CHAPTER 4

INPUT AND OUTPUT CONTROLS: THE PRACTICE OF FISHING EFFORT AND CATCH MANAGEMENT IN RESPONSIBLE FISHERIES

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1. INTRODUCTION

Fishery resources are limited. Consequently, if fishing pressure is not controlled in some way, it will increase until at best the fishery just breaks even economically and at worst the stock collapses through being unable to reproduce itself. Various forms of management are possible. These are

- technical management (controls on the types of fishing gears allowed and restrictions on times and areas of harvest, see Chapters 2 and 3),
- economic management and social management (see Chapter 5), and
- management of the inputs and outputs to a fishery, the subject of this Chapter. These are the limits on the total intensity of use of the gear fishers put into the water in order to catch fish (fishing effort management or input controls) or the limits on how much fish they can take out of the water (management of catch or output controls). Collectively we sometimes refer to these as "direct conservation measures". This is in order to make it clear to Ministers that these measures, like technical conservation measures, are designed to conserve fish and are not just a way of slicing up the pie! They are essentially concerned with limiting the proportion of fish killed each year by fishing, rather than limiting the sizes, areas and times at which fish are captured.

Conservation of fish stocks is at the heart of the FAO Code of Conduct for Responsible Fisheries (FAO, 1995a) because if the fish do not exist all other objectives fail (Code of Conduct, Paragraphs 6.2, 6.3, 7.1.1 and particularly 7.2.1). Hence limiting the intensity of fishing is a key tool of conservation (Code of Conduct, Paragraphs 7.1.8 and 7.6.1). Consequently this chapter describes how this can be achieved by limiting inputs (fishing effort) and outputs (catch) and explains the requirements and the advantages and problems of these approaches to conservation.

2. WHAT ARE INPUT AND OUTPUT CONTROLS?

2.1 Input controls or fishing effort management

As defined above, input controls are restrictions put on the intensity of use of gear that fishers use to catch fish. Most commonly these refer to restrictions on the number and size of fishing vessels (fishing capacity controls), the amount of time fishing vessels are allowed to fish (vessel usage controls) or the product of capacity and usage (fishing effort controls). Often fishing effort is a useful measure of the ability of a fleet to catch a given proportion of the fish stock each year. When fishing effort increases, all else being equal, we would expect the proportion of fish caught to increase.

For some fisheries, vessels may deploy a variable amount of fishing gear. In these cases the definition of fishing effort would also need to contain a factor relating to gear usage per vessel. In principle, input controls might also refer to limits placed upon other vital supplies of fishing such as the amount of fuel use allowed (energy conservation is desirable, see Paragraphs 8.6.1 and 8.6.2 in the Code of Conduct) but the commonest form of input controls are those put on the various components of fishing effort. In simpler less mechanised fisheries input controls might relate to the number of fishing gears deployed (e.g. the number of static fish traps) or to the number of individual fishers allowed to fish.

2.2 Output controls or catch management

By contrast, output controls are direct limits on the amount of fish coming out of a fishery (fish is used here to include shellfish and other harvested living aquatic animals). Obvious forms of output control are limits placed upon the tonnage of fish or the number of fish that may be caught from a fishery in a period of time (e.g. total allowable catches; in reality, usually total allowable landings). Another form of output control is the bag limits (restrictions of the number of fish that may be landed in a day) used in many recreational fisheries. Limiting bycatch might also be seen as an output control. It is worth immediately noting that to limit fishing intensity it is necessary (unless, as is not usually the case, fish can be released alive) to limit the catch (the amount taken from the sea) rather than the landing (which may well contain only a selection of the catch). The unlanded part of the catch (the discards) may be a substantial proportion of the total catch (Alverson *et al*, 1994) and may undermine the intent of catch management.

