3. TECHNIQUES FOR REGULATING FISHING MORTALITY

3.1 Catch limits

Recently the standard procedure for regulating fishing effort in most of the developed world has been by catch limits (TACs). There are a number of advantages and disadvantages in setting catch limits and in regulating fishing effort by these means. The most serious disadvantage, which was touched on in the Introduction, is that catch limits in isolation are, even if successful, only capable of solving problems of resource conservation. Unless they are allocated in some way, either between national groups, or within a nation's fishing community the problems of over-capitalization remain.

In this section we consider firstly the relevant technical details of the procedures for calculating TACs before considering their allocation.

3.1.1 Calculation of a Total Allowable Catch (TAC)

Implicit in the calculation of a TAC are criteria which specify some aim of management. These criteria could, for example, reflect a desire for MSY, for a particular target fishing mortality, say $F_{0.1}$ (Boerema and Gulland, 1972) or for a long-term maximization of yield per recruit. Pope(1984) reviews the problems faced by scientists in interpreting ambiguous goals in order to give scientific advice on TACs. Readers are referred to Pope for details, but it should be emphasized that such goals should as far as possible be unambiguous. The main problem is that many management goals do not directly translate into a target fishing mortality rate. Accordingly it is often necessary to interpret the goal in these terms before proceeding with the calculation.

Given some specified goal, the calculation then involves the following procedures. Initially, it is necessary to make some assessment of the abundance and biological structure: e.g., age or length composition of the stock. Such a process can be done directly or indirectly. Direct methods involve, for example, acoustic surveys supplemented by random samples of the size composition of the stock. This is a method favoured for species whose recruitment is highly variable and whose mortality rate is sufficiently high that recruitment forms a significant proportion of the total stock. A variety of small pelagic species - capelin, sardine, anchovy, herring - are assessed in this way.

Indirect assessment of current abundance can be done using the technique of Virtual Population Analysis (VPA) or by means of production models which relate catch rates to the abundance of the resource.

Direct methods are costly, but can provide reasonably accurate assessments of current abundance. Indirect methods are cheap, often relying solely on data collected as a matter of course during fishery monitoring, but are often inaccurate, sometimes grossly so.

It should not be inferred that in all cases direct methods can provide a reasonably accurate estimate of abundance. There are a number of problems of sample design and calibration which (in some cases) render them ineffective. For example, the interpretation of acoustic data on shoals of mixed species is highly ambiguous.

The main problem with indirect techniques is that they rely for estimates of current abundance on a variety of ad hoc methods for calibrating effort efficiency. They are correspondingly inaccurate where effort calibration is difficult. Pope (1979), and Pope and Shepherd (1982) discuss the mathematical details of this process. A second problem is that the calculations can be sensitive to the estimate of the natural mortality rate of the fish stock. In many cases this parameter can only be estimated with considerable uncertainty.

Once an assessment has been made of the abundance of the resource, the calculation of a TAC according to specified criteria is straightforward. Indeed the mathematical apparatus for such calculations

has been available for several decades (see Ricker, 1958; Beverton and Holt, 1957).

Pope (1984) considers in some detail the calculation of TACs given a specific goal and an estimate of abundance. He describes a number of problems, all of which point to a substantial level of uncertainty in the calculations. Apart from this conclusion the technical details are inappropriate for consideration in this study. The main problems may be simply stated. If it is possible to obtain estimates of abundance of each age class in the fish stock, the fate of these age classes in the future can be predicted, using a fixed natural mortality rate and some specified level of fishing mortality. Extrapolations concerning the total stock will be subject to error due to the incoming recruitment (which cannot be readily estimated) and that associated with the estimates of current abundance and natural mortality. Where the fish stock has a low total mortality rate (defined as the sum of fishing and natural mortality), these extrapolations will be reasonably accurate as the new recruitment is a small part of the stock. If the species has a high natural mortality, or fishing pressure has made total mortality high, the stock will consist of few age classes and recruitment will be correspondingly important. In such situations predictions will tend to be inaccurate. The corollary of this observation is that high fishing rates can lead to greater unpredictability.

Where these problems are acute, direct estimates of recruitment strength are sometimes made to supplement the indirect estimates of the older post-recruited part of the stock. Examples occur in a number of fisheries for pelagic species. Typical fisheries are those for various herring stocks in the North Atlantic and anchovetas and sardine of the Eastern Pacific.

