BIO-ECONOMIC MODELS BRING SYNERGY TO THE EFFICIENT MANAGEMENT OF FISHERY RESOURCES

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"On July 2, as Canada's Minister of fisheries and Oceans, I took the drastic step of establishing a two year moratorium on our northern cod fishery in the Northwest Atlantic. It took effect immediately and will continue until the spring of 1994". (WORLD FISHING : September-1992)

The gravity of these words of Mr. John C.Crosbie will be clear only when we know that this action implies unemployment for approximately 20,000 people and apparent hardship for thousands of others in the 400 communities that depend on the Northern cod fishery.

If any one still holds the age old 'Huxleyian' faith in the inexhaustibility of the fishery resources of the sea, the above news should provoke them to review their stand. Slowly but surely, considering the pace of exploitation of the fishery resources in almost all maritime states of the world, we often hear the type of news, in some form or the other, as reported in World Fishing.

The health of a fishery must be judged by the catch of fish, the viability of the fish stock which yields the catch, the profitability of the fishing vessels, and the earnings and employment prospects of the men employed in the industry (Pope,1982).

Repercussions

As with most real life situations, there exists different ways of judging the success of a fishery. This implies a difference of opinion on the relative health of the fishery. Obviously, a single 'best situation' is seldom identified for any fishery to be in. However, compromises are derived from the view-points of the majority of people concerned. Even then situations are such that an optimal solution and a compromise may not coincide or atleast come within a closer range. The effect of taking short-sighted steps to boost the immediate benefits, as is happening in most places, will certainly have repercussions much more damaging and long lasting than one can think of. Unless a holistic approach is adopted to analyse the complex systems no solution will have a lasting effect. It is at this juncture that the use of models gain importance.

Modelling and its objectives

Models are extensively used to analyse complex systems and to predict how the system will react to a set of actions. The proliferation of models in the last three decades has encompassed virtually all disciplines including fisheries (Gates, 1988). Bio-economic models in fishery analyses the relationship between the various economic forces affecting the fishery industry and the biological factors that determine the production and supply of fish in the sea. The basic objectives of bio-economic modelling can, by and large, be derived from the objectives of the fishery developmental policies (Willmann, 1989). These policies may aim at the general welfare of the people with specific objectives like improving the level of income of the fishing families, increasing the supply of fish to the domestic consumers, creation of employment opportunities (not necessarily for fishermen) and increasing the exports. The objectives and their priorities may vary from nation to nation and time to time. Bio-economic modelling in fisheries aims at understanding how public policies will affect the fishing industry and consumers of fish. It can help to predict the consequences of government policies taken at macro as well as micro levels.

A Simple Biological (Schaefer's) Model

As management of fisheries was the concern of biologists, until recently, it is not surprising that models in fisheries are primarily used in biological field for estimation of the abundance of resources and the maximum yield that can be sustained. If stability can be achieved by some method, the plethora of problems related to fisheries management will simply vanish. Maximum stability would be achieved obviously with no fishing when stocks are large and contain many year classes (long-term variations due to natural causes being ignored.). This can be explained with the help of Schaefer's (1954) model (Fig. A&B).

Any assemblage of fish species colonizing in a finite ecosystem grows in weight until it reaches the maximal carrying capacity of the ecosystem, after which the net growth ceases. This is theoretically the most stable situation. As fishing effort is applied to this virgin stock the catches increase initially and reach a peak where the biomass is reduced approximately to its half. Catches will decrease for any effort beyond this level. Obviously the yield, barring the fluctuations in the recruitment, can be stabilised if the effort is kept constant. In real situations this will be achieved only in lightly exploited fisheries. Practically it is impossible to have both constant catch and constant effort at the same time. If it is desired to have larger stocks, higher yields, improved stability and higher profitability, fishing effort must be kept down indefinitely. However, restricting the effort nearer to a level where the yield would more or less be equal to MSY, is what biologists would consider as desirable. If more effort is put in, the stock is said to be overfished biologically - a situation detrimental to the biological sustainability of the stock in the long run. The effect of changes in the fishing effort on the yield according to Schaefer's model is depicted in figures C and D. However, this model does not give any explanation to the overexploited and overcapitalised state of many fisheries.