2.3 The need for fishing effort and catch management controls to be generally applied

It is important to notice that neither the management of fishing effort or of catch are likely to be effective unless they apply to all the fishers (or at least the overwhelming majority) engaged in a fishery. Partial controls leave space for the uncontrolled part of a fishery to expand into any gap left by controls placed upon other parts of the fishery. In the past a number of countries only controlled the effort of the larger fishing units on the basis that they created the most fishing pressure. Small vessel sectors of fishing fleets were left uncontrolled since they were thought to take only a small slice of the catch. This resulted in an uncontrolled expansion of the small vessel sector, which modern technology can render very effective at killing fish. Consequently the Code of Conduct encourages managers to take measures for all vessels under their jurisdiction (Paragraphs 6.10 and 7.6.2)

3. WHY WOULD YOU WANT TO USE EFFORT OR CATCH MANAGEMENT?

3.1 How do they link with the objectives of fisheries management?

The quick answer to the title of this section is given in the introduction to this Chapter. It is because fishery resources are limited and if fishing mortality is not controlled, it will increase until the fishery becomes economically non viable or the stocks collapse to extinction (see Chapter 6, Section 2). Thus in most cases the management of fishing effort or of catch are seen as pure conservation measures.

Restricting the amount of fishing by either effort or catch management is one way of protecting fish stocks from becoming over-exploited or of encouraging the recovery of stocks that are depleted as a result of having been over-exploited in the past. So they are one means of achieving the biological conservation of fish stocks. However, as described in Chapter 7, fisheries necessarily involve people and therefore have social and economic as well as biological objectives. Thus, viewing these or other management measures purely as conservation tools is naïve. The social and economic objectives are why people fish and why managers particularly wish to conserve fish. Because of this, the Code of Conduct requires managers to take social and economic factors into account when setting objectives and designing management approaches (see Paragraphs 7.2.2 and 7.6.7). Thus, it is important to consider how the management of fishing effort or of catch may effect the social and economic outcomes of the fishery. By doing this, managers may chose approaches that match the outcomes they desire or at least avoid approaches which would result in undesired outcomes (FAO, 1983; Pope, 1983; McGoodwin, 1990).

Uncontrolled fishing effort tends to increase until, on average, individual fishers make at best only moderate profits and often no profit at all. In unmanaged fisheries this tendency often leads to the fishery becoming biologically over-exploited by being subjected to too much fishing effort and hence to an excessive annual removal rate of fish. This results in fish being caught at a size before they have realised their full growth potential and often before they have an adequate chance to reproduce. This latter tendency is of course far more dangerous. In single-species fisheries the imposition of suitable technical conservation measures may be able to prevent the biological over-exploitation by protecting young fish and/or spawning fish and/or by making the fishery sufficiently inefficient that the zero profit level is reached before the stock is over-exploited. Where the social objective of maximum employment from the fishery is desired this may seem a perfectly sensible approach to management. Just stop fishers doing the things that would lead to over-exploitation (e.g. depleting the spawning population) and then let them fish as much as they wish to. However, this approach may fail if either the costs of fishing decrease (e.g. fishing gear becomes cheaper or more efficient, or fuel becomes cheaper) or the price of fish increases. Consequently the Code of Conduct encourages the limitation of fishing capacity to prevent uncontrolled increases in the amount of fishing (Paragraphs 7.1.8 and 7.6.1).

There may also be problems with a technical management approach if more than one species is targeted in a fishery or if the fishery takes bycatches of vulnerable non-target species (e.g. marine mammals). What may be a suitable technical conservation measure for a species which grows to a small size may be inappropriate for a species which grows to a larger size but which is exploited by the same fishing vessels at the same time. Examples of this are the fisheries for the flatfish species, plaice and sole, caught by the beam trawl fisheries of Northern Europe. Mesh size is smaller than would be optimal for plaice to allow for the catching of the small, lithe but more valuable Dover sole. Thus limiting inputs or outputs from such multi-species fisheries may be a better way of managing them to avoid biological over-exploitation.

If it is desired to maximise the economic benefits of the fishery then other approaches than technical measures are required. If the economic benefit is intended to go wholly to the state then it may suffice to use fiscal measures such as taxation. If set at a level appropriate to the economics of the fishery, such measures can both extract rent from the fishery and also lead fishers to reach the break even/no profit level point with fishing effort that does not over-exploit the stock. However, if it is intended to allow at least some of the profit to devolve to the fishing industry, then it is necessary to stop fishers from increasing their fishing effort at some level short of the zero profit point. It will also be necessary to devise ways to prevent them dissipating their profit by investing in additional uncontrolled inputs, or by engaging in activities such as discarding less valuable fish in order to high grade their landing (Townsend, 1998 discusses new approaches). Hence fishing effort or catch management may be used to secure the biological and either the social or economic objectives of fisheries or some trade-off between biological, economic and social benefits (see Chapter 5). However, how social and economic objectives balance out in practice depends upon the details of how catch or effort restrictions are shared between fishers and this is discussed in Chapter 6.

