented in the seminal works of Gordon (1954) and Scott (1955). Hardin also refers to much older works expressing the same ideas regarding open access to the common-pool resources in ancient literature (e.g. Aristotle). From an economic perspective the only tragedy is, however, that the benefits of the first market failure (to get the resource free of charge) are wasted by building up overcapacity (because of open access to the resource value). Without proper management, the value of the scarce resource is lost, as the unit cost of harvest increases with the decline in stock biomass.

1.4 Fleet diversity, costs, markets and stock fluctuations

Bioeconomic theory provides the manager with insight in how the two dynamic systems (i.e. the resource and the fishery) interact. Open access fleet dynamics (see subsection 2.1) illustrates the consequences of the fishers' economic rational behaviour. Assuming economic rational behaviour is useful when aiming to predict fishers' response to management decisions. The manager's problem is however that he does not have all the information on cost and harvest production of the fisher. Cost of fishing and change in cost by management decisions and stock fluctuations are known (within limits) by the single fisher, but are to a large degree hidden to the manager.

Systematic studies of costs and earnings of different vessel groups are useful to control the achievement of management goals, predict the performance of the fleet and foresee the behavioural reaction on future management means. As described in subsection 1.1, obtaining accurate data may be demanding and the monitoring cost should to be in balance with the expected benefits. The fleet itself should preferably cover the monitoring cost or a part of it.

Most fisheries are characterised by a highly diverse fleet structure. The fleet diversity has to be understood on the basis on the fluctuations caused by the dynamic systems (ecological and economic dynamics), constantly changing the conditions of the economic activities. Equilibrium

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[2] Unfortunately, in this paper, Hardin introduced confusion between common property and open access corrected only 30 years after when Hardin published a paper about the tragedy of **unmanaged** commons (emphasis added). Hardin, G. 1998. Extensions of the "Tragedy of the commons". Science. Essays on science and society, 280 (5364): 682-683

theory predicts that the single most cost-efficient vessel type in the long run will be totally dominant, as no other types of fishing will be economically viable (bioeconomic equilibrium, discussed in subsection 2.1). Fleet diversity therefore could be regarded as reflecting a rational economic response to stock variability, changes in demand for fish products and changes of costs on input factors in effort production.

Differences between vessels and fishing gears in catch pattern and technological efficiency (for example differences in stock-output elasticities as explained in subsection 1.6), cost composition (between the three types of cost elements listed in subsection 1.1), price on fish products (which may have different seasonal profiles), contribute to extending the area of cost-efficiency of the total fleet. One vessel type being the most cost-efficient during one period at a certain market situation and stock biomass composition and size, may be less cost-efficient than others during another period. Higher diversity is an economic response to increased fluctuations, both in the ecosystem and in the economy of the fleet, including the fish markets. This should be recognised by managers and policy-makers when they establish policies and regulations.

1.5 Fish stock resources as the basis of economic development

Fishing has been and still is the employer of last resort for many people without land, money and job. Free and open access to fish stock resources is access to instant food which can be obtained by manual power or simple technology involving almost no cost other than the labour of the fisher. In such cases *the fisher is not poor because he is fishing; he is fishing because he is poor*, as expressed by MacKenzie (1979).

Free access to common-pool resources is essential for the survival of many poor fishers and their families (e.g. for subsistence fishing). If a demand for fish products exists in accessible markets for the fishers, excess catches may bring income as well as food to the poor fishers and their families. Given necessary public goods (first of all infrastructures) and stability over time, exchange of goods and services in a community develop markets. As the economy develops, these market places become more important in defining the value of the resource. In a subsistence fishery, the market is not playing an essential role. Similarly lack of access to markets becomes a critical constraint on further economic development. Lack of necessary infrastructure is usually the most important constraint in market development, as public goods like roads, electric power and water supply are not usually produced through standard market mechanisms. The development mechanisms are further discussed in section 4 of this chapter.

1.6 The economics of harvest production

Economically, fishing is a production process where the input factors are fishing activity (often referred to as fishing effort) and the fish stock resource, while the output is fish harvest. The two input factors are both equally essential, as no catch could be produced without the presence of both factors. As discussed above, harvest production is interlinking two dynamic systems, ecosystem dynamics and economics (reflected in fleet dynamics) and the harvest is influencing the dynamics of both systems. Management measures targeting inputs in harvest production as well as output, therefore also have the potential of affecting both systems' dynamics.

A simple bi-linear relationship between output and input factors is commonly assumed in fisheries models. This implies that 1% change in stock size (up- or downwards) gives a corresponding 1% change in catch if fishing effort remains unchanged (the technical term expression this is that *stock-output elasticity* equals one and implies that catch per unit of effort, CPUE, is linearly related to stock abundance). Most all studies on this matter (see for example Hannesson, 1983 and Eide et al., 2003) conclude however that usually *stock-output elasticity* is less than one, indicating that the change in catch is less than the corresponding change in stock biomass and, therefore, that the relative efficiency of fishing increases as the stock goes down[3]. In the case of typically schooling species the *stock-output elasticity* may even approach zero, indicating that the catch is almost independent of stock biomass, given that the stock is not extinct. When aiming to control a fishery through effort regulation, this point becomes essential, as well as when interpreting information available from catch and effort data. Information on catch per unit of effort (CPUE) becomes less useful as a stock biomass indicator when *stock-output elasticity* is very different from one.

Fishing effort is an input factor in harvest production, but it could also be regarded as on output from another production process involving the use of labour and capital. Labour and capital are substitutes in the production of fishing effort. A certain amount of fishing effort could for example be produced by a large number of fishers (high labour) fishing with hand line from dugout canoes (low capital). The same amount of fishing effort could be produced by a few fishers (low labour) on a trawler with more advanced fishing gear and fish finding equipment (high capital). As fishing effort is the same in the two cases, the harvest produced by the effort also will be the same, given equal selective properties and stock biomass.

Economic development normally leads to labour being substituted by capital, as labour over time becomes relatively more expensive than capital. This has several consequences also from a management perspective. First of all, since labour in the short run normally is easier than capital to move between sectors, economic development may affect the entry/exit dynamics in harvest production. In the long run both a labour intensive and a capital intensive fishery need to cover their total cost of fishing. In the short run they need at least to cover their running costs (e.g. having a positive contribution margin). Since a capital intensive fishery normally has higher sunk cost while the input factors of a labour intensive fishery are easier to move to other places, the first is expected to change tardier than labour intensive fisheries. Fixed costs constitute most likely a larger share of the total costs in a capital intensive fishery than in a labour intensive fishery. As a positive contribution margin is needed also in the short run, to stay in a fishery, this factor also leads to higher entry/exit rates in labour intensive, usually less developed, fisheries.

[3] Fishing efficiency can increase with time through fishers' learning or adoption of better fishing gear and practices, but also as a function of input variables in fishing, due to the properties of the stock or the gear technology. Gill net fishing on homogenously distributed fish species are normally expected to result in catches linear in stock biomass (random fishing and stock-output elasticity equal one), while fishing gears luring fish (e.g. by bait) or approaching fish (e.g. trawl) typically have stock-output elasticities below one. Similarly shoaling species also affect the relative efficiency, as changes in total fish stock biomasses not is correspondingly reflected in fish densities within the shoal.

