Economic principles of Fisheries Management

Draft paper by Arne Eide

Fishing is an economic activity. The aim may be to get food for own consumption, fish products for a market or even to get recreational value. This economic activity interacts directly with natural resources, usually a common fish stock resource pool. Fishing could be unrestricted, but is now more often regulated. Old-established fisheries regulation systems aimed to solve social and economic problems caused by the unregulated fishing. One example is the Lofoten Act in Norway of 1816, targeting problems of gear collisions caused by high fleet density on the fishing grounds. Other regulations focused market and trade issues and put limitations on landing and production facilities. Resource based management targets the stock situation and the idea is to sustain an exploitable fish stock. Fishing needs in an increasing number of cases to be secured by reducing the fishing effort from the level of open access.

This chapter deals with economics of fishing activities and is separated into three sections. The first section examines market failures in fisheries and four common reference equilibriums. The second section gives a more detailed discussion on the economics of fisheries management and proper management means, contributing to establish the preferred balance between inputs and output in the fishery. Finally some perspectives on development dynamics are presented on the basis of the two previous sections.

An economic perspective on fishing

Harvest as a production process

From an economic point of view fishing is a production process where the output is fish harvest and input factors are fishing activity (often referred to as fishing effort) and the fish stock resource. Both production factors are equally essential, as no catch could be produced in absence of one of them. A simple bi-linear relationship between output and input factors is consistent with this and an often assumed product equation in fisheries. Harvest (Y) could then me expressed by input factors fishing effort (E) and stock biomass (B) by the equation

$$Y(E,B) = q \cdot E \cdot B\ ,$$

when the parameter q is a catchability coefficient. The relationship links fishing effort easily to the fishing mortality rate (F), as $Y = F \cdot B$, hence $F = q \cdot E$, stating a linear relationship between the fishing mortality rate and the fishing effort. However the relationship, even though it is often assumed, has in a number of studies (see for example Hannesson, 1983 and Eide et al., 2003) shown to be non-linear, also including other variables (i.e. the stock biomass or year class biomasses). Rather than equal one, the stock output elasticity is most likely to be less than one. In most cases the relationship

$$Y(E,B) = q \cdot E \cdot \sqrt{B}$$

will be a better product function approximation, hence the fishing mortality rate expressed by the two input factors is $F = q \cdot E / \sqrt{B}$.

Input factors in production processes are most often outputs from others. Fishing effort – one of the two input factors in harvest production – is the output of another production process; as fishing effort is produced by labour and capital. Consider a fixed level of fishing effort E_0. As shown in Figure 4.1, E_0 may be produced by low input of capital and high input of labour (A) or conversely (B).

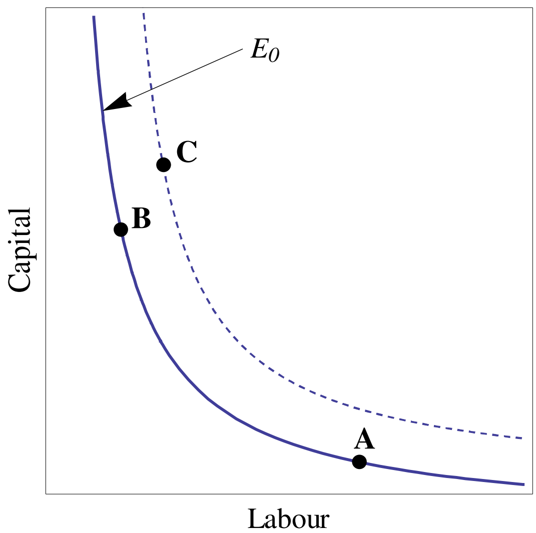


Figure 4.1 *The solid curve represents a fixed fishing effort level as a function of the two input factors labour and capital. In point A the fixed fishing effort is produced by a low capital level and extensive use of labour, while point B shows a situation where most of the labour in A is substituted by capital. The dashed curve represents an effort production level higher than the solid curve.*

Assume point A in Figure 4.1 to represent a high number of fishers (high labour) fishing with hand line from dugout canoes (low capital), while the same fishing effort is produced in B by few fishers (low labour) on a trawler with advanced gear control and fish finding equipment (high capital). In terms of fishing effort produced they are equal (both producing E_0) and should equally affect the fish stock (for simplicity reasons assuming A and B to affect the stock similarly). However, from a social economic perspective A and B represent two very different fisheries, as they represent two different stages of economic development. Typically fisheries develop from less capital intensive effort production technologies (A) to more capital intensive (B). This should not be confused with the often simultaneous movement towards higher levels of fishing effort (as for example Point C in Figure 4.1). The movement along the constant effort curve of E_0 (substituting labour by capital and conversely) is driven by changes in price ratio of labour and capital (e.g. wage vs. interest rate). The relative price of labour tends to increase as the economy develops, providing the population with increased buying power and speeding up the economic growth. As labour is substituted by capital the ability to move production factors between sectors is affected.

Basic market failures in fisheries

Economists often argue that the market should take care of efficient allocation of goods and commodities, according to standard economic theory social welfare efficiently is maximised by perfect markets. Even though some market imperfection exists markets show an amazing ability to find solutions close to social optimum. But sometimes market dynamics systematically fails to reflect real social values. Such market failures are common in fisheries and the market failures may give economic reasons of introducing management means aiming to correct for the market failures.

Fish stocks are typically common property resources, even though property right systems have been introduced in a number of fisheries around the world. Common property resources may have value, even when they are available for free. The value of a fish resource is then not reflected by a market price on access to the stock, but by the discrepancy between real value and the price of zero. The real value is referred to as the resource rent of the fishery. The resource rent reflects the scarcity of the resource. As in a normal market the price increases as supply is reduced, increased scarcity increases the per unit resource value. In an unregulated open access fishery the fisher is not paying for utilising this resource, and the cost of harvest production is less than the actual cost, when taking into consideration the real value of the scarce resource (as a part of the total cost of production).

Of the two input factors of fish harvest production, in an open access situation only fishing effort involves cost for the fisher. Since fishing effort and stock biomass could substitute each other in the same way as labour and capital in Figure 4.1, you should expect the fisher to take advantage of the free resource by reducing fishing effort and substitute it with stock biomass. The obvious fact that stock biomass can not be directly chosen by the fisher, makes it unrealistic to expect such reductions of effort. On the contrary, further increase in fishing effort may be the result of stock decline, aiming to keep up the catch level.

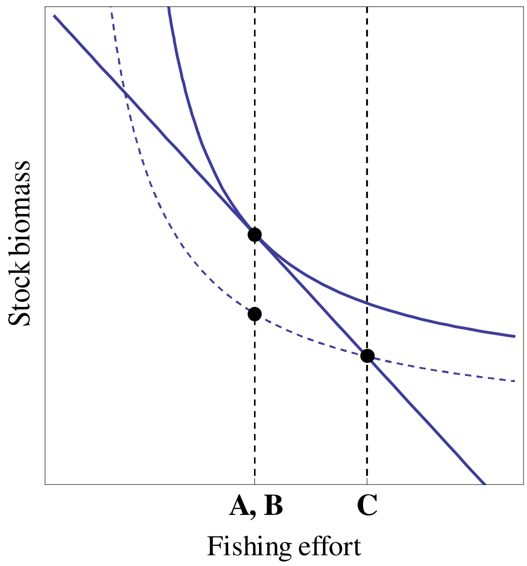


Figure 4.2 *The dashed curve represents a constant level of harvest produced by different combinations of the input factors Fishing effort and Stock biomass (similar to the production of fishing effort in Figure 4.1). The down-sloping line gives the stock-effort long term relationship. The fishing effort shown in Figure 4.1 (A, B) sustains a higher stock biomass than the fishing effort C (see Figure 4.1) with a constant level of harvest.*

The long term interrelationship between stock biomass and fishing effort represents another market failure in fish harvest production. Fishing effort adds mortality to the fish stock and leads to stock reduction. Increased fishing effort in the long run leads to decline in stock size, illustrated in Figure 4.2 by the down-sloping line. The two input factors are therefore not independent of each other; there is a functional relationship where the fishing effort influences the future stock level. In the long run the use of one input factor (stock size) is therefore determined by the former use of the other (fishing effort), dramatically affecting the substitution possibilities.