4. HOW WOULD YOU IMPOSE FISHING EFFORT MANAGEMENT AND CATCH MANAGEMENT?

4.1 Requirement for restrictive licensing

From the previous subsection we have seen that effort management and catch management might serve the biological, economic and social objectives of a fishery. There are a number of ways that effort or catch management may be established but it is the way that they are imposed that will determine which, if any, objectives are satisfied. It is common for countries to require fishing vessels to be licensed. Where they fish on the high seas the UN Fish Stocks Agreement (Article 18) requires the Flag State to control its vessels through licences, authorizations or permits (see also Code of Conduct, Paragraphs 7.6.2, 8.1.1, 8.1.2, and 8.2.1). However, typically such basic registration schemes are not of themselves restrictive, i.e. traditionally a licence might be had by filling in a form and paying a nominal fee. Although such schemes are useful as a basis for statistics and some forms of fisheries control they do not limit the amount of fishing unless coupled to a limited entry scheme.

Clearly, the measures to limit inputs require some form of restrictive licensing which will limit the total number of vessels engaging in a particular fishery together with their fishing power. Often, in order to reduce resistance to restrictive schemes, licensing lists are initially inclusive. They include all vessels, some of which seldom take part in the fishery. Such little used vessels constitute a latent fishing capacity, which might expand its usage to take a larger part in the fishery should it become more profitable. Consequently, it may be wise to extinguish or at least heavily limit these rights if they are not taken up regularly. Failure to do this may force the government to buy out rights when they have become valuable and it is wise to plan for this need when licences are first issued. For the same reason it is also important that the restrictive licence records such characteristics as the size and engine power of the vessel that affect its ability to exploit fish. If these are not fixed then the licence may be transferred to a new, more powerful, vessel or the vessel may be upgraded. Either type of change will allow growth of fishing capacity (Paragraph 7.4.3 in the Code of Conduct suggests studies of these effects).

If restrictive licences are in any sense transferable between owners then they are likely to acquire substantial value to the holder and be transferred at high price. In order for a Government to avoid claims that they are encouraging dangerous practices, typical licence transfer rules must allow for at least limited transfers from an old to a new vessel or from parent to child. The result is that some value is likely to attach to a restrictive licence giving the Government the dilemma that something that they have issued, often for a flat fee, has acquired substantial value that they will probably have to recompense if they wish to rescind the right. In principle this might be overcome by issuing such licences for a fixed term rather than in perpetuity. However, license schemes typically grow from earlier registration schemes and both socially and politically it may be difficult to deny fishers the right to earn a living in a traditional family occupation without offering them compensation. Even where fishing is not a traditional occupation, short-term licences might further discourage fishers from focusing on protecting the long-term productivity of the fish stock. Such issues are discussed further in Chapter 6.

4.2 Reducing fleet capacity

In many cases licensing schemes have been adopted after over-fishing has occurred. In these cases the fleet is already too large. Even where licensing has been brought in early it is quite possible that technological advances in vessel and gear design and improvements in fish-finding and navigation equipment may cause the effective fishing capacity of a fleet to increase through time. Indeed technological improvements in efficiency are often "guesstimated" to increase at about 2% a year. The actual figure may well be higher, particularly if restrictive licensing puts a premium on vessel efficiency. The rules of compound interest mean that even a 2% annual rate of increase in effective fishing capacity will lead to a doubling in fleet capacity in about 36 years; a 4% annual increase leads to a doubling in effective capacity in 18 years. Hence, it is not uncommon for managers to find either that the fleets they are concerned with already have too high a capacity or that they will develop this over time (As an example of this, the over-capacity situation in the European Community is described in the Lassen Report 1996). Thus, if despite licensing, the fleet is too large for the particular fishery then it will be necessary to reduce its capacity (Code of Conduct, Paragraph 7.6.1). This may be arranged in the following ways:

- by removing vessels from the fleet;
- by making all vessels fish for shorter periods;
- by limiting the amount or size of gear that a vessel can carry;
- by reducing the efficiency of fishing effort (e.g. by closing areas where catch rates are high).

Note however that none of these approaches will succeed in reducing the amount of fishing unless entry into the fishery is first ring-fenced (restricted by a limited licensing scheme).