2. BIOECONOMIC REASONING AND REFERENCE EQUILIBRIUMS

In 1954 an economic theory of a fishery based on open access to a common-pool fish stock resource was published by the Canadian economist H. Scott Gordon (Gordon, 1954). The economic reasoning behind his paper was not new (some elements are represented already in the early quote by Adam Smith cited in the introduction of this chapter), but the mathematical formulation of the problem, including natural growth of the fish stock, was new and groundbreaking. The actions of rational profit maximising fishers were shown to affect future profits of all fishers. All fishers exploiting the same stock are affected by the market failure described in the previous section, as the availability of one input factor (the fish stock) depends on previous fishing activities. Gordon presented a comparative static analysis of a fishery, focusing on two reference points: bioeconomic equilibrium (open access solution) and resource rent maximisation (maximum economic yield; MEY). Short descriptions of these reference points and two more (the equilibriums of maximum sustainable yield and social economic optimal solution), are provided in the following.

2.1 Bioeconomic equilibrium, the consequence of an unregulated fishery

As all fishers within a fishery harvest on the same stock resource, the state of the resource affects the catch of all fishers. Assuming a homogenous fishing fleet in terms of harvest efficiency, vessel revenue equals the average revenue of the whole fleet, given the same fishing effort of each vessel. Each vessel may however differ in terms of effort costs. Let us, for the sake of the argument, assume equal unit cost of effort throughout the fleet. If opportunity costs are included in the cost, the net revenue of each vessel equals the resource rent obtained by the vessel. The resource rent derives from the fact that the access to the valuable natural resource (the fish stock biomass) is free.

If the resource rent is positive, this will attract more vessels or increase the effort of the vessels participating in the fishery. Since there is free access to the fishery, fishing pressure will increase, stock will decline and so will the revenue per unit of effort (average revenue). Since effort will increase until net vessel revenue becomes non-positive, in the long run the resource rent is lost i.e. the fishery will develop to the point where the benefit achieved by the last unit of effort recruited to the fishery (marginal revenue), equals the cost of this effort (marginal costs). This is shown graphically in Figure 4.1. The resource rent is actually lost by being converted into excess effort (overcapacity). In an open access fishery therefore resource rent is wasted, in effect subsidising fishing activities beyond the levels by which abnormal profits (positive rent) could be obtained.

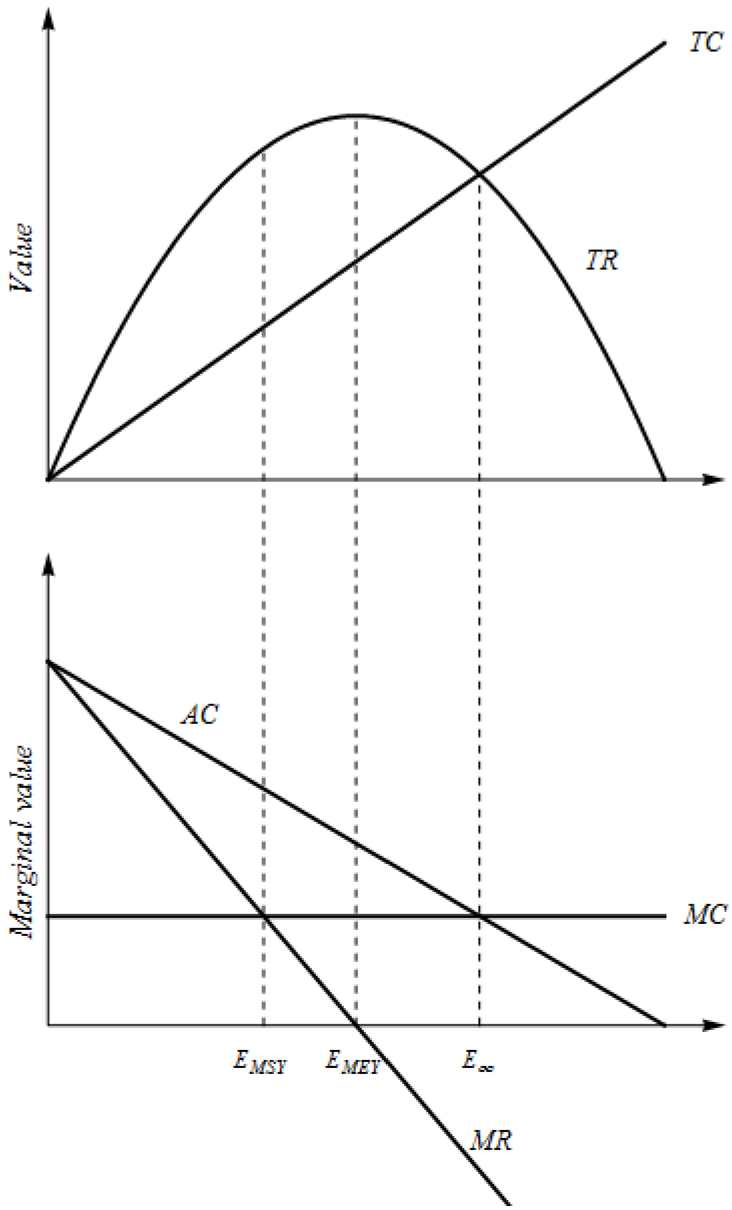


Figure 4.1 *The standard textbook bioeconomic model (the Gordon-Schaefer model). The figure presents the three first reference equilibriums: open access equilibrium effort (E_{∞}), maximum sustainable yield (corresponding to the equilibrium effort E_{MSY}) and maximum economic yield (corresponding to the equilibrium effort E_{MEY}). TR and TC in the upper panel represent total revenue and total cost respectively, both as functions of fishing effort. The cost includes opportunity costs of labour and capital. The lower panel shows the situation per unit of effort; MR being the marginal revenue, AR the average revenue (per unit of effort) and MC the marginal cost with respect of effort (explained in the text). Resource rent is maximised when MR=MC, while bioeconomic equilibrium occurs when AR=MC. MSY is equivalent with maximising revenue (MR=0), assuming constant unit price of catch.*

Brief look at aggregated data, establishing useful reference points. An example

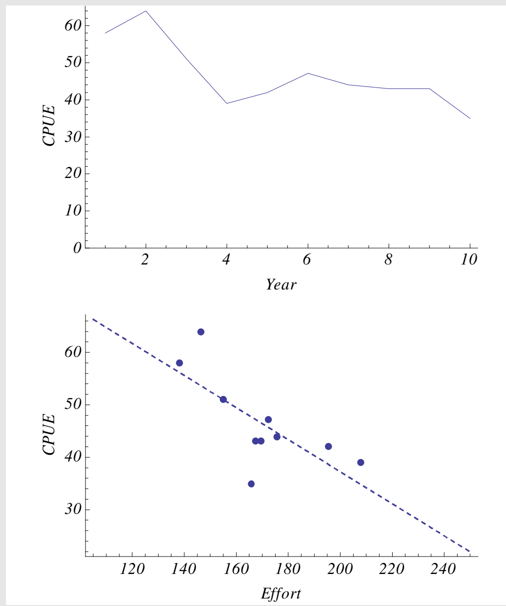
In this example, ten years catch (Y) and effort (E) information is available, as shown in the table below. It is always useful to take a thorough look at the data from different angles. Graphical plots are useful tools for comparing different data series and testing hypothesis. The common assumption of a linear relationship between catch and catch per unit of effort (CPUE) provides us with a simple but powerful method of calculating indicators reflecting the state of the stock. In this example a logistic model for growth of biomass and a linear relationship between CPUE and biomass are assumed; CPUE is then proportional to the stock biomass.