Access to a scarce common pool resource could potentially provide the human population with positive resource rent by the use of proper management means, targeting these market failures. Without such management the scarce resource will normally lose its value as the unit cost of harvest increases with the decline in stock biomass.

Opportunity costs

The cost of producing fishing effort is the value spent on the two input factors, labour and capital. This includes investments (fixed costs) and variable (running) costs. The forgone opportunities of utilising labour and capital elsewhere also represent a cost, known as the opportunity cost. The highest return which could be obtained by investing the capital elsewhere is the opportunity cost of the capital. If this is higher than the return earned in fisheries, in the long run capital is expected to move from fisheries to investments giving higher return. Correspondingly capital moves from other sources into fisheries in the opposite case; when the return in fisheries exceeds return on capital in the best alternative investment. In a perfect market therefore in the long run the return on capital level out in all possible placements and this return define normal profit on capital investments. This goes to all input factors in production, not only capital. Normal profit then is the profit necessary to cover all opportunity costs in the production.

Assume a constant unit cost of fishing effort, *c*. The total cost (*TC*) of producing the fishing effort *E* is

$$(1) \quad TC = c \cdot E \,.$$

c includes all costs involved in producing one unit of effort, including the opportunity costs of the input factors. Assume further a constant unit price of harvest, *p*. The revenue earned in the fishery (*TR*) is

$$(2) \quad TR = p \cdot Y(E)\,,$$

when *Y*(*E*) is harvest per unit of time (e.g. per year) obtained by the fishing effort *E*. Given perfect factor markets the fishers earn normal profits if *TR*= *TC*, since the opportunity costs – and thereby a demand of normal profit – are included in the unit cost *c*.

Opportunity costs are not constants. As the economy develops opportunity costs changes and even though factor 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 economic development has on all sectors, including fisheries. Opportunity cost of labour may be close to zero in a fishing village where virtually the whole population depend on fishing activities, as no labour is demanded from market outside the fishing sector. Assume a labour intensive industry to be established in the village. The industry offers low salaries, but still more than nothing. The new demand of labour affects the fishing activities. Some fishers will move to the new industry and more fishers will queue for jobs giving higher payments than he receives from fishing. Consequently the industry may reduce their salaries and still have enough employment to carry out the work. The reduced number of fishers will on the other hand also affect the profitability in the fishery and hence the return to labour. In the short run this may be due to a higher price on catch caused by catch reduction by less effort, while in the long run this may cause stock increase and thereby reduced unit cost of harvest. Market equilibrium in the labour market is achieved when industry wages equal the return to labour in the fisheries, higher than zero and more than the initial return. The unit cost of effort has increased as a consequence of the new industry established and the increased cost has caused a reduction in fishing effort, assuming it to be correlated to number of fishers.

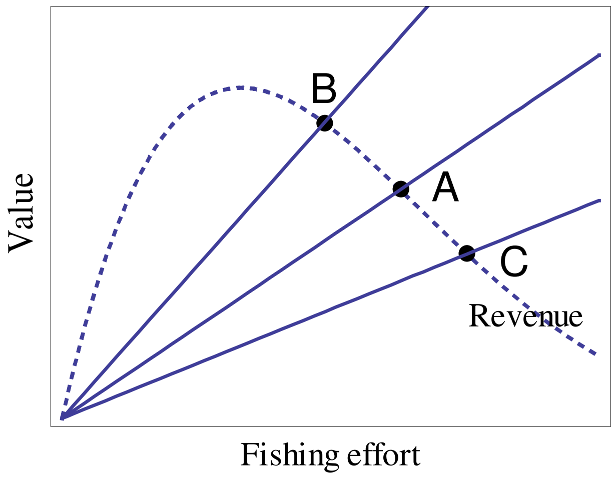


Figure 4.3 *The dashed curve shows the equilibrium revenue as a function of fishing effort. The three solid lines represent different unit costs of effort, whereof the points A, B and C are the corresponding bioeconomic equilibriums.*

A consequence of economic development in a community is increased unit cost of effort, as the normal profit increases (e.g. an increase in opportunity cost of labour), illustrated by the moving from point A to point B in Figure 4.3. Another effect of economic development is improved technology and empirical evidences from fisheries normally indicate that the technological development outranges the effect of increased cost of effort. The economic development tends therefore to take the fishery to point C in Figure 4.3 rather than to point B, when including all effects. The overall result over time therefore is expected to be reduced cost of standardised effort and a tendency of substituting labour by capital in effort production. Several analyses give reasons to establish following rule of thumb: In average the efficient fishing effort is expected to increase by 2% per year.

Open commons – blessing or tragedy?

Hardin titled his famous paper in Science in 1968 "The tragedy of the commons", referring to how open access to common pool resources leads to over-population and over-exploitation. Fisheries are often used as a case illustrating Hardin's point. In fact early bioeconomic works, as seminal papers of Gordon (1954) and Scott (1955) present similar reasoning. Hardin also refers to older works and similar thoughts related to property rights of the common found in ancient literature (e.g. Aristotle). The new metaphor Hardin created proved to be a powerful rhetoric phrase. The phrase is captivating because of its surprising labelling (tragedy) of a situation most people regarded as beneficial; the common. The strength of the metaphor may be found my measuring how few regarding the common as a good thing today. The original negation (the positive common and the negative tragedy) is now converted to a list of two negatives. But are the commons unwanted and bad constructions? Is it a tragedy to have free access to a natural resource?

The answer to this question is, as it often is, depending on the context. It is clearly linked to development issues reflected by the three situations (A, B and C) shown in Figures 4.1 - 4.3. It is well-known that fisheries have served as an economic buffer providing people with food and employment in periods of starvation and lack of other options. Fishing has been the last resort of people without land, money and job, using their only assets, - their manual power. Free access to an accessible fish stock resource means that food is available by simple technology involving almost no other cost than your own labour force (the extreme of situation A in Figures 4.1 – 4.3). In such a case *the fisher is not poor because he is fishing; he is fishing because he is poor*, as expressed by MacKenzie (1979).

Common property resources are essential for the survival of poor fishers and their families. Such use of fish stock resources characterise a development stage of the economy. When Finns (now moreover referred to as the Kven people) migrated to the northern areas of Norway 200-300 year ago, they utilised common resources in the area, to a large extent fish resources. The common helped them survive and later develop markets, trade and other industries. Similar migrations are going on today. In Mozambique the coastal population increased during resent periods of war and civil war, consequently fish stock exploitation rates increased. The coast area provided the people with safety and open access to food resources, the last resort to poor people from the devastated interior of Mozambique. The fish stock resources provide people with a possibility to immediate access to food, different from land resources where crops are grown, but take weeks or even months before food is produced.