<u>*Removing vessels from the fleet*</u>

Typically removing vessels from a fleet requires the rescinding of a Government licence. In essence this requires removing a right from an individual for the general good and a just system requires there to be compensation to the owner. Such vessel removals are typically arranged by adopting a Government funded Buy Back or Decommissioning scheme. If the restrictive licences are freely transferable the Government might simply enter the licence market to buy up excess licences. More usually governments announce schemes for fishers to tender for the decommissioning of their vessels or by announcing a price at which they will buy licences.

A general problem with all such voluntary schemes is that the vessels decommissioned are likely to be the least efficient in the fleet. As a result their removal will not cause an equivalent reduction in the ability of the fleet to catch fish. A further problem is that fishing communities are frequently tight-knit and the money paid to an older owner to retire from the fishery may then be recirculated into the fleet capacity, for example by being used to improve the efficiency of a relative's vessel. Indeed as licences become more restrictive there is likely to be a greater incentive to increase vessel efficiency, which may maintain the effective capacity of the fleet and also make successive Government Buy Back schemes more expensive. Thus, there is probably a need to back up such schemes with fiscal measures such as higher licence fees. One rational approach might be to regard Government Buy Backs as an investment loan to the whole industry, which would be funded in whole or in part by subsequent loan repayments from the remaining industry. In general removing vessels from a fleet will tend to increase the profitability of the remaining vessels and thus would serve an economic objective of maximising profit.

Reducing the amount of time vessels are allowed to fish

Reducing fishing time may be arranged by imposing limits on the days vessels may spend fishing. But, once a vessel is over the horizon it may be difficult to check its precise activities! It is true that satellite tracking has the potential to help with defining days fishing but unless special sensors are fitted it can only confirm the vessel was on the fishing ground but not that it was actively fishing (see Chapter 8, Section 3.2.5). Consequently, fishing is usually more practically reduced by limits on days at sea.

Direct restrictions on days fishing are of course possible. A vessel could be given a quota of days during which it might fish (interpreted usually as a number of days that it could not fish and had to be tied up in harbour). Such allowances might be transferable and traded between vessels. In this case they might acquire considerable value if the fishery were profitable. Trading would presumably eventually lead to fleet reductions by all the available days fishing becoming concentrated in an efficient subset of the fleet who could best afford to buy up the rights of other fishers. Thus it is an approach which might tend to generate an economically effective fishery rather than one which emphasized direct employment. As with all effective reductions in fishing effort such schemes may contain the seeds of their own failure by encouraging capital investment in fisheries equipment and/or replacement vessels, which increases fishing capacity. This tendency, called Capital Stuffing, is always present in any input control designed to increase the profitability of fleets for the benefits of their owners. It might be anticipated and counteracted by legislating for days at sea allocations to reduce progressively over time and/or by enforcing reductions in the registered fishing capacity of replacement vessels.

Managers should be aware that unless some transitional compensation is offered, the sudden imposition of days at sea restrictions will be seen by the fishing industry as "decommissioning on the cheap". Such restrictions will usually be resisted since, until the stock responds to lower exploitation, they will reduce or overturn any profit that the industry might hope to make. Days at sea measures (particularly for specified seasons) may be attacked by fishers' groups on the argument that they may encourage people to go to sea to take up their allocation at times when it is dangerous to go out fishing. A general problem with days at sea measures may also be that they often clash badly with fishers' self perception of being free spirits who can go to sea as and when they choose. The success of the implementation of the Faeroese scheme described below was linked to close consultations with the fishing industry.

Other restrictions on time at sea are possible. Where a group of fishers are effectively the sole users of part of a resource they may themselves impose quite heavy restrictions on fishing times. Such restrictions are quite common in European Community fisheries of the Mediterranean where fishers groups (e.g. the Confederes of Spain) impose their own rules. Ports in Catelonia for example fish on a daily pattern and have strictly set hours in which vessels may be at sea. Breach of these cause the vessel to be "fined" additional time the next day.

The fate of the UK's days at sea restrictions proposed in the UK Sea Fisheries Act 1993 should stand as an object lesson to managers of the problems of imposing a days at sea scheme. Though this Act was passed by the UK Parliament it was fiercely opposed by the collective fishing industry, subjected to Judicial review and to an adverse Parliamentary Select Committee report. Though it remains available for use, the will to impose it was lost. Clearly such schemes are better imposed at the beginning of a fishery when they need not be onerous rather than when real sacrifice is required in the face of severely depleted stocks.