Measured effort and catch over a period of ten years.

Year	Effort (1000 vessel hours)	Catch (tonnes)
1	138.05	8007
2	146.52	9377
3	155.06	7908
4	207.72	8101
5	195.36	8205
6	172.40	8128
7	175.46	7720
8	167.58	7206
9	169.54	7290
10	165.91	5807

A linear regression of CPUE (catch/effort) vs. effort gives expected CPUE – CPUE(E) as a function of effort (lower graph on right),

Fitting a regression line gives the equation: CPUE(E) = 98.387 – 0.306 E. CPUE is defined by Y/E. Multiplying both sides of the equation by E gives the following expected catch function:
$Y(E) = 98.387\ E - 0.306\ E^2$.



Graphical presentation of the tabled data.

An estimate of MSY is easily obtained by maximising the Y(E) function: MSY= 7916 at a fishing effort E=161. The effort of today (year 10 in the table) should in the long run result in an annual harvest more than thousand tonnes above today's harvest. The dramatic drop from year 9 to 10 may indicate that there are other explanations than those included in the model; or the catch statistics of year 10 could be less reliable; or the temporary effects of the previous years' increase in effect may have the observed effects before the long run equilibrium is achieved.

Since this is an open access fishery, equilibrium effort is in the long run expected to provide the fishers with a normal profit. The effort over the last three years seems to stabilise around 165-170 thousand vessel hours, which may indicate a situation close to that open access equilibrium. The cost/price ratio of the fishery should then be close to the open access catch/effort ratio, in this case about 40 (from the figures in the table). Given a market price for fish product of 2 $, unit cost of effort should be close to 80 $ per vessel hour. This may however be an overestimate, since the recent catches have been very low. This illustrates how a time series on effort and catch data (together with some market observation) may contribute in providing the manager with some rough information on harvest potential, including cost estimates.

It is easy to understand the new recruitment of fishers to a fishery where labour and capital earn more than elsewhere. But why should the fishers already inside the fishery spoil their future chance of obtaining resource rent by increasing their fishing effort of today? The economic keyword in this context is *externalities*. The negative long term effect caused by the increased effort production of one fisher is shared with all fishers within the fishery, while the immediate gain is individual and not shared with any. Therefore all fishers have incentive to increase their fishing effort until the individual gain is non-positive (no economic rent).

Given a stable situation (with no change in stock and fishing effort) and no regulations, a fishery is in the long run expected to approach bioeconomic equilibrium. Based on this reasoning, assuming not to be too far from equilibriums, time series of catch and fishing effort (if available) may be utilised to calculate rough estimates on growth properties, biomass history of the stock and also cost/price ratios for the fishery. If a time series of catch and effort also covers a wide range in effort and calculated catch per unit of effort (CPUE), valuable information may be obtained even from relatively short time series and highly aggregated data. The boxed example illustrates one possible rough approach to obtain some immediate ideas of the state of the stock and the fishery and how essential economic information connects to this.

2.2 The economics of Maximum Sustainable Yield (MSY)

The bioeconomic equilibrium of a fishery (open access equilibrium) includes the biological equilibrium (sustainable catch: biological net growth in stock equals harvest) in coexistence with an economic equilibrium (constant effort; since a normal profit – see Section 1.2- is obtained in the fishery). This theoretical concept is a useful reference point, similarly to the better known reference point of maximum sustainable yield (MSY), which is presented in the following.

Maximum sustainable yield (MSY) refers to a theoretical long term biological equilibrium (as indicated by the term '*sustainable'*), but it is not likely to represent the economic equilibrium (providing participating fishers with a normal profit). The bioeconomic equilibrium depends on the cost of fishing per unit of effort and the productivity of the stock and may be at lower or higher biomasses than that corresponding to MSY. Only by coincidence may it occur at the MSY biomass level. If the open access bioeconomic equilibrium occurs at a stock biomass above that of MSY, the latter could not be achieved without subsidising the fleet, since the high cost of effort would keep effort below the effort level necessary to obtain MSY.

A situation which is probably more often found in open access fisheries is the bioeconomic equilibrium in a region in which biological overfishing the stock would be taking place, at a stock level below that which would produce MSY. MSY could then not be obtained without reducing fishing effort, e.g. by the use of fisheries management. The MSY reference point therefore has no general economic interpretation. By coincidence it may be obtained by open access fishery, but it may also be out of range due to economic constraints. In developed, commercial fisheries, overfishing is however most likely to be the consequence of open access to the resource and effort reduction is needed if aiming to harvest a maximum yield on a sustainable basis.

The arguments given above (and the fact that the exact levels of effort and yield corresponding to MSY are usually known only approximately and too late) highlight the problem of selecting MSY as a development target. The conclusions of the 1995 UN Fish Stock Agreement therefore was to refer to MSY as a *limit* to be avoided, rather than a target to be reached. MSY is however still a useful reference point, as provides a basis for the term '*biological overfishing*' and by that defines the ultimate limit of biologically sound exploitation levels of a fish resource.

2.3 What is resource rent maximisation?

If the management objective is to maximise the sustainable profit from the fishery in the long term, the effort always needs to be below the effort of MSY, moving closer to this as the unit cost of effort is reduced (as seen from Figure 4.1).

Resource rent is the profit beyond the normal profits (see the description given in point 1.2) and is maximised when marginal revenue equals marginal cost (including opportunity cost). Resource rent maximisation always represents a more conservative approach in relation to state of the stock than maximising sustainable yield does. As explained in subsection 1.3 the equilibrium of Maximum Economic Yield (MEY; the point where the rent is maximized) could not be obtained without controlling the access to a common-pool resource. Different types of control are discussed below.

The MEY reference point is shown graphically in Figure 4.1 in a model often referred to as the Gordon-Schaeffer model. The work of Schaffer which Gordon (1954) utilised in the development of his model is also presented in other chapters of this book (Chapters 2.3.1 and 13.5.1).

2.4 A capital theoretic approach

Fish stock resources are a natural renewable capital which can be utilised in different ways. Renewable natural capital may also be exploited to an extent where it is totally depleted and renewing becomes impossible. The other extreme is not to utilise the capital at all, as in cases where the cost of harvest exceeds potential revenue. Ongoing fisheries are somewhere in between the two extremes.

The biological properties and the natural environment of the stock determine how the stock grows, i.e. how the nature capital change. From an economic perspective the biological growth rate corresponds to an interest rate on nature capital, the value of which is added to the stored capital or withdrawn from the stock through harvest in a fishery. The comparison with an ordinary bank is however not perfectly valid, as the nature capital (e.g. the fish stock in the ecosystem) offers an interest rate that increases (up to the biomass at which MSY occurs) as the natural capital (the stock biomass) decreases. Normally a monetary banks practice the opposite principle. This phenomenon is illustrated by the downsloping average revenue curve (AR) in the lower panel of Figure 4.1, corresponding to the average interest earned at different biomass (nature capital) levels. As the nature capital increases, the capital increment per unit of time declines; and the other way around.