The procedure for calculating TACs may be illuminated by considering the recent practice of the Advisory Committee for Fisheries Management (ACFM) of the International Council for the Exploration of the Sea (ICES), which provides scientific advice to countries fishing in the North-East Atlantic area. In their reports the ACFM typically shows catches as a function of the fishing mortality that they will impose on the stock. Such a graph can then be used to show how the appropriate management objectives of the administrative body can be achieved (Hoydal, 1984).

In other management bodies, for example, in the International Whaling Commission (IWC), once the status of the stock has been assessed relative to its MSY level, the calculation of a TAC comes automatically from the rules of the New Management Procedure (NMP). In a similar manner, proposals for managing the Californian anchovy assess the relationship of the stock to its optimal sustainable yield, and then assess TACs on the basis of simple rules (McInnis, 1984).

Although simple in concept there are a number of problems associated with these procedures for the calculation of a TAC which are not widely recognized. The most obvious problem is that they rely on a history of accurate data on the age or size composition of the catch, the effort and the catch per unit effort of the various components of the fishery. Such data are often not available on fisheries in developing countries and clearly are not available in newly developing fisheries. However, the most important disadvantage of management based on TACs has become apparent recently. The problem is that the adoption of TAC management has often been accompanied by a marked deterioration in the quality of the data. Under-reporting of catches undermines all the techniques of resource assessment. The scientists are quite unable to perform assessments if data are not available or are unreliable. It is a reflection of the magnitude of this problem that a number of scientific groups have declared themselves unable to calculate TACs on the basis of the data made available to them (Griffith, 1982; Hoydal, 1984).

A less important, but still significant problem involves the allocation of scarce scientific manpower, which is often called upon to make annual assessments of stock status and TACs. Hoydal (1984) reviews current practice of the International Council for the Exploration of the Sea (ICES). He documents an extremely elaborate system of working groups and committees meeting for a significant portion of the year. Clearly such concentration of manpower cannot be done at low cost.

A reasonable question to consider in this context is the potential trade-off between the average level of catch obtained and the precision required of the estimate. For example,if it is required that the TAC should correspond to the level where MSY can be obtained, it will be necessary to monitor continuously the stock abundance and to revise TACs on a regular basis. By contrast, if the management was aiming to catch only some small proportion of the MSY level, the need for monitoring and regular changes in TAC levels is substantially reduced. The trade-off between the level of catch and the costs associated with scientific monitoring have rarely been quantified, but there is clear scope for investigating the possibility for less frequent monitoring.

In multi-species fish communities, the standard methods for assessing stock abundance, fishing mortality and potential yield are all exacerbated. Here, the setting of a global catch level faces the problem that substantial numbers of by-catches and discards occur.

The problem of by-catches has been recognized for some time. In particular, management in the North-West Atlantic, under ICNAF, operated on a whole range of individual TACs, all with separate by-catch regulations. In the ICNAF area these by-catch regulations often meant that the TAC was unattainable, given the selectivity and areas of operation of the fleets (Brown, Brennan and Palmer, 1979). Current regulation of the sprat fishery in the North Sea forbids a by-catch of herring greater than 10% by weight (ICES, 1982). With decreasing sprat and increasing herring this presents problems for fishermen in complying with regulations.

Discards occur when fishermen choose to throw away less valuable fish in order that their quota consists only of the most valuable. Such a problem is not unique to multi-species fisheries, but also occurs in situations where a wide range of age classes of a single species are harvested and larger and older fish are more valuable per unit weight. Indeed legislation to regulate the rate of discarding has some history in the North Atlantic, and sorting machines (which enable small fish to be separated) are banned for certain fisheries.

3.1.2 Allocation of TACs

Without allocation, the tendency for fishing enterprises is to move towards an over-investment in equipment and labour in order that they may increase their share of the common TAC. This has in the past caused severe problems, with a major disruption in the seasonal pattern of a fishery as fishermen rush to obtain their share of the quota. Often vessels increase in size and add engine power both to get more quickly to and from the grounds and to operate with greater fishing power, while there. Allocation can occur between nations and within a nation.

3.1.3 International Allocation of TACs

There are four main types of international allocation: firstly where there is fishing with open access; secondly where there are shared stocks; thirdly where there are anadromous stocks; and fourthly where there is foreign fishing within a national EEZ.

Under the pre-LOS conditions, the open-access fishing was typical; since the LOS and the Declaration of EEZs only a few high seas stocks, such as the tunas, are harvested in this manner.