Other time at sea restrictions may be arranged with schemes such as no fishing on weekends. In some cases such rules may accord with local customs and be welcome but in other cases they may discriminate between different groups of fishers. For example a weekend ban might favour small vessel day-boat fishers over those who make more extended voyages. In general reducing the amount of usage of fishing vessels may tend to make the fleet less effective and thus possibly preserve employment, though possibly for shorter working periods. If the time that vessels can be used can be traded between vessels such a restriction might ultimately improve profitability but more slowly than the direct removal of vessels would. As always managers need to think carefully if a particular regulation will have effects beyond the ones they intended or wished (see Code of Conduct, Paragraph 7.6.2).

Restricting vessels use of fishing gear

Some fishing vessels (e.g. otter trawlers) tend to use the size of fishing gear that is appropriate to the vessel's size and horsepower, but even for this gear newer developments (e.g. three bridle twin trawl rig) may increase a vessel's effective fishing power. Restricting the use of such gears may be one way of restricting the increase of the efficiency of fishing effort. For a number of other fishing methods, the amount of gear deployed in a day may have an even less clear relationship to vessel size or engine capacity. This is particularly the case with static gears such as gill nets, pots and creels. The amount of such gears carried by a vessel (or more properly the numbers deployed) may be increased if restrictions are placed upon other aspects of the vessel's efficiency or use. Thus when vessels use fixed gear (e.g. gill nets) days at sea restrictions alone may not be sufficient because fishers may leave out gear that is still fishing while they are in port. Moreover, days at sea restrictions may give an incentive to using more nets or adopting longer gear soak times, in order to maximise the output of catch within the constraint. Such responses by fishers to the legislation may reduce fish quality and may also increase the loss of fixed gear resulting in an increase in ghost fishing. Ghost fishing is caused by lost gear continuing to kill fish (see Chapter 2). In such cases it may be necessary not only to restrict the vessel's capacity and days of usage but also the amount of gear carried. However, this may be a far less easy factor to restrict and manage than vessel days at sea. One approach is to insist that gear is tended by the vessel and lifted when it goes into port. Such restrictions may also be sensible in order to avoid the dangerous overloading of vessels or unsound fishing practices (e.g. leaving gill nets in the water too long; Code of Conduct, Paragraph 6.7).

In southern Newfoundland where inshore cod fishing is mostly pursued with static gears measures were introduced in the 2000 fishing season to restrict the use of gill nets to the summer season where they were less likely to catch spawning fish or be left fishing or lost due to adverse weather. More generally there seems a movement amongst some inshore fishers in southern Newfoundland to favour a return to more traditional gears such as hook and line and fish traps.

In Bermuda, there is very tight control of the gear used in their fishery for spiny lobster. The government retains ownership of the standard traps, which are the only ones allowed for use in this fishery, and each year leases out a maximum of 300 of these traps to a maximum of 20 licence holders. The traps must be returned to the government at the end of each year for reallocation.

Reducing the efficiency of fishing effort.

Closed seasons are often seen as technical conservation measures and are discussed in detail in Chapter 3. However, they may be seen as a way of restricting effort if their motivation is to reduce fishing time, rather than to affect selection by protecting fish at seasons when certain sizes are particularly vulnerable. Equally the decision to close an area to fishing could be regarded as a *de facto* input control, if it were motivated by a desire to restrict vessel efficiency. Such input restricting closures would be in areas of high catch rates rather than areas where vulnerable ages of fish were found. Obviously, such decisions may well be motivated both by a desire to improve selection (technical conservation) and by reducing the amount of fish removed (direct conservation) and the boundary between these two approaches may become rather fuzzy at this point. Such measures to restrict efficiency will clearly tend to reduce profitability and maintain or increase employment by enabling a greater number of vessels to fish the stock. Such schemes are often adopted by those members of the European Community with Mediterranean seaboards where social objectives tend to dominate.