In a subsistence fishery as described above, the market is not playing any significant role. Given the necessary stability over time exchange of goods and services in a community creates a market and catch value is identified. 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 common goods like roads; electric power and water supply are usually not produced by ordinary market mechanisms. The development mechanisms are further discussed in the last section of this chapter.

Bioeconomic reasoning

A theory of a common-property resource use was published in 1954 by the Canadian economist H. Scott Gordon (Gordon, 1954). The economic reasoning behind his paper was not new (as illustrated by the article by Warming in 1911, translated by Andersen; 1983), but the mathematical formulation of the problem, including biological growth, was new and groundbreaking. A rational profit maximising fisher was shown to affect future profits of other fishers as well. This external effect (the market failure described above) effectively includes all fishers exploiting the same stock resource, as the availability of one of this input factors (the fish stock resource) depends on all past fishing activities. Gordon presented a comparative static analysis of a fishery, focusing two reference points: Bioeconomic equilibrium (open access solution) and resource rent maximisation. Short descriptions of these reference points as well as two more, namely maximum sustainable yield (MSY) and social economic optimal solution, are given below.

An unregulated fishery, bioeconomic equilibrium

A fisher's behaviour could be described by the following model: Let *E* denote the number of fishers in a fishery (as one of several possible measures of fishing effort). Further assume homogeneity in fishing effort, e.g. each fisher produce the same fishing pressure. This assumption is baked into equation (1) above, but the following reasoning may also allow the unit cost to vary among fishers. The marginal cost (*MC*) in the fishery expresses the cost of each fisher. If the price *p* is given for all fishers as assumed in equation (2), per fisher revenue equals the average revenue $AR = TR / E$. From the perspective of each fisher, he is not able to influence the stock biomass and his profit from the fishery is maximised when

$$AR = MC$$

$$\frac{p \cdot Y(E)}{E} = c$$

$$(3)\quad \frac{Y(E)}{E} = \frac{c}{p}.$$

Since equations (3) is identical to TR = TC (equations (1) and (2)), in the long run the fishing activities provide the fishers with normal profits[1]. Bioeconomic theory shows that economic rent (abnormal profit) may be obtained by reducing the overall fishing effort below the open access level. This economic rent, which is the profit additional to the normal, is referred to as resource rent and derives from the fact that the valuable natural resource (the fish stock biomass) has no price.
In an open access fishery resource rent is wasted, in effect subsidising fishing activities beyond the levels by which abnormal profits could be obtained.

Assume the sustainable yield $Y(E)$ to be a square equation of effort (E)[2],

$$(4)\quad Y(E) = a \cdot E - b \cdot E^2,$$

a and b being positive constants. The bioeconomic equilibrium effort, E_∞, is found by inserting equation (4) into equation (3),

$$(5)\quad E_\infty = \frac{1}{b}\left(a - \frac{c}{p}\right).$$

Resource rent is normally not obtained without introducing management means. If the political objective is to obtain resource rent, the challenge is to identify desired levels of effort, stock size (inputs) and harvest (output). A sustainable solution need to balance these three elements so that fishing effort in the long run contribute to establish the preferred stock level, where annual increment in stock biomass is harvested by the chosen fishing effort and resource rent could be obtained.

[1] In the case of a non-linear TC-equation equation (3) is still the valid condition for an open access fishery, and no resource rent is obtained. The overall profit will however exceed normal profit, as intra-marginal rent is obtained. Intra-marginal rent origins from differences between fishing units, not from the property of the stock resource.

[2] This is consistent with a logistic biologic growth equation and a bi-linear short term catch equation. If the natural net growth of the stock per unit of time is described by the equation $f(B) = r \cdot B(1 - B/K)$, r being the intrinsic growth rate, K the environmental saturation level (in terms of stock biomass level) and B the stock biomass; and the harvest as a function of stock biomass (B) and fishing effort (E) is expressed by $Y(B,E) = q \cdot B \cdot E$, equilibrium harvest is found to follow the parabolic equation of E $Y(E) = q \cdot K \cdot E(1 - q \cdot E / r)$, which equal equation (4) when $a = q \cdot K$ and $b = q^2 K / r$.

Possible equilibriums are illustrated in Figure 4.2 by the down-sloping line. The three points seen in Figure 4.4 (1, 2 and 3) also represent bioeconomic equilibriums.

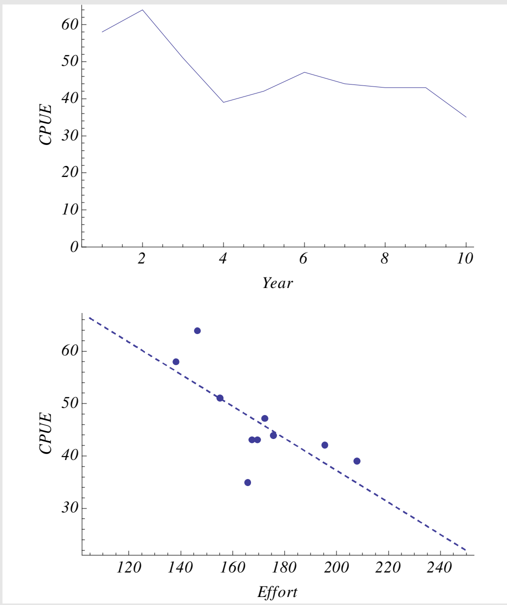
Given a stable situation without regulations has existed over a long time, one could expect the fishery to be close to bioeconomic equilibrium. This knowledge could be utilised if catch and effort information are available over some years. If this information in addition span out a range both in effort and calculated catch per effort (CPUE), valuable information may be obtained even from 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.

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

Ten years catch and effort information is available, as shown in Table 4.1. It is always useful to take a thorough look at the data from different angles. Graphical plots are always useful tools in relating data series to each other. The straight forward relation between catch and effort (CPUE) is obviously important as it is linked directly to the state of the stock. In the example we assume logistic biomass growth and linearity in catch between effort and biomass (see footnote 2 for details), CPUE is then a stock indicator 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



Graphical presentation of the tabled data.

A linear regression of CPUE (catch/effort) vs. effort gives expected CPUE as a function of effort, CPUE(E) = 98.387 – 0.306 E. CPUE is defined by Y/E, which gives the following expected catch function:
$Y(E) = 98.387\ E - 0.306\ E^2$ (see equation 4). An estimate of MSY is easily obtained by maximising the Y(E) function, MSY= 7916 at a fishing effort E=161.

As seen from the table, the effort giving MSY is not far from the actual effort, while the catch is significantly lower and has dropped dramatically from year 9 to year 10.

Since this is an open access fishery actual effort is expected to be described by equation (5). Based on current effort and estimated catch equation, the c/p ratio is calculated to 47.67. Assume that the market price of the fish product is observed to be 2 $, the unit cost of effort is 95.34 $ per vessel hour. This may however be an overestimate, based on the resent low catches.