A Bio-Economic Model

It was Gordon's (1954) classic work on the theory of 'common property' fishery which gave sufficient explanation to the low income of fishermen and also clarified the overfishing problem. It explained how 'economic overfishing' would occur in any unregulated fishery while ' biological overfishing' would occur whenever price/cost ratios were sufficiently high (as in the case of shrimps, lobsters etc.). By incorporating Gordon's results in the Schaefer's model we get a simple bio-economic model which can explain both the biological and economic phenomena simultaneously.

In Gordon-Schaefer model (Fig. B) it is assumed that price of fish and cost of unit effort are constant so that the total cost and revenue lines vary in proportion with the effort and catch respectively. An important finding from this model is that the 'resource rent' (the difference between the cost line and revenue line) attains a maximum value at a point before the MSY (Maximum Sustainable Yield), which from the economic point of view is optimum, termed MEY(Maximum Economic Yield). The level of effort at this point gives the maximum profit. Paramount among the bio-economic phenomena is the influence that discounting of the future revenues has on incentives for resource conservation (Clark, 1985). It is a fundamental principle in resource economics that the higher the rate of discounting used by the exploiters, the lower the degree of conservation. This principle is particularly relevant to fisheries, in which lack of resource ownership forces the exploiters to adopt in essence an INFINITE discount rate. In any such unrestricted fishery, so long as the existing units are earning a profit, further units are attracted to the fishery until a point is reached where no profit remains for sharing. This point at which the units break their costs and revenues even is termed the 'bio-economic equilibrium' and it is the point where every unrestricted fishery would eventually reach. It should be noted that any additional unit entering into the fishery after attaining the maximum economic yield while sharing the available profits, also add an external cost to the existing units.

In the long-run some of the units facing the diseconomies may leave the fishery or a technological change may bring down the cost curve thereby allowing some more units to enter the fishery. Escalating price of fish (and also demand) may also induce more effort to be put into the fishery which paradoxically (unlike the positive supply of agricultural commodities in response to increase in price) results in lesser supply.

The Need for Complex Models

The above model sufficiently explains the overfishing and related problems in a static, single species context. In reality, the systems are complex and dynamic. We commonly encounter multi-species, multi-gear fisheries in the tropics with inherent problems in their management (pauly, 1979). A simple model, though easy to understand and apply, implies many assumptions which may not hold true in the field. Complex and dynamic models, though difficult to formulate, are much simplified in application to the use of computers. Whether simple or complex, these models can bring about a vital change in the realm of developmental planning and policy making in fisheries.

Advantages : The advantage of bio-economic models is that both the biological characteristics of the fish population as well as the economic aspects of the industry are analysed together. This warrants closer collaboration between biologists and economists thereby improving the quality of the fishery policies. Bio-economic models also help to determine the most relevant data and to identify the gaps in it, for arriving at the most rational decisions. This envisages planning and designing of an effective fishery information system. It is encouraging to know that a highly versatile computer based bio-economic model (BEAM-4) developed at the FAO fisheries department (Sparre & Willmann, 1991) was demonstrated in our country recently. This will certainly open up new vistas in the management of our fishery industry.

The author wishes to state that the views expressed in this paper are his personal views and they need not necessarily reflect the views of the organisation which he serves.