In an unexploited stock, the biomass in natural equilibrium reflects the environmental saturation level or carrying capacity of the ecosystem. This carrying capacity varies naturally from year to year. However, assuming that this carrying capacity is constant (at equilibrium) on average, there will be no net growth in the natural capital at that level. As the natural capital (stock biomass) is reduced, the stock compensates for the reduction by growing at a faster and faster rate (increased growth per unit of biomass). Stock biomass and interest rate increase work in different directions (are inversely related), giving rise to a point at which maximum sustainable production occurs: the MSY reference limit.

When stock biomass is considered as a capital deposit, the time perspective becomes important. Gordon's model represents a comparative static approach to fisheries but a dynamic approach was later introduced by several authors, e.g. Smith (1968). A comprehensive review with several examples is given by Clark (1990).

The dynamic approach brings back the, time dimension, making it relevant to give a value to time. With the consideration of time, the concept of discounting is essential for understanding economic adaptation to fishing activities as a dynamic process. It is therefore reasonable to refer to the dynamic view as a capital theoretic approach, where resource value is not only related to availability, markets and biological growth, but also to time. The value, or benefit to be collected in the future, is valued less than that which can be obtained today, due to the fact that it is not presently available and that there is a cost associated with the delay in time. The present value of the catch is more than the nominal value collected in future. The difference between the values at the two different times reflects the degree of impatience of waiting for the benefit to be available, and is measured in terms of interest or discount rate.

The long term social-economic optimum is found by maximising the present value of all future flows of resource rent from the fishery. The control variable for maximising this criterion is the input (fishing effort) or output (harvest) of the fishery. In the case of an over-exploited fishery, since today's resource rent per unit of harvest is valued higher than tomorrow's one, there is a trade off between, on the one hand, the cost of building the stock up to a level where the annual resource rent is increased and, on the other, the benefits of not making such an investment which would produce a reduced profit today. This dynamic problem reach an equilibrium solution if and when *the immediate gain of fishing one unit more today equals the long term discounted profit reduction caused by the last unit caught today*. As long as the immediate gain exceeds the long term losses, present value of all future profits increases while fishing more today, and vice versa. The equilibrium is often referred to as the Golden Rule of optimal economic harvest. It says that the present value of profits of future fishing could not be increased by fishing less or more today. The discount rate represents the potential growth of the natural capital if it was placed elsewhere (the opportunity cost of the capital). The growth in value of this natural capital is determined by the natural growth of the stock and the change in cost/price ratio as a function of stock size. The biological effect natural growth is shown above to increase as the biomass decreases, while the economic effect due to changes in harvest cost as stock density changes, works in the opposite direction. The stock growth per unit biomass increases as stock biomass declines, while the cost of harvest declines as the stock biomass increases.

In the light of the reasoning above, the properties of the open access bioeconomic equilibrium and maximum economic yield reference points are also better understood, as the two may be regarded as special cases of maximising present value of the resource rent of the fishery. The MEY-solution actually corresponds to the optimal solution of maximising present value of all future resource rent, given a zero discount rate while the open access solution maximise the present value in the case of an infinitely high discount rate. For the owner today, if the discount rate equals zero, the value of the income a thousand years from now would be regarded as equal to the nominal value of the present income. In contrast, with an infinitely high discount rate the value of all future incomes would equal zero.

2.5 Including more dimensions

The presentation above has strictly been dealing with an idealised situation of one targeted species and a homogenous fleet assuming equilibrium and reversibility. The purpose has been to present useful reference equilibriums (note however that the capital theoretic approach describes a dynamic process towards a stable equilibrium) related to some basic management principles. The reference equilibriums represent different concepts and may prove to be useful also when considering situations not corresponding to these idealised situations, even when no stable equilibriums exist. Other dimensions which may be included are:

- Selection: the inclusion of year classes (or cohorts) in management considerations
- By-catch regulation and ecosystem considerations
- Multispecies fishery
- Seasonal changes in targeted species and gear use
- Fleet diversity (see subsection 1.2)

Theoretical stable equilibriums may still exist when including some of these additional dimensions (as shown in Figure 4.2), but their existence is not critical for the usefulness of the related economic theory. It may however be a problem if reference equilibriums are employed as realistic goals of management actions.

Fisheries management has to be multi-dimensional, as the economic activities utilising fish stock resources are. In the next section the economics of practical management options are discussed, given that the basic management objectives are identified. Even in case of varying objectives and uncertainty the basic principles of the economic reasoning will be the same.

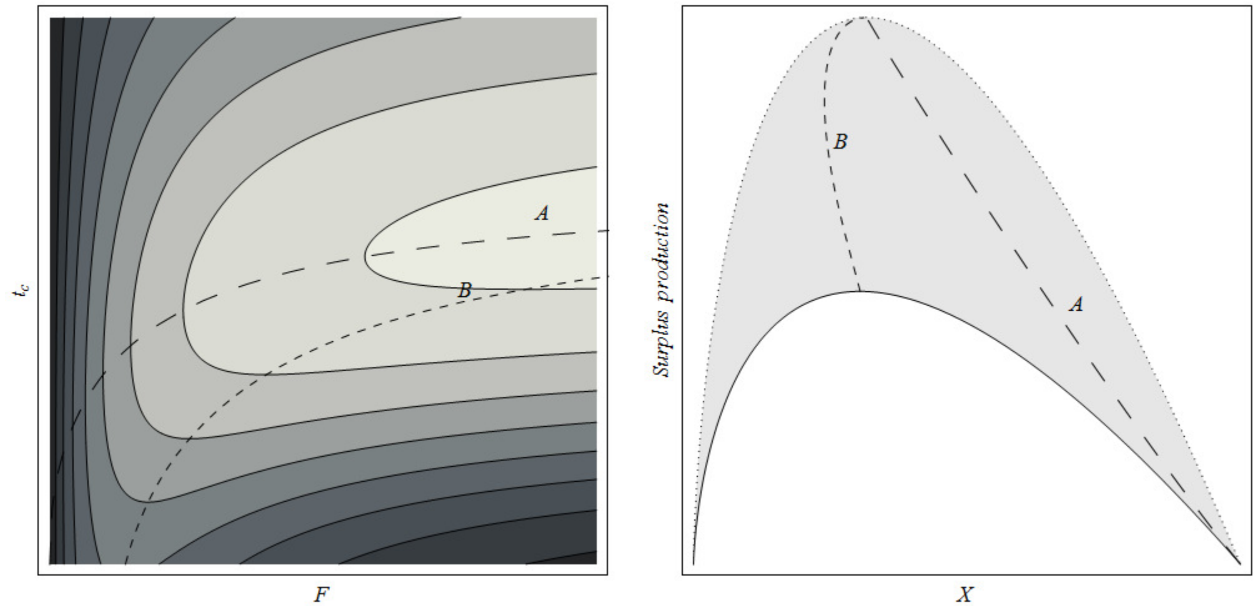


Figure 4.2. *Relations between fishing mortality (F), age at first catch (t_c) and yield (X). The left panel shows the well-known yield-per-recruit contour map from Beverton and Holt (1957) as function of fishing mortality (F, horizontal axis) and age of fish at first catch (t_c vertical axis). Yield per recruit decreases as the shading gets darker. The dashed lines A join maximum yields obtained by changing t_c for given Fs. The dashed lines B join maximum yields obtained by changing Fs for a given $t_{c.}$ The shaded area in the right panel shows the same range of yield, here presented as a surplus production model with equilibrium stock size (X) as the variable. Each point found in the shaded area is defined by a unique pair of (F, t_c)-values.*

3. AN ECONOMIC PERSPECTIVE ON FISHERIES REGULATIONS

This part should be read in connection with the section on Management Measures and Tools (chapters 7-11). The basic principles of management are described in details by those chapters, while this part adds a few economic considerations to the use of some of the management measures discussed. Firstly a short note is paid on the relation between economics and politics, before pointing at economic issues related to different types of management.