Maximum sustainable yield

Bioeconomic equilibrium of a fishery (open access equilibrium) exists when biological equilibrium (biological net growth in stock equals harvest) coexists with economic equilibrium (a normal profit is obtained in the fishery). This theoretical concept is a useful reference point, similarly to the reference point of maximum sustainable yield (MSY). MSY also represents a biological equilibrium (indicated by the term 'sustainable'), but it is not likely to represent any economic equilibrium. Figure 4.4 shows the special case when MSY occurs at the bioeconomic equilibrium (point 2). Point 1 shows a fishery by which MSY could not be obtained without subsidising the fleet, since the high cost of effort keeps the effort below the necessary level to obtain MSY. Point 3 shows a situation of biological overfishing where MSY could not be obtained without effort reduction, e.g. fisheries management. The MSY reference point therefore has no economic interpretation. By accident it may be obtained in open access fishery (2), but it may also be out of range due to economic constraints (1). In developed, commercial fisheries overfishing is however most likely to be the consequence of open access to the resource (3), and effort reduction is needed if one aims to harvest the maximum yield on a sustainable basis.

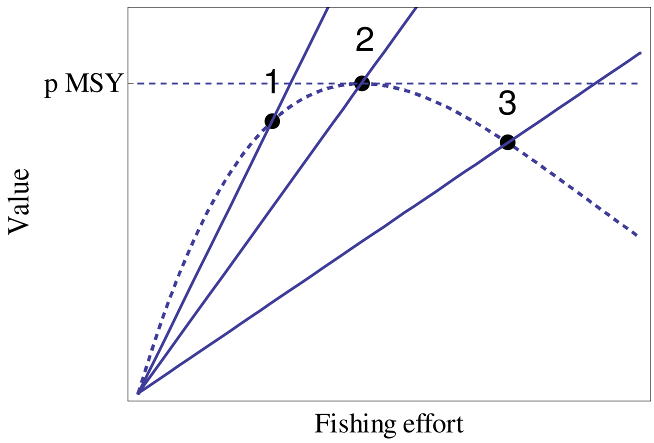


Figure 4.4 *The dashed curve shows the equilibrium revenue as a function of fishing effort. The three solid lines represent different unit costs of effort, as in Figure 4.3. The points 1, 2 and 3 are the corresponding bioeconomic equilibriums. The revenue obtained at maximum sustainable yield (MSY) is indicated by the horizontal dashed line, when the unit price of harvest is p.*

Resource rent maximisation

As shown above MSY gives no guarantee for profits beyond the normal. If the management objective is to maximise the sustainable profit from the fishery, the effort always needs to be below the MSY-effort. Resource rent (RR) is expressed by equations (1) and (2) in the following relationship:

(6) $RR(E) = TR(E) - TC(E)$.

The first order condition of maximising RR is that the marginal revenue equals the marginal cost.

(7) $MR(E) = MC(E)$.

According to equations (1) and (2) this implies

(8) $\frac{dY(E)}{dE} = \frac{c}{p}$.

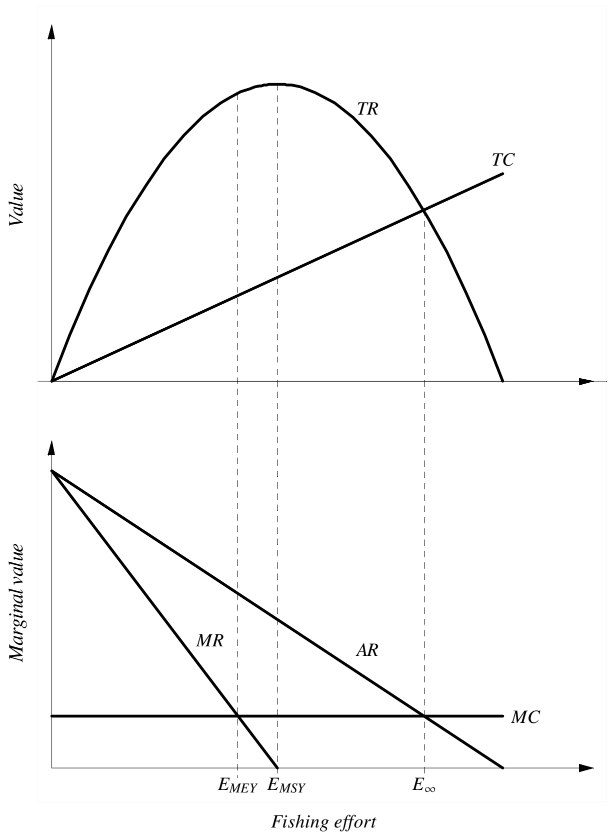


Figure 4.5 *The figure presents the three first reference equilibriums, open access (equilibrium effort E_{∞}), maximum sustainable yield (equilibrium effort E_{MSY}) and maximum economic yield (equilibrium effort E_{MEY}). The upper panel shows how the reference point relates to total revenue (TR) and total cost (TC), while the marginal picture is shown in the lower panel.*

The effort maximising resource rent, often referred to as maximum economic yield effort (E_{MEY}), is found by inserting equation (4) into equation (8),

$$(9)\quad E_{MEY} = \frac{1}{2b}\left(a - \frac{c}{p}\right).$$

The MEY reference point, together with MSY and open access (bioeconomic equilibrium), is shown in Figure 4.2. The figure offers a simplistic bioeconomic model where the long term stock-effort relationship is inversely proportional, as illustrated by the down-sloping line in Figure 4.2.

Resource rent maximisation always represents a more stock conservative approach to resource exploitation than maximising sustainable yield does and could never, in case of a common pool resource, be obtained without management if not some natural constraints limits the possibility of producing fishing effort. Such constraints may very well exist in the early development of fisheries, where the technology is not limiting substitution from labour to capital or capital is not sufficiently available. In case of a sole, profit maximising owner of the resource, as discussed by Gordon (1954), MEY turns out to be the expected long term equilibrium, as market failures due to external effects are resolved and the external effects internalised in the economy of the sole owner.

The MEY reference point is shown graphically in Figure 4.5 in a model often referred to as the Gordon-Schaeffer model. The work of Schaffer which Gordon utilised in the development of his model is presented in other chapters of this book.

A capital theoretic approach

Fish stock resources are renewable capital which can be utilised in different ways. The capital may even be exploited in such a way that 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 the revenue. Ongoing fisheries will however be found somewhere in between of the two extremes.

The nature capital a fish stock represents is renewed by different growth rates depending on stock properties. Tropical stocks typically have higher growth rates than what is found elsewhere. The growth rate is the interest rate of the nature capital, which could be added to the capital or withdrawn from the stock in terms of harvest in a fishery. The similarity with an ordinary bank is however not complete. In the bank of nature capital the interest rate depends on the amount of capital you have placed in nature (the stock biomass). This is not uncommon in banks either, but in nature the principles of a bank is turned upside down. The marginal growth rate (interest rate) in the nature capital is higher when the amount of nature capital is reduced, as seen from the average revenue (AR) in the lower panel in Figure 4.3.

In an unexploited stock the stock biomass reflects the environmental saturation level and there will be no net growth in the nature capital. As nature capital (stock biomass) is reduced, the stock will seek to compensate the reduction by growing faster and faster as the stock biomass declines. The two movements, stock reduction and interest rate increase, causes the existence of a maximum sustainable growth and the possibility of an MSY fishery. When regarding stock biomass as capital deposit in nature, the time perspective becomes important. Gordon's model represented a comparative static approach to fisheries. 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 hidden time dimension, which makes it necessary to value time. The concept of discounting is essential for the understanding fisheries decisions as a dynamic process. It is therefore natural to refer to the dynamic view as a capital theoretic approach, were resource value is not only related to availability, markets and biological growth, but also time. Value to be collected in the future is valued less today due to the fact that is not available unit future becomes present. The present value is less than the nominal value collected in the future. How much less reflects our impatience to get the value and is measured by interest or discount rates.