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Fig. A : The growth of biomass over time (Schaefer's model) is assumed to take the logistic curve which theoretically attains a maximum B_{∞}, also called the virgin stock of the population, in a given time. The growth rate dw/dt assumes its maximum value when the biomass reaches $B_{\infty}/2$

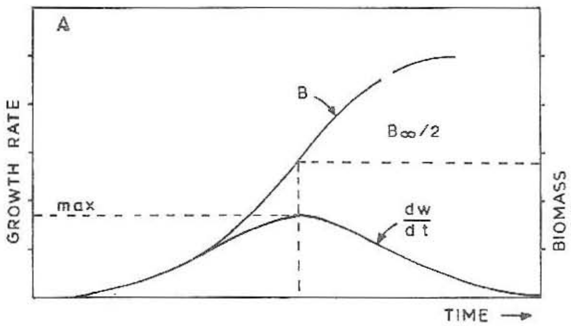
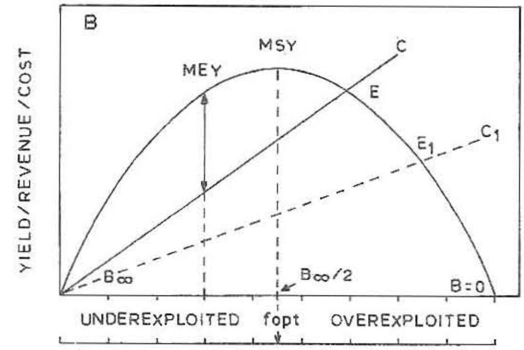


Fig. B : When fishing effort is applied to a virgin stock, the yield in response to the increase in the effort takes an inverted 'U' shaped curve (Schaefer's model). This yield curve will have a maximum at $B_{\infty}/2$ which is the biological optimum or MSY. The effort required for this yield 'f_{opt}' is the optimum effort. A stock is said to be overexploited (underexploited) depending on whether the effort 'f_{opt}'. The introduction of cost line 'C' into the schaefer's model results in the Gordon-schaefer static bioeconomic model. Assuming constant cost per unit effort & price, this model gives the maximum economic yield (MEY) where the 'resource rent', shown by the two headed arrow is maximum. This also shows the equilibrium point E (break-even point) where an unrestricted, open access fishery will evenually reach. The dotted cost line C1 shows the effect of a decrease in the cost per unit effort, shifting the equilibrium further down to E1.

Fig. C: The effect of a change in the effort in the resource management perspective is clear from the figure. An increase in the effort gives a short-term gain with grave loss in the long-term. A reduction in the effort, on the other hand, results in a short-term loss but gives a gain in the long-run.



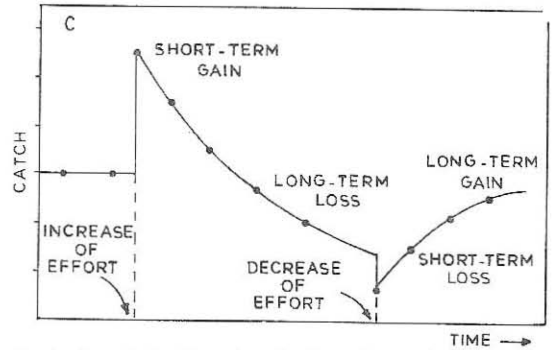
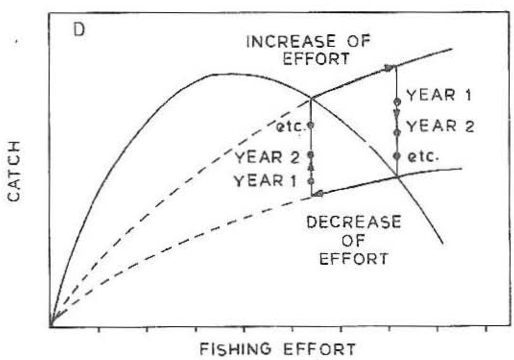


Fig. D : In real situations (as effort is not increased gradually), the yield curve may not strictly follow the inverted 'U' shape but may approach the values closer to the curve by a few intermediate points as represented by year 1, year 2 etc. Thus in the long-run the curve assumes the typical shape.

(A & B adapted from Pauly 1979 and Clark 1985. B & C adapted from Shepherd 1992)



MAC INDUSTRIES

MAC Indeustries would soon be commissioning its imported IQF machinery for its aquaculture project. In 1992-93, exports earnings of the Group from aquaculture are stated to have gone up. Acquisition of a total of 115 ha for the company's shrimp aquaculture project is expected to be completed shortly. At present an area of 20 ha are stated to have been brought under culture.