3.1 How do politics interfere with economics?

From an economic perspective, management can be considered as the regulation of markets, based on political priorities. The approach may be to correct for market failures or to create market failures with the view to reach a political objective. The aim of fisheries management usually is to remove the effect of the market failures described in the first section of this chapter. To achieve this, governmental interventions are normally needed. The political objectives of the regulation may however vary.

Fisheries are complex societal constructions involving traditional rights, community characteristics, economic values, environmental considerations, cultural habits and life style properties. Political documents therefore often address several of these issues without establishing clear priorities. Typically the political objectives may at the same time be to increase economic benefits, secure employment and conserve the resource. The risk of arriving at situations of conflicting objectives is high and management may not be able to solve all issues at the same time.

Fisheries management needs to be based on expressed political objectives, preferably with clear priorities. Bioeconomic theory is a useful tool for the analyses of the biological and economic effects of different exploitation levels and of the possible management means needed to obtain these effects. But there is, in principle, no built-in normative theory which makes it possible to omit the basic political decision on how to utilise the natural value of a fish resource. The following discussion related to the use of different management means therefore presumes a clearly expressed political objective for the utilisation of the fish resource. For simplicity, resource rent maximisation is assumed as a political goal in the following, if an identified goal is needed. This should however not be interpreted as a normative statement, since an infinite number of other objectives are possible.

Economists like to express political goals in terms of object functions which should be maximised under given constraints. An object function may be to maximise resource rent (as in our examples), present value (as explained in the discussion of the capital theoretic approach), employment (as a common political objective often related to goals on regional settlement pattern, may be obtained by open access to the resource), food supply (as in traditional supply oriented economies, e.g. the former Soviet Union, may be represented by the MSY reference equilibrium), marine mammal biomasses (as seemingly proposed by some environmentalist groups), stable delivery for the processing industry (more difficult to express in terms of a maximisation problem), etc.

If the market is hindering the fulfilling of the political objectives, management measures are needed. Management therefore first involves the political process of identifying goals and thereafter proper means and finally implementation, control and evaluation. As such it is an iterative process which is open to adaptive implementation mechanisms in which knowledge is gained from previous experiences and new information, and finally, used to improve management. Similarly to other political processes, this is also influenced by the activities of different stakeholders, not only within the industry, but now more often also from other groups. Rent-seeking groups within the industry have interests in both the processes of setting political objectives and the management implementation.

3.2 The short history of resource conservation

The history of fisheries management developed as adaptation to recurring crises (cf. Chapter 1). Governmental interventions are meant to solve existing problems and are consequently more urgent when problems are substantial and new regulations are most needed when a crisis occurs.
When the International Council for the Exploration of the Sea (ICES) was established in 1902 one of the two scientific committees of the council was the Overfishing Committee, reflecting

the increasing concern related to the introduction of new efficient steam trawlers in the North European fisheries. One of the results of scientific work carried out within the Overfishing Committee was the groundbreaking work of Beverton and Holt (1957) after the Second World War. Their ideas and modelling approach were however not utilised in fisheries management until crises and collapses of major fisheries asked for some immediate actions in the late 60s.

The history of resource based fisheries management is rather short. Up to fairly recently, when technological advances led to rapidly escalating fishing effort and more and more cases of over-exploitation, marine biological resources were, to a large degree, treated as being immense and effectively impossible to deplete. Crises in large fisheries and collapses of major stocks after the Second World War lay the ground for the widespread use of management measures to protect resources in order to secure the possibility of future resource use.

The immediate objective throughout such periods of crisis is to reduce fishing effort. The concern is not so much to prevent biological extinction, as in most cases the cost of fishing out a stock to extinction in most cases will be astronomic. The main concern of the manager is usually to keep the stock at an exploitable level and to avoid the loss of long stock recovery periods with low or no catch after overfishing. In this way, the resource conservation perspective can be seen, first of all, as an economic concern in order to secure future economic activities related to the fish resource.

Still there exist a number of fisheries where a biological concern is not dominant or non-existent. Such fisheries may be characterised by a high biological turn-over rate, extreme costs or other reasons why a sound, exploitable stock may exist and be used without management. The following example illustrates the point. The Mozambican kapenta fishery in the Cahora Bassa dam is the largest fishery of Mozambique in terms of quantity caught. The stock (*Limnothrissa miodon*) originates from the Tanganyika sardine which was introduced in Lake Kariba (higher up in the river), floating down to the later constructed Cahora Bassa dam. After a few years a significant fishery developed. The biological concern is insignificant or non-existent because if the kapenta stock went extinct, it could, in principle, be reconstituted from the Tanganyika sardines stock, soon bringing back a viable fishery.

Even when there are no biological reasons for managing the fishery, there may however be economic reasons to do so. It might be good reasons to manage the kapenta fishery if the aim is to retrieve resource rent from the fishery. There are political and economic reasons for managing even though biological reasons are hard to find. It all depends on the fisheries objectives (policy) and how these objectives could be best met.

If the fisheries policy requires the use of management means in order to reduce fishing effort, a set of possible measures are available (see Chapters 7-11). The economic consequences of major management categories are discussed in the following.

3.3 Technical measures

Technical regulations (Chapter 7) are probably the first type of regulation systems aiming to protect the biological recourse. From an economic point of view, the reason, or almost inevitable consequence, of these regulations is to make the fishing gear less efficient, which is equivalent to increasing the cost of standardised effort. Usually the idea is to develop a more selective fishing gear aiming at certain targeted species or year classes. There might be an economic gain related to this, if the handling costs are reduced (by a cleaner catch) and higher valued products are retained. The cost of implementing the technical measures is paid by the fisher, except for the control cost which in some cases could be substantial. This, combined with the effect of an improved exploitation pattern and increased cost of effort, makes technical measures an efficient economic regulation tool. Technical measures alone have however in most cases shown to be insufficient to approach common management goals, and other measures need to be added. This management measure does not have the property of retrieving resource rent, although it may have the effect of increasing the production of the fishing gear industries.

3.4 Taxation

Gordon (1954) proposed the use of effort (input) of harvest (output) taxation to reduce effort and retrieve rent. The attractive property of taxation is that, in principle, the open access solution could remains as a stable solution, since the increase in cost or reduced revenue (due to taxation) automatically would lead to reduced effort, following ordinary market mechanisms. The equilibrium profit of the fishers left in the industry will still be normal and the regulation will not distort labour and capital markets, though excess labour and capital will be available for other use. The economic reasoning behind the measure is based on comparative statics (Section 2.4), while there are low or no legitimacy of introducing taxation during periods when the fisheries economy is critical (e.g. after overfishing due to open access and low costs of fishing). Introduction of taxes, including entry fees, therefore are difficult during crises; while it is easier in sound fisheries, having a good economic performance. In case of the latter management issues are however usually not on the top agenda. Therefore it seems to be politically easier to introduce negative taxes (subsidies) that taxes aiming to retrieve resource rent from the fishery.