The social economic optimum is found by maximising the present value (PV) of all future flow of resource rent from the fishery, expressed by

$$(10) \qquad PV = \int_{t=0}^{\infty} RR(t) \cdot e^{-\delta \cdot t} dt \, ,$$

$RR(t)$ being the resource rent as a function of time t and δ the discount rate. The control variable of the maximising problem of equation (10) is input (effort, E) or output (harvest, Y) of the fishery. Since early resource rent per unit is valued higher than later, it is a trade off between building the stock up to a level where RR itself is maximised and the benefits or earlier resource rent. The dynamic problem may have a stable equilibrium where the optimal trade off is found,

$$(11) \qquad \frac{RR(B)}{Y(B)} = \frac{1}{\delta} \cdot \frac{dRR(B)}{dB} \, .$$

The left hand side of the expression represents the immediate gain of fishing one unit more and the right hand side gives the long term discounted losses due to the early benefits. Equation (11) is often referred to as the Golden Rule expressed as

$$(12)\qquad \delta = Y'(B) + \frac{k'(B)}{k(B)}Y(B), \qquad \text{when } k(B) = \frac{RR(B)}{Y(B)}.$$

Expression (12) tells that the present value could not be increased when the discount rate (d) equals the sum of the speed of natural biological growth and percentage change in resource rent; this sum up the biological effect and an economic effect. The two effects is balanced, as the marginal biological growth per unit of biomass increases with decreasing biomasses, while the economic effect is the cost-effect of changes in population density, decreasing the unit cost of harvest as the biomass level increases.

The properties of the open access and maximum economic yield reference points are also better understood by the interpretation on the newly established social economic optimal solution. Figure 4.6 displays the two sides of equality (11) and the new reference point is found where the two braches intersect each other. The intersections the two curves have with the horizontal axes give the two other reference points, representing corner solutions of the first. The MEY-solution is maximising present value for a discount rate equal zero, while the open access solution maximise the present value function when the discount rate moves towards infinity.

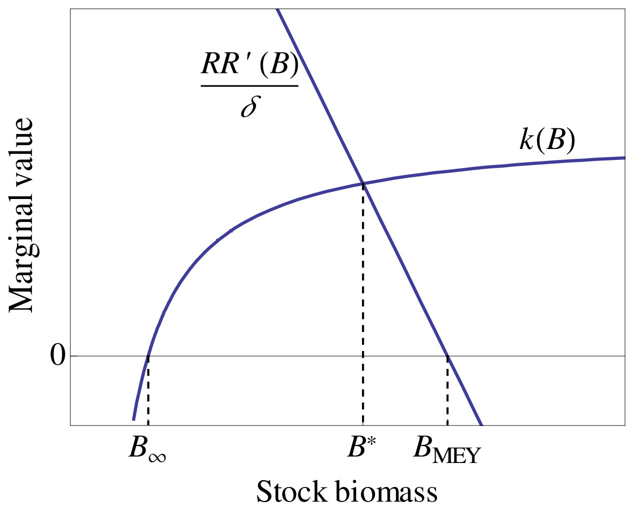


Figure 4.6. *Graphical representation of the branches of equality (11), displaying three of the four reference points presented above. See the text for details.*

Fisheries management

Politics and economics

Management is regulation of markets based on political priorities. The objective may be to correct for market failures or to create market failures. The latter is the motivation when many countries for example regulate taxi services by licenses. A licensing system gives some market power to the license holders, but it also gives the authorities easier access to information and better control of the quality of the industry. Market failures are introduced to increase security, quality and reliability of the service. Other examples of governmental interventions efficiently introducing market failures are sales of spirits and tobacco, where age-regulations define legal and illegal markets. These market failures are introduced because of health arguments. More often governmental intervention is based on the opposite reasoning; the aim is to reduce or remove market failures. This is the case in fisheries management. The political objectives 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 usually address several of these issues without making clear priorities. Typically the political objectives may at the same time be to increase economic benefits, secure employment and conserve the stock resource. These may potentially be conflicting objectives, hence proper management means may not exist.

Fisheries management needs to be based on expressed political objectives. Bioeconomic theory is useful for consequence analyses, analysing bioeconomic effects of different exploitation levels and necessary management means to obtain these effects. But there is in principles no built-in normative theory which makes it possible to omit the basic political decision on how to utilise the natural value a fish stock resource represents. The following discussion related to the use of different management means therefore presumes therefore a clearly expressed political objective of the fish resource utilisation. For simplicity reasons resource rent maximisation is assumed as a political goal where a clearly identified goal is needed. This should however not be interpreted as a normative statement, as a number of alternative objectives are possible.

Economists like to express political goals in object functions which should be maximised under given constraints. The object function could 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), food supply (as in traditional supply oriented economies, e.g. the former Soviet Union), marine mammal biomasses (as 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 not allowing the political objectives to be obtained, management is needed. Management therefore first involves the political process of identifying goals and thereafter proper means and finally control and evaluation. As such it is an iterative process which opens for adaptive processes to be implemented. Knowledge is gained from previous experiences and new information. As other political processes also this is 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 the process both of deciding political objectives and management implementation.

Resource conservation

The history of fisheries management development is a history of gradual evaluation through crises. Governmental interventions are supposed to solve existing problems and are more urgent when the problems are great and most needed when a crisis occurs. As pointed out in the introductory part of this chapter the biological conservational perspective is a rather new development in the history of fisheries management.

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 Hold (1957) after the Second World War. Their ideas and modelling approach were however not utilised in fisheries management until crises and collapses of huge fisheries asked for some immediate actions in the late 60ies.

The history of resource based fisheries management is rather short. Up to recently marine biological resources to a large degree have been regarded immense, impossible to deplete. Crises and collapses of large fisheries learnt both fishers and government different lessons and management were introduced to protect resources in order to open for the possibility for future resource use. The management objective throughout periods of crisis is to reduce the fishing effort. The concern is not so much to prevent extinction, as the cost of fishing out a stock to extinction in most cases will be astronomic. The main concern is to keep an exploitable stock and to avoid spending decades in building up stocks to exploitable levels after overfishing. In that sense the resource conservation perspective actually is an economic concern, as the aim is to avoid the cost of mismanagement.

Economics of management

Fish stock resources are naturally fluctuating due to ecosystem dynamics, seasonal variation and environmental changes. Fishing activities are one of many factors influencing the stock dynamics, but may be the only manageable factor. In many fisheries today fishing effort is a crucial factor causing stock decline and ultimately possibly stock depletion. Resource conservation is therefore by far the dominating motivation for resource management.