The European Economic Community is a unique example of a group of nations which have agreed to combine their fishery resources and act as a single State. Having done this they now allocate their common resources among themselves and negotiate as a unit, with other States, concerning shared stocks.

Although there is clear need for there to be some allocation between countries when stocks are shared, it is quite clear that there will be no hard and fast rules for such allocation. When stocks are shared, criteria that have been used in the past have involved the biological characteristics of the shared stock. These include the location of spawning grounds and the migration routes of juvenile and adult fish. In some sense such information can be used as a basis for allocation, although the details clearly involve political negotiations, in which other factors may play a more important role.

Where countries do not have sufficient industrial capacity to land the TAC within their EEZ they may choose to allocate a proportion to foreign vessels.

The allocation of a TAC to foreign vessels when the stock is solely within the jurisdiction of a single coastal State is clearly the right and prerogative of the coastal State. Two decisions are to be made: How much of the TAC is to be declared as surplus to the needs of the coastal State and thus is available for foreign fishermen? How is the total allowable level of foreign fishing to be allocated among various nations? In the past such allocation has been made on the basis of historical performance, i.e., where, when and how often fishing by foreign vessels had occurred in pre-LOS conditions. More recently the allocation appears to have been made on the basis of the provision of data and cooperation in research and enforcement.

It is often the case that countries will consider the allocation of a TAC to foreign vessels to be of a temporary nature until such time as they are able to build up their own capacity. However, where the resource fluctuates in natural conditions in a substantial manner it can often be economically optimal to choose to develop the fishing industry to a level where the domestic capacity can always be satisfied. The surplus to this capacity is then allocated on a year-to-year basis to foreign fleets. These fleets, given sufficient lead time and a number of different stocks where they have temporary access rights, may find such an arrangement attractive. Beddington and Clark (1983) have investigated in some detail the theoretical basis of policies of this type.

Intra-national Allocation of TAC

When a country is the sole owner of a fish resource, or has agreed in international negotiation to its proportion of a TAC, it faces the problem of allocation of that TAC amongst its national groups. Such allocation can be highly detailed and technical or can be of a general nature. Often the aim will be to improve both the efficiency of individual enterprises or to make the allocation between different groups of fishermen more equitable. The improvement of the efficiency of an-individual enterprise is best achieved by the allocation of a proportion of the TAC to that enterprise. Where this occurs there is no incentive for fishermen to over-invest in equipment and labour in the hope of improving on their share of the global TAC, Such allocation, however, conveying as it does, an effective property right to individuals, must be considered in the overall context of the fishery management policy of the country.

Allocation to individual groups of fishermen often can occur on a geographical basis. Thus allocation rights to a quota to artisanal fishermen may best be achieved by dividing up the appropriate TAC amongst different sectors of the coastal population. A similar allocation between industrial and artisanal sections can also be made.

Administration of Catch Limits

A significant problem alluded to above concerns the necessity of enforcing a TAC, both in terms of the information that is collected for scientific purposes and to ensure proper management. The nature of many fisheries means that enforcement of catch limits will often be, if not impossible, on the high seas, extremely expensive. In such situations there are distinctive advantages in monitoring catches and enforcing quotas at the point of first sale. Analogies can be drawn between illegal catches, i.e., greater than the allocation, and the receiving of stolen goods. The buyer of fish from fishermen being clearly in the key position to provide evidence that the fish purchased were not in contravention to regulations. Accordingly an attractive idea is to involve the fish buyer in the enforcement process. This occurs in some Alaskan fisheries (Tillion, 1984).

There are clear interactions between the enforcement of TACs and the collection of accurate data for the purposes of stock assessment. Past failures in the developed world have already been referred to in this context. It is clearly undesirable that regulations put a premium on cheating and that enforcement fails to stop it.

The cost of enforcement needs to be set against the benefits to be obtained by operating a TAC form of regulation. It is apparent that in many developed countries the cost of enforcement is extremely high (Derham, 1984; Schowengerdt, 1984). In a similar manner, developing countries should rightly query the benefit of operating a TAC - based management when they have to face the problem of financing enforcement.

3.2 Indirect methods of controlling fishing effort

Although the most obvious way to control fishing effort is by directly regulating either the catch or the amount of effort, such direct methods of control do have a number of problems. In particular they are difficult and complicated to enforce and hence expensive. Furthermore they are in the words of Caddy (1984b) “information hungry”, i.e., for their proper administration they demand considerable amounts of data collection. Accordingly there are attractions in methods which are neither as complicated nor as costly. We now consider such methods.

3.2.1 Closed Seasons