The introduction of management measures during crises almost always has the objective of reducing effort. In an open access situation, normal profit is obtained in equilibrium. In crises, which could origin from biological or economic causes, profit is more likely to be below normal level. Solving such crises by imposing taxation is not considered to be legitimate in a situation where in fact the fishers are worse off than others. Subsidies (which in principle are negative taxes) are more likely to be introduced in such situations. Without legitimacy, the political cost of imposing taxation on fishers will be too high. Most people will argue that fishers in crises need help rather that increased cost.

On the other hand; if fishers earned a resource rent, i.e. a more than normal profit, imposing taxation would cause less protests. If this was done and the levels of profit was reduced to normal, it would contribute in sustaining a situation where resource rent could be obtained and collected by the tax imposing authority. However, due to the fact that new regulations seldom are introduced without crises, subsidies rather than taxation may be the proposed measure.

Taxation is a type of economic incentive working at several levels in the economy, also outside the domain of fisheries management. Purchase taxes, property taxes, taxes on businesses and on factors of production, emission taxes and licenses, all represent different types of economic incentives aiming to control the behaviour of the object of taxation. In general and in fisheries management, besides the governmental need of income, the expected effects of the incentives are the justifications of imposing tax. If the taxes were not regarded as justified there would be a legitimate economic incentive for cheating the taxing authority. Imposed taxes are also incentives for changing behaviour to avoid taxes (e.g. reducing costs by reduced speed, causing lower carbon emissions). Since changed behavioural pattern is not known, the outcome of indirect measures (incentives) is less predictable than the effect of direct management means. It may be easier to predict the effects of weaker incentives like indicative measures (information and appealing to responsible behaviour) as they seldom show any significant change in behavioural pattern.

3.5 Entry limitation

Indirect management means have often proven to be insufficient to solve management problems of a fishery. If the aim is to reduce effort the straight forward way to do this is directly to control fishing effort, e.g. through limited entry as discussed in Chapter 9.

Management based on limiting entry to a fishery involves also problems related to the initial conditions of the system to be regulated. Closing the fishing for others than those already inside may be a way to limit entry. Reducing effort by distributing fishing rights to some fishers while excluding others may be controversial. The situation may to some extent be eased by including several fisheries in the limited entry scheme, distributing different fishing rights at the same time. Different concepts of distributing fishing rights, monitoring and enforcement are discussed in details in Chapter 10.

Let us assume that through a successful limited entry system with effort limitation and control, the effort has been reduced and the fishers earn a profit exceeding normal level (rent). Normally, the additional profit is likely to be invested in making each licensed unit more efficient, within the frame of the existing regulation scheme. This could result in the following two effects: a) the actual fishing effort produced by the license owners is increased even if the nominal effort (the magnitude controlled) is kept constant; b) the unit cost of the measured effort is increased through new investments (e.g. introduction of new technology). Together this will cause resource rent to vanish and fishing pressure to increase.

Two problems arise from the above: to control the actual (standardised) fishing effort over time is a non-trivial task. This problem also involves the difficulties of measuring product functions of the fishing fleet, how fishing efficiency varies with stock density (as expressed in terms of *stock-output elasticities* in subsection 1.6). Secondly the success of the management system also represents a threat to the system, because profits exceeding normal levels usually find their way back to the industry, increasing the overall capacity of the licensed fleet. Rent may be invested outside the fishing industry, but in most cases the fishing companies seem to believe that they are better off by feeding the rent back into the industry where it as generated. Occasionally rents from fishing bring substantial investments to other industries, as for example investments in aquaculture industry from Norwegian purse seiners a few decades ago.

3.6 Quota regulations

Quota regulations include a variety of management systems. The basic principle is simple; instead of controlling directly the input (as above), the management controls it indirectly by controlling the output. Quota management has many attractive properties and has in many ways been the dominating management measure in fisheries management throughout the world in recent years in single-species, commercial fisheries. Chapters 9 and 10 give comprehensive descriptions of different types of quota management systems.

Quota management interacts nicely with biological models and since the management organisational structure usually is based on biological advice, output quantities can be convenient regulation measures. The well-known concept of total allowable catch (TAC) fits very well into this picture. In principle catch outputs are easily measured, by far easier than measuring fishing effort, particularly in well developed fisheries where comprehensive catch statistics and market information are available.

The simplest form of TAC-based management is to keep a common total quota covering the whole industry without subdividing the quota on individual fishers. This creates a "race for fish" where all gained resource rent is wasted on investments aiming to increase the capacity of each fishing unit. For example, boat owners invest in larger and more powerful engines so that their vessels reach fishing grounds before the others in order to get a larger share of the TAC. This may result in increased unit cost of effort, reduced price (if the catch quality is reduced by increased competition) and loss of resource rent. These problems exist even when TACs are set at levels where resource rent, in principle, should be obtainable (i.e. at levels below the currently expected catch in an unregulated open access fishery).

In order to avoid these undesirable effects of a race for fish, TAC allocation rules for subdividing the catch into quotas are included in most quota-regulated fisheries. Such allocation rules could be market-based or not. Let us first have a look at the latter.

Allocation of TAC is an allocation of fishing rights (Chapter 10). The legitimacy of introducing a TAC system often depends on how previous fishing rights are converted into the new quota system, i.e. the quota allocation rule. The discussion on principles of the subdivision rules often overshadows the first TAC calculation procedure, as the conflict in interests are more pronounced on distributional issues. There may be a more general acceptance of the TAC than of the quotas because the TAC is basically a biological issue and its value is founded on scientific reasoning, while the subdivision of the TAC is dominated by societal and economic (basically political) conflicts. TAC allocation principles may be agreed and allocation rules may be negotiated as the basis of future allocation, e.g. a certain percentage of the annual TAC to be allocated to each vessel, fisher, community, etc.

Given an allocation rule, the different TAC shares distributed, most probably will have different values for the different right holders. If the individual quotas are not transferable, there will still be a pressure toward trading quota rights and proper control will be needed to counter it. If quotas are transferable, this control is not needed or it could be converted into a market control system to regulate the quota market. This market is often expected to be able to allocate quotas to the most cost-efficient fishers, as they are able to pay the highest quota price. However, as shown in chapter 10 the ability of ITQ systems of establishing efficient quota allocations may not always be that obvious.

The economics of transferable and non-transferable quotas systems differ in many respects. Given a successful non-transferable quota system, the resource rent gained is left with the right holder (assuming no taxation). Even when avoiding the most extreme race for fish by using quota allocation rules, the resource rent is expected to find its way back to the industry, increasing the probably already established overcapacity. Eventually the increasing overcapacity will cause a significant political pressure towards increasing the total allowable catch for the fishery. In other words, the resource rent obtained as a result of successful management, may very well create even larger fleet capacity than before, effectively threatening the successful management system. Imposing taxation when profits exceed normal level may prevent this from happening.

A transferable system works differently. Here the quota right immediately has a market value which may be traded. The value depends on how successful the management system has been and successful management tend to increase the quota value. Even if quota rights initially were given for free, they have value in a quota market and therefore represents an opportunity cost for the quota holder, equal the best alternative use of the quotas (i.e. the value obtained by selling them in the quota market). The foregone possibility of income by selling the quotas has to be covered by the fishing activities when utilising the quotas for fishing. Those buying quota rights in the quota market, of course, also experience increased unit cost of effort in comparison to an open access situation. This increase consequently moves the theoretical open access equilibrium to lower levels of total fishing effort. In fact the increased cost reflects the resource rent or the shadow value of the stock resource. If the TAC setting brings total effort close to the previous open access level, the shadow value of the stock (the rent) approaches zero and so does the value on the quota right.