Table 4.1. *A four-field table showing all management means in fisheries as combinations of direct/indirect control of input or output from fishing activities.*

	Input control	**Output control**
Indirect control	• Tax on use or production of fishing effort • Restrictions on use of capital and/or labour • Injunctions on registration and administrative regulations on fisheries (e.g. restrictions on participation) • Infrastructure (roads, water supply, electricity) essential for producing fishing effort	• Harvest taxation • Sales and market regulation (e.g. price regulation) • Infrastructure (roads, water supply, electricity) essential for reaching markets • Quota market regulations (e.g. ITQ regulation) and other issues regarding distribution of fishing rights
Direct control	• Technical measures (mesh size regulation and other gear restrictions) • Limited entry regulation • Closed season regulation • Marine protected areas (MPA) or other area closure	• Quota setting and corresponding MCS regulation (e.g. harvest control rules, precautionary approach management, etc.) • Minimum size regulation • By-catch regulation

Still there exist a number of fisheries where biological concern is not dominant or not existing at all. Such fisheries may be characterised by a high biological turn-over rate, extreme costs or other causes securing a sound, exploitable stock. One such example is the Mozambican kapenta fishery in the Cahora Bassa dam. The kapenta stock now is the base of Mozambique's largest fishery in terms of quantity caught, but the stock origins from the Tanganyika sardine introduced in Lake Kariba higher up in the river, floating down to the Mozambican dam. After a few years a huge fishery could develop. The biological concern therefore is neglectable or not at all existing. If the kapenta stock goes extinct, a few new buckets of Tanganyika sardines will soon bring back the fishery.

Even when there are no biological reasons for managing the fishery, there may be economic reasons. As in the kapenta example above; it might be good reasons to manage the kapenta fishery if the aim was to retrieve resource rent from the fishery, of economic reasons rather than biological ones. It all depends on the fisheries objectives (policy) and how this objectives best could be met. In the following some management measures are presented and the economic properties of those measures discussed.

If the fisheries policy requires the use of management means in order to reduce fishing effort, a set of possible measures are available. The complexity of regulation problems normally call for combining several management means rather than solving the whole management challenge by imposing one single management mean. In order to discuss the properties of the different management means presented in Table 4.1, it is however useful to isolate some core elements.

Technical measures

Technical regulations are probably the first type of regulation systems aiming to protect the biological recourse. From an economic point of view the idea 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 toward 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 the high value products are retained. The cost of the implementing the technical measures is paid by the fisher, except 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 regulation tool. Technical measures alone have however in most cases shown not to be sufficient to approach common management goals. Usually also other means are needed, at least if the aim is to collect resource rent. Selection properties of technical measures could contribute in increasing potential resource rent, but when keeping open access combined with technical measures, normal profits should still be expected.

Taxation

Gordon (1954) proposed the use of effort (input) of harvest (output) taxation to reduce effort. The attractive property of taxation is that in principle the open access solution remains, as the increase in cost or reduced revenue due to taxation, automatically should lead to reduced effort following ordinary forward 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. The economic reasoning behind is most valid focusing equilibriums, the problem occurs when including the dynamics between the two equilibrium situation without and with taxation.

As mentioned before, management means are normally only introduced when crises make it necessary to take actions. The objective almost always is to reduce effort. In an open access situation a normal profit is obtained in equilibrium. In crises, which could origin from biological or economic causes, profit is most likely to below the normal level. Solving such crises by imposing taxation is not easy, if not impossible. Subsidies (which actually are the opposite of taxes) are more likely to be introduced. There is no legitimacy of imposing taxation on fishers earning less than others. People will argue that fishers in crises they need help rather that increased cost.

On the other hand; if fishers earn resource rent, i.e. more than normal profit, imposing taxation will cause less protests. Due to the fact that new regulations are seldom introduced without crises, taxation is seldom proposed in such situations. However, if this is done and the levels of profit reduced down to normal levels, it will contribute in sustaining the situation of resource rent collection, now collected by the tax imposing authority.

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 it is to directly control the fishing effort put on the stock. Limited entry regulation is in principle such a regulation. In fisheries where each participant (e.g. each vessel) could be controlled, it is attempting to control the activities of each single decision maker.

Limited entry involves also some problems related to the initial conditions of the regulation system. Reducing effort by giving fishing rights to some and excluding others may be controversial. The situation be to some extent be eased by including several fishing rights in the initial right distribution. Fishing rights allocation may often be based on previous fishing activities or allocated in a fishing right market (e.g. by auction). Given that the first distribution is regarded fair and accepted, next problem is to control that the regulation is met in the industry and the actual fishing effort reduced according to the agreement.

The control task may be regarded easy if the problem is to count number of vessels or fishers in fishing and check if they are licensed for the performed fishing operations. The task of effort control is however more challenging.

Assume a successful limited entry system, the effort has been reduced and the fishers earn a profit exceeding the normal. Normally this additional profit should be expected to be invested in making each licensed unit more efficient, of course 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; b) the unit cost of effort is increased. Both effects will cause the resource rent to vanish and the fishing pressure to increase.

Two problems arise from the above: To control actual (standardised) fishing effort over time is a non-trivial task. This problem also involves the difficulties in measuring actual stock output elasticises in the fleet, as briefly discussed in the first section above. Secondly the success of the management system also represents a threat to the system since profits exceeding normal levels usually find its way back to the industry, increasing the capacity of the fleet.

Quota regulations

Quota regulations constitute a major field of a variety of management systems. The principle is simple; in stead of controlling input directly (as above) the output is the object to be controlled. Quota management has many attractive properties which have made it dominate the resent year's management systems of the world.

First of all quota management interacts very nicely with biological model and since the management organisational structure often is built on the base of biological advice, output quantities are convenient regulation measures. The well-known concept of total allowable catch (TAC) fits very well into this picture. In principle catch outputs are easy measurable, easier than measuring fishing pressure, particularly in well developed fisheries where comprehensive catch statistics and market information is available.

A quota management scheme includes the following steps:

- *Fisheries policy.* Identify fisheries objectives
- *TAC setting.* On the bases of objectives and current scientific knowledge a TAC is calculated
- *TAC allocation.* TAC is distributed according to fisheries objectives, governance practice, legitimacy, and scientific knowledge.

- *Adaptive management.* If possible, experience and knowledge gained through previous TAC-calculations and allocations is implemented in the TAC-setting and allocation procedure. This brings adaptiveness to the management scheme.

The simplest form of TAC based management is to skip point number three above and let the quota allocation be determined by who's first in an open access fishery until the TAC is reached and the fishery closes. This creates a race for fish where all gained resource rent is invested in increasing the capacity of getting to the fishing grounds first, in order to get the biggest piece of the TAC-cake. The result may be increased cost per unit of effort, price reduction and loss of resource rent, even when the TACs are set at levels where resource rent should be obtained (i.e. at levels below currently expected catch in an unregulated open access fishery).

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

Allocation of TAC is allocation of fishing rights. The legitimacy of introducing a TAC system often relates to how previous fishing rights are converted into the new quota system, i.e. the quota allocation. Often the effect of this two step procedure is that the discussion on the distributional issues overshadows the of the TAC calculation discussion. Often there is a general acceptance that the TAC value is a scientific, basically a biological issue. The TAC allocation rules may be negotiated and some basic TAC allocation principles agreed upon. A certain percentage of the annual TAC could for example be allocated each vessel, fisher, community, etc.

Given such allocation rules, 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 is needed to stop this.

If the quotas are transferable, this control cost is not needed, or it could be converted into a market control system, regulating the quota trading. In principle the quota market should allocate the quotas to the most cost efficient fishers, as they are able to pay the highest quota price. Such allocation systems are known as individual transferable quota (ITQ) systems. The efficiency of ITQ markets depends on a number of factors:

- The duration of the quota right
- Individual expatiations on future fisheries, including expected TAC setting, biological growth and fluctuations, market development, political conditions, etc.
- Individual financial conditions
- Mix of other fisheries the fisher participate in
- Other constraints on the quota market

Several of these factors could potentially disturb the market sufficiently to hinder an economic efficient quota allocation in the quota market. Possible constraints reflecting political objectives could be restrictions on transferability between regions, vessel groups, etc., causing separate quota markets to co-exist without legal right to transfer quotas between the different markets. In order to increase the time span of the quota right, instead of trading quota values quota shared could be the market object. In principle this commodity could be without time restrictions, while the TAC value is set each year.

The initial distribution of fishing rights in an ITQ system does not need to follow any predefined allocation rules, it could simply be take care of by an initial auction, already there reflecting fleet efficiency through willingness of paying (with all possible error sources pointed out above). Initial allocation rules could also be combined with auctions, for example where indigenous people are acknowledged to have special historical rights.

The economics of transferable and non-transferable systems are quite different from each other. 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 should be expected to find its way back to the industry, increasing the probably already existing overcapacity. Eventually the situation of increasing overcapacity will put a great pressure towards increasing quotas. In other word, the resource rent obtained because of successful management, may very well create even higher fleet capacity effectively threatening the successful management system. Imposing taxation when profits exceed normal level may prevent this to happen.

A transferable system works differently. Here the quota right immediately has a market value as it can be traded. The value depends on how successful the management system has been; successful management will increase the value. If the quota right is given for free it still represents an opportunity cost for the owner, since the forgone possibility of converting it into money in a market is the consequence of utilising it by fishing. Those buying quota rights in the quota market of course also experience increased unit cost of effort compared to an open access situation. The increased cost also 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 the effort close to the previous open access level, the shadow value of the stock approaches zero and so does the quota right.

New inventions

In many regards modern fisheries management tools assume full knowledge to exist or at least that full knowledge could be gained on biological and economic dynamics in the fishery. A pure deterministic system is assumed and the challenge, also for the manager, is to identify the still hidden functionalities in the system. A different approach is to acknowledge as a fact that full knowledge could not be gained and that the management challenge rather is to cope with uncertainties than to completely unmask the system. The precautionary approach to fisheries management represents one possible way to deal with such uncertainties.

The precautionary principle was introduced to international agreements and treaties in the 1980ies and confirmed by the UN Rio Declaration on Environment and Development in 1992. The aim of a precautionary approach is to reduce the probability of unwanted events, acknowledging the fact that decisions have to be taken on the basis of poor knowledge. The precautionary approach is included in the FAO Code of Conduct for Responsible Fisheries. The idea is to create a buffer zone where the probability of harmful decisions is acceptably low. One practical implementation is to use a confidence interval border rather than expected values.

The state of a fish stock resource could only be measured directly. The importance of choosing good and relevant measuring methods therefore becomes crucial, but also which stock properties to measure. The chosen properties are referred to as indicators. Precautionary approach is often implemented in fisheries by the two indicators spawning biomass and fishing mortality rate, utilising the lower and upper 95% confidence interval of two respectively. If the current measure tells that the spawning biomass is below the lower 95% confidence interval of the minimum acceptable level and/or the fishing mortality rate is higher that the upper 95% confidence interval of the maximum acceptable, the fishery is outside the precautionary area. In case of quota regulation, the quotas need to be reduced or the fishery should be closed, according to a precautionary approach.

This reasoning introduces some quite new ideas to fisheries management. The example above shows how the quota setting could be automated based on some predefined rules of action; if this, then that. Such rules are now commonly referred to as harvest control rules (HCR) in fisheries. HCR may include precautionary approach, but also corresponding economic reasoning. A set of relevant indicators needs to be activated and the control system could be implemented similarly to fuzzy logic control. The learned effect of different previous decisions could be utilised in refining the predefined rules and by that implementing adaptive management.

In many ways this ideas represent a paradigm shift in fisheries management, as the focus shifts from the direct stock-catch relations to the interpretation of some stock indicators which relates to rules of actions. The first is based on known functionalities, the latter on experienced effects.

The new concept of HCR also opens for new methods to include other ecosystem effects not fully understood, as year-to-year and seasonal fluctuations, multispecies relations, ecosystem dynamics, but also economic dynamics as fisher behaviour, fleet dynamics, skill and technical differences, etc. As an example a comparative static approach does not explain observed fleet diversities in unmanaged fisheries, as only the most cost efficient according to economic theory should remain in bioeconomic equilibrium. Slowness of adaptation to changing conditions, natural fluctuations in age structures and other properties of stocks, cost composition, stock output elasticises, differences in future evaluation, etc. opens for other solutions.

Fisheries development

Bioeconomic theory and the economic properties of available management means provide the manager with a toolbox to apply for consequence analyses of different management decisions and proposing efficient regulations to achieve given political objectives. Fisheries management issues are often, of obvious reasons, focusing 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 exploiters, the fisher and the community around him.

Resource based management could from an economic point of view be substantiated by the market failure introduced by an open and free access to a valuable resource, the fish stock. This value is the reason why such a resource could serve as a last resort. An open access fishery therefore gives value for free to the fishers which opportunity cost of labour is less than or equal the open access earning. To the last consequence 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. 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 idea of technical regulation is to reduce gear efficiency and 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 stock resources? In this section we will try to address some of these questions.

Market failures and poverty

In the first section of this chapter we discussed some basic market failures in fisheries. Without these failures the common pool resource would be a pure public good, a non-rivalness or collective consumption good. If a huge common pool resource is utilised only as food for a few families of 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 does practically not exist. If no other constraints are actively preventing it to happen, one should hence expect the population to grow until the problem of external costs becomes visible.

> "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)

The importance of a common pool fish stock resource as a last resource is discussed earlier. From a food supply perspective the external costs do not represent any problem as long as the total fishing effort is at a level less than the effort of MSY (to the left of point 2 in Figure 4.4). In fisheries with poor technology and lack of markets, as often seen in coastal communities in developing countries, this is probably often the case. In such cases the external costs are not causing food supply to decrease, but it increases at a diminishing margin. The external costs are the loss of resource rent, 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-effort has good properties. If the effort produced reach levels above this, the community may be better off maximising resource rent, as the abnormal profit could finance food from other sources. The organisational challenges are however substantial and potential resource rent may easily be spent on other commodities or wasted.

In the previous discussion of the capital theoretic approach to fisheries, 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 impatiens in resolving the situation. Hence social optimal solutions move toward open access equilibriums, being a way of immediately releasing food resources for use of a starving population.

Public goods and market development

The dynamics of technological development is a complex mix of a number of factors, but first of all it needs to be understood in a market perspective. The market seeks the most efficient solutions, unless market failures are hindering this to happen. Market dynamics is constrained by the context within it exists, first of all by existing infrastructure.

Access to central markets represents a major obstacle in many artisanal fisheries. Necessary infrastructure as roads, electricity etc. is often absent or in poor condition and only local markets can be accessed. Market development therefore in the first place depends on the existence of public goods as the mentioned infrastructure. Technical inventions like the recent mobile phone revolution also have shown to make great impact (note that also mobile phones depend on infrastructure which not necessarily is available without governmental interference).

Figure 4.7 displays under which market and resource conditions a resource based management regime is needed. Increment in fishing effort production is here explained as a function of market developments. At a technological level below A, the resource is never threatened, even if all available capital and labour resources are utilised in this fishery. At a market development level below B the demand for fish products will be too low to support a fishery in open access, threatening the resource.