Transferable quota rights are based on individual quota allocation. Non-transferable individual quota systems should in principle not bring any opportunity cost to the quota, as there is no alternative use of the quota. Such systems may however include other regulations giving value to the use of quota rights. Informal and even illegal quota markets may however create substantial value to the quotas, depending on differences in efficiency and risks related to disregarding non-transferability.

3.7 Future perspectives

Until recently, modern fisheries management in principle was based on the assumption of full knowledge on biological and economic dynamics in the fishery. The new approach is to acknowledge that full knowledge cannot be obtained and the management challenge is to cope with uncertainties. The precautionary approach to fisheries management presented in Chapter 13.3, represents one possible way to deal with such uncertainties.

This reasoning introduces some quite new ideas to fisheries management. The introduction of indicator-based management rules (cf. Chapter 12) makes it possible to automate quota setting by predefined rules of action. Such rules are now commonly referred to as harvest control rules (HCR). HCR may include a precautionary approach, but also corresponding economic reasoning. The learned effect of different previous decisions could be utilised in refining the predefined rules, implementing adaptive management. In many ways this idea represent a paradigm shift in fisheries management, as the focus shifts from model-based indicators to indicators based on more performance and feed-back observations, which relate to rules of actions. The first is based on known functionalities, the latter on experienced effects.

The new concept of HCR also opens the way to the inclusion of other ecosystem effects, year-to-year and seasonal fluctuations, multispecies relations, the dynamics of ecosystems, economics, fisher behaviour, and fleets, as well as differences in skills and technology, etc. Chapter 13.5.2 discusses management issues from an ecosystem perspective. An Ecosystem Approach to Fisheries (EAF) may also be implemented through the use of relevant ecological, economic and social indicators in a HCR management scheme. The challenge is to establish and measure relevant indicators and to relate sets of indicator values to rules of actions. A set of rules based on combinations of indicator values could be implemented as fuzzy logic control (Zadeh, 1973). In addition, as in the more conventional system, evaluation of the effects of previous decisions could be utilised in refining the predefined rules, adding a dimension of adaptive management to the rule based control system.

4. FISHERIES DEVELOPMENT

Bioeconomic theory and the economic properties of available management measures provide the manager with a toolbox to apply for performance analyses of different management decisions and for proposing efficient regulations to achieve given political objectives. For obvious reasons, fisheries management issues are often, focussed on the state of the resource base and the measures aim to protect the stock from overexploitation. The state of the resource is essential, but so is the state of the users, the fisher and the community around him.

From an economic point of view, resource-based management could be substantiated by the market failure introduced by an open and free access to a valuable resource, the fish stock. However, under some circumstances, such a resource could serve as a last resort. We have stressed that an open access fishery gives value free of charge to the fishers for whom the opportunity cost of labour is less than or equal to the open access earning. In extreme cases, this earning may only be sufficient to feed themselves and their families, as in subsistence fisheries. In such cases the open access situation is not removing poverty, it is preventing starvation as long as the resource is maintained. Closing the commons could then take the situation from bad to worse, if no other alternatives are presented.

How could the previous sections be interpreted in a development perspective? We learned above that the objective of technical regulation is to reduce gear efficiency and thereby to increase cost of standardised effort. In fisheries development, NGO’s and governmental aid agencies often support extension services in fisheries where the idea is the opposite; to develop more efficient gears and harvesting methods. How does this fit into the idea we have on sustainable, economically optimal exploitation of fish resources? In the following section we will try to address some of these questions.

4.1 Market failures and poverty

In subsection 1.3, we discussed some basic market failures in fisheries. Without these failures the common-pool stock resource would be a pure public good, a rival-free or collective consumption good. If a large common-pool resource is utilised only for food to the few families within a community without any significant effects on the stock resource, it may be regarded as a pure public good and the external cost (market failure) in fishing would be practically non-existent. Without any other active constraints one should expect this situation to remain unchanged until population growth eventually caused external costs to become visible.

The importance of a common-pool fish stock resource as the employer of last resort has already been discussed. From a food supply perspective, external costs do not represent a problem as long as total fishing effort is at levels less than the effort corresponding to MSY (see Figure 4.1). In fisheries with poor technology and lack of markets, as often found in poor coastal communities of developing countries, this is may often be the case. In such cases external costs are not causing food supply to decrease, but an increase in supply through increased fishing effort may take place at a diminishing rate. Ecosystemic effects such as species replacement, etc. may help maintain productivity up to a point. External costs are the loss of resource rent, which is value spent on employing more fishers. If the political objective is to provide the community with seafood, the unregulated fishery producing fishing effort below the MSY level has good properties. If the effort produced reaches levels above this, the community may be better off maximising resource rent, as the abnormal profit could finance food from other sources (given the necessary political decisions regarding allocation of resources). The organisational challenges would however be substantial as the potential resource rent may easily be spent on other commodities or wasted and in any case not used to support those excluded from the fishery.

"How can fisheries policy best help the poor? Often there seems to be an assumption that the poor must be helped to become better exploiters of fisheries resources. However, the best way to help the poor may not be to help them to become better fishers, nor to encourage them to become fishers at all, but to use the wealth of the fishery to create alternative employment opportunities for them. In this view, poverty alleviation is considered to be a macroeconomic, and not a sectoral issue (save in the exceptional case of a very large fishery sector). Attempts to improve the incomes of the poor in the fisheries sector alone seemed doomed to failure because incomes in the fisheries sector are linked to those in the rest of the economy. If a policy successfully improves incomes in the fisheries sector, the relative attractiveness of this sector will increase, attracting more fishers and restoring the equilibrium position where opportunity incomes are earned. The new equilibrium can emerge via a combination of price and quantity effects. The problem is that quantity effects in particular are likely to run counter to conservation goals. Increased numbers of fishers will generally mean lower fish stock sizes."

(Cunningham, 1999)

In the previous discussion on the capital theoretic approach to fisheries in subsection 2.4, open access equilibrium was found to coincide with the social optimum with an infinitely high discount rate. In a situation of severe poverty, famine and starvation, the discount rate needs to be very high, reflecting the urgent need and impatience in resolving the immediate situation. Hence socially optimal solutions move toward open access equilibriums, as a way of immediately releasing food resources for a starving population.

4.2 Contextual issues related to fisheries development

The dynamics of technological development is a complex mix of a number of factors. First of all it needs to be understood in the perspective of market dynamics. The market seeks for the most efficient solutions, unless market failures are hindering this from happening. Market dynamics are constrained by the context in which they exist, and first of all by the existing infrastructure.