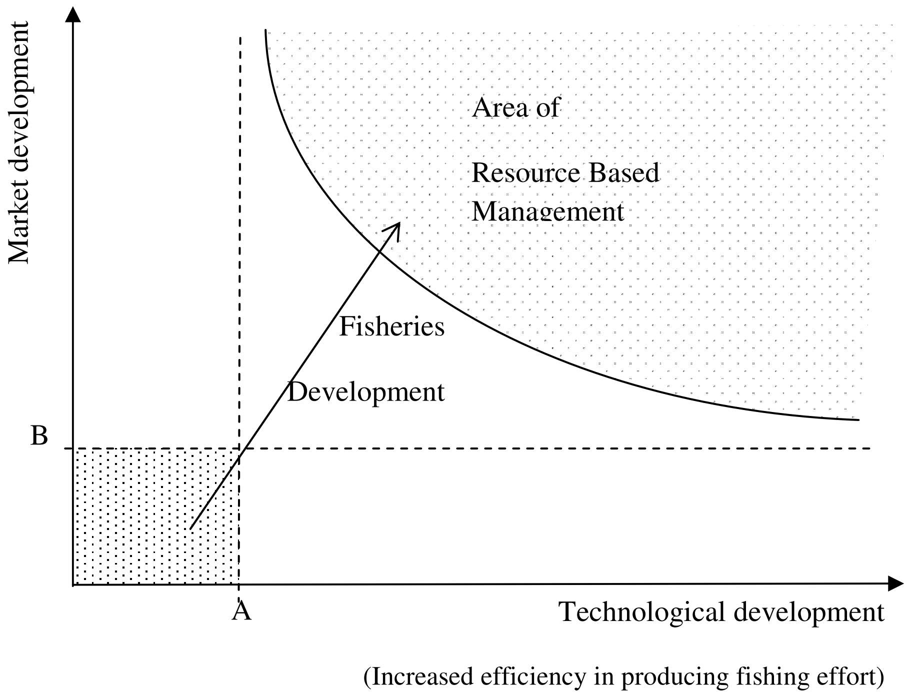


Figure 4.7. *Area of Resource Based Management defined by the development of two variables over time, markets and fishing effort. Development of a fishery over time, describes a path north-east in the plane as indicated by the arrow.*

Development stages – when is it appropriate to manage?

In order to collect the greatest resource rent on a sustainable basis, fishing effort needs to be reduced below the level of open access. In an open access fishery the resource rent is wasted in subsidising fishing effort exceeding the levels of positive resource rent. The resource rent could potentially be spent more efficiently (e.g. by employing more people) by placing it into other sectors. Economic development itself could contribute in reducing the fishing activity if the increase in opportunity cost of labour more than compensates the change in profits in fisheries (caused by increased price and reduced unit cost of effort). Some fishers will be better off moving from a fishery to other economic activities. This is however only a replacement of the open access equilibrium, while resource rent never is obtained without management means.

Poverty alleviation in fisheries therefore needs to be discussed in a broader community and society perspective, rather than being a sectoral task. It is however still essential to keep in mind the fisheries dynamics and in particular the dynamics of fisheries development which is to be examined here.

Fisheries development was in many years regarded as a matter of developing proper fishing technology, increasing catch and reducing post-harvest losses. This is still important, but of the obvious reasons pointed out above, it will not be sufficient for poverty alleviation and it may not secure a sustainable fishery. In recent years more emphasis has been put on management and different types of co-management regimes have been introduced; the management perspective has entered the fishing communities. But is the idea of management always appropriate?

Figure 4.8 and Table 4.2 show three stages of development in terms of labour substitution by capital and increased effort production (in the figure), in additions to infrastructure, markets and risk of negative stock effects (table). Fisheries management becomes an issue at stage 3, possibly also at stage 2, while stage 1 calls upon other types of governmental interaction, for community development. All three development stages need however to be monitored to ensure that the biological resource is utilised according to the given political objectives.

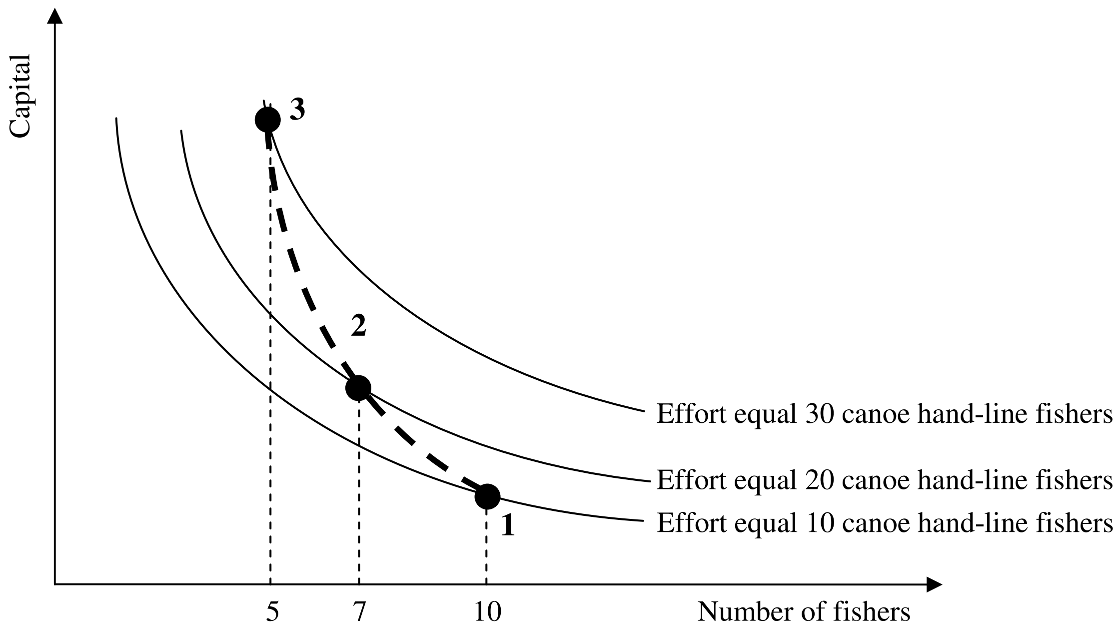


Figure 4.8. *The figure refers to Figure 4.1, where fishing effort is produced by the two input factors labour and capital. In this example 10 fishers using canoes and hand-line is placed in point 1. Point 2 corresponds to twice the fishing effort of 1, now produced by 7 fishers in long-line boats. Finally, in point 3, the long-line boats have got outboard engines, the number of fishers is 5 and they produce three times the fishing effort of the 10 fishers in point 1. The thick dashed curve indicates a development path in the fishery, including labour substituted by capital and an overall increase in fishing effort. The figure is further elaborated in Table 4.2.*

The vision for 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 stakeholder 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; and
- poverty and food insecurity do not persist; and where the social, economic and ecological systems are managed in an integrated and sustainable manner, thereby reducing conflict.

The vision represents a guideline for all small-scale fisheries and emphasizes 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 itself it involves more than management issues, in fact it is not obvious that management means is the answer at all in some cases.

This could not be achieved without necessary infrastructure for markets to develop. Infrastructure is however only a necessary, not a sufficient condition to fulfil the vision. Some basic political challenges exist and some political decisions need to be taken on the basis of relevant biological and economic knowledge.

Table 4.2. *Properties of the three development stages displayed in Figure 4.8 and 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

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