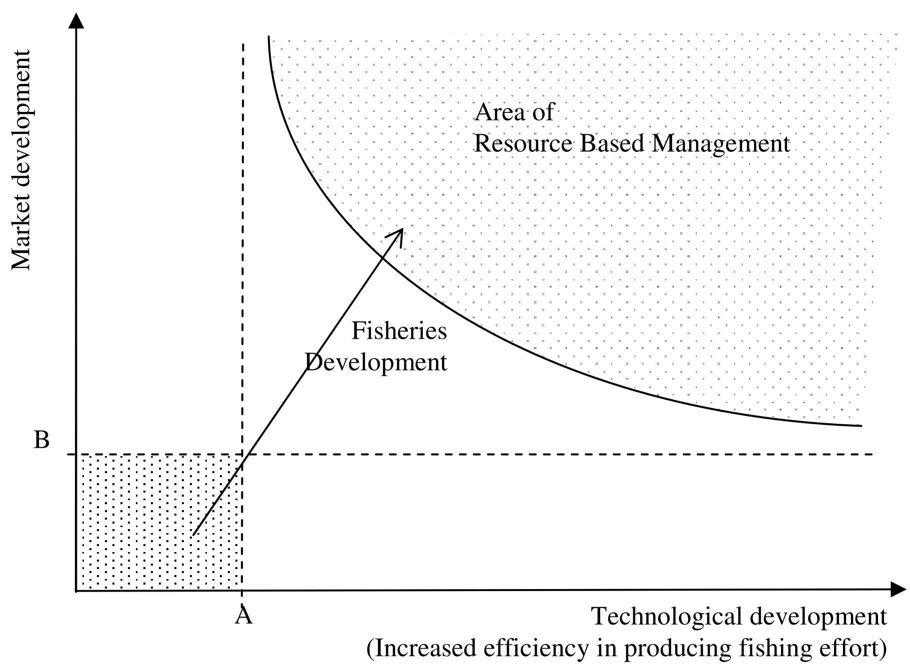


Figure 4.3. *Relation between market and fishing development. The figure shows the area of resource-based management defined in the context of development along two dimensions: markets and fishing effort. Development of a fishery over time is shown by the arrow.*

As discussed in Section 1.5, access to central markets represents a major obstacle in many artisanal fisheries. The importance of infrastructure for market development is obvious. Technical inventions like the mobile phone have also been shown to have great impact, replacing the former scarce public goods by normal goods accessible in functioning markets (noting however that accessibility to mobile phones depends also on infrastructure not necessarily available without governmental interference).

Figure 4.3 displays the market and effort conditions under which a resource-based management regime is needed. Increments in fishing effort production are a function of market developments. Below a certain technological level A, the resource is never threatened, even if all available capital and labour resources are utilised in this fishery. Below a certain market development level B, the demand for fish products will be too low to support an open access fishery threatening the resource. Development of markets and technology is interlinked and the development direction (shown by the arrow) reflects the linkage between the two. Beyond the area limited by A and B, fisheries management may be needed.

4.3 Development stages – when is it appropriate to manage?

In an open access fishery, the resource rent is wasted in subsidising fishing effort beyond the levels of a positive resource rent. In order to collect resource rent on a sustainable basis, fishing effort needs therefore to be reduced below the level of open access. The resource rent collected could potentially be spent more efficiently (e.g. for example employing more people) by investing in other sectors. Economic development in other sectors could lead to a reduction in fishing activities if the increase in opportunity cost of labour more than compensates for the change in profits of fisheries (caused by increased price and possibly reduced unit cost of effort). Some fishers will be better off moving from fishing to other economic activities.

Table 4.1. *Properties of three development stages as described in the text.*

Type of fishery	Use of labour	Use of capital	Infrastructure	Markets	Stock risk
1	High	Low	Poor/No roads, water and electricity supply	No markets, subsistence fisheries	Low
2	Medium	Medium	Roads	Reaching commercial markets by roads	Medium
3	Low	High	Roads, electricity, water	Access to new markets after access to ice and trucks	High

Poverty alleviation in fisheries therefore needs to be discussed in a broader community and society perspective, rather than being a sectoral issue. It is, however, still essential to keep in mind the fisheries dynamics and in particular the dynamics of fisheries development. The latter was for many years regarded as a matter of developing proper fishing technology, increasing catch and reducing post-harvest losses. Considering population increases, this is still important, but for reasons pointed out above, it is not sufficient for poverty alleviation and it may not be enough to secure a sustainable fishery. In recent years more emphasis has been put on management, different types of co-management regimes have been introduced and the management perspective has entered the fishing communities. But is the idea of management always appropriate?

Table 4.1 shows three development stages of fisheries differing in terms of labour and capital used for effort production, infrastructure and markets available, and risk for the stock. In general, fisheries management becomes an issue at stage 3, possibly also at stage 2, while stage 1 (found for example in remote islands) calls upon other types of governmental interaction, for community development. Stage 1 may correspond to the area in Figure 4.3 constrained by A and B. All three development stages need however to be monitored to ensure that the biological resource is utilised according to given political objectives.

The vision for the future of small-scale fisheries in general, as expressed by the FAO's Advisory Committee on Fishery Research, is that:

- they are not marginalised and their contribution to national economies and food security is recognised, valued and enhanced;
- fishers, fish workers and other stakeholders have the ability to participate in decision-making, are empowered to do so, and have increased capability and human capacity, thereby achieving dignity and respect;
- poverty and food insecurity do not persist, and the social, economic and ecological systems are managed in an integrated and sustainable manner, thereby reducing conflict.

This vision represents a guideline for all small-scale fisheries and emphasises the importance of participation, poverty alleviation and food security. How the vision can be realised is, however, a more complex task than expressing it. As indicated in the vision it involves more than management issues, in fact it is not obvious that management measures are the answer at all in some cases.

The vision could not be realised without the existence of basic infrastructure for markets to develop. Infrastructure is however only a necessary, not a sufficient condition to fulfil the vision. The challenge is of political nature as political decisions need to be taken on the basis of relevant biological and economic knowledge, if the main objectives of poverty alleviation and food security should be achieved. The challenge is essentially the same also in the developed fisheries in rich countries, as expressed objectives (e.g. sustainable use of natural resources in order to maximise welfare and equity) ask for the same type of approach, management measures and distributional problems.

5. SYNTHESIS

A fishery is a complex system with numerous interlinked components, a high resource and fleets diversity, operating within strong natural and market fluctuations. Opportunity costs, discount rates and market regulations (mitigating or aggravating market failures) have potential effects on the economics of harvesting, the fate of the fish stocks and the wellbeing of the people.

Unregulated fisheries may easily miss the objective of producing maximum food (as biological overfishing follows if the cost of fishing is sufficiently low) or maximum economic rent (as the economic overfishing is the consequence of open access fishery). Fisheries regulation is therefore necessary in most cases to achieve long term social welfare.

In fisheries management, politics interfere constantly with biological or economic rationality, introducing priorities and time constraints as well as distributional objectives that complicate substantially the task of a manager. This task gets more complicated as more dimensions of the fisheries are taken into account, e.g. under an ecosystem and precautionary approach to management.

The short story of fisheries regulation, during the last half century, has illustrated the performance (particularly the economic performance) of the various types of management measures presented in chapters 7 to 11. It has shown the usefulness of technical measures but also their cost and their incapacity to deal, alone, with overfishing. It has also shown the complexity of economic measures such as taxation, the perverse effects of some economic incentives (e.g. subsidies), the complexity of the control of inputs (by limited entry) or outputs (through TACs) and the necessity, in many cases, to introduce various forms of fishing rights in the form of quotas.

The close connection between development and management performance is often forgotten. The development objectives of providing growth, employment, food security, and reducing poverty lead to political and economic decisions that determine a large part of the context within which fisheries and the fishery manager operate. Market failures may be introduced or tolerated to mitigate poverty in the short term, aggravating it in the long term. Whether management is necessary or even possible is indeed dependent on the development context.

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