Effort Management in the Faeroes

The Faeroes, a group of Islands laying between Iceland and the Shetland Isles at the north of the United Kingdom, are part of Denmark but are locally autonomous in most matters including fishing. Fishing is of major importance to the Faeroese economy and an important means of employment. Local tradition favours providing employment for all Faroese but by the early 1990's the need to conserve the local fish stocks particularly those of cod, haddock and saithe was apparent. A total allowable catch system was introduced in 1994 but some fleets misreporting their catches led to the fishing industry rejecting the concept of total allowable catches. Consequently an effort management scheme was introduced in 1996. This imposed limited days at sea, which are transferable within vessel classes, for all but the largest vessels. Larger vessels were restricted from fishing within 12 miles of the coast and a series of area closures was imposed to protect spawning grounds and to reduce the efficiency of fishing. Incentives for fishing beyond the distribution of cod and haddock are also provided by allocating extra days to vessels fishing these areas. There are also bycatch limits of cod and haddock on the larger vessels and on all trawlers. These measures seem to have controlled fishing mortality on the cod and haddock stocks somewhat but have not brought the full reductions intended. They seem generally accepted by the industry as the best compromise possible. Whether the transferable nature of the effort restrictions will lead to concentration of the effort quotas into fewer hands and thus negate the partly social objective of the measure remains to be seen. It also remains to be seen if technical improvements to vessels will require further reductions in fishing effort and if movements of effort between stocks in response to relative abundance generates a virtuous or a vicious cycle of exploitation.

4.3 Forms of catch management

Restrictions on catches may take several forms, the most obvious being the limit on the total catch. This is usually called a total allowable catch (TAC) though catch quota and allowable biological catch are used in some areas. This may sometimes be in terms of numbers of fish (particularly for species that are harvested at a fairly uniform size) but most usually total allowable catches are given in terms of tonnage. Strictly to be effective they should relate to the catch of fish but for administrative convenience they are often limits on landings rather than catches.

The intention of a total allowable catch is to restrict harvest rates to sustainable levels. In reality such restrictions often also provide for the allocation of the resource between user groups. This is particularly important in internationally shared fisheries where some allocation between countries has to be negotiated if a management system is to work. To politicians and to fishers these allocation aspects of total allowable catches may sometimes seem to be more important than the requirements of conservation. Asking how they would share the last fish may put the emphasis back to conservation requirements.

Bag limits are a simpler form of catch limit designed to restrict certain types of fishery by limiting the numbers an individual person or vessel can catch during a short period, typically a day. Such limits do not of course restrict the total catch of the whole fishery. However, they may be effective in restricting sectors such as recreational, first nation or small-scale fisheries that consist of numerous and often dispersed operations that might otherwise be difficult to limit. Such fisheries may have a surprising ability to catch fish. For example recreational fisheries in the United States of America are estimated to take sizeable percentages of a number of species which are also subject to regulation of commercial fishing. One virtue claimed for bag limits is the prevention of recreational fisheries from expanding into semi-commercial operations partially financed by the sale of catch. Another is the prevention of commercial fishing masquerading as recreational fishing; a potential problem when small-scale inshore fisheries are restricted by TAC.

Bycatch restrictions may also be viewed as forms of output control as they restrict either the catch of bycatch species or the proportion that these species form of the total catch, often on a trip by trip basis. The intention of such limits may be to avoid the targeting of depleted species or species protected under some legislation, such as marine mammals. Such rules may need supporting by onboard observers if the restricted bycatch has little or no commercial value. Bycatch limits may also be adopted to restrict the catch of permitted small mesh gears, as far as possible, to those species for which they are intended (e.g. as shrimp). In these cases the limit is placed on the proportion of larger species that may be caught during a trip using the smaller mesh gear. When used in this fashion bycatch limits are adjuncts to technical conservation measures rather than intended as an output control as such. The main output control typically remains the total allowable catch.

The intention of a total allowable catch is to allow sustainable harvest. A TAC should act by restricting the harvest to a safe proportion of the exploitable stock of fish. Therefore to be truly effective, such catches must be related to the size of the exploitable biomass of fish and since this often fluctuates annually, so should the total allowable catch. In practice estimating the size of the exploitable biomass of fish in the sea is a difficult and expensive task (see Chapter 5). It needs be done with reasonable precision because if, for example, the TAC were set at half the exploitable biomass (a not abnormally high proportion) then overestimating this by 100% would in principle allow the whole stock to be caught with disastrous implications for conservation.

Sometimes TACs are set on the basis of average abundance of the stock, and if a stock is relatively lightly exploited this may suffice. However, the effect of average TACs (sometimes called precautionary[1] TACs) will be to harvest a larger proportion of the stock when it is smaller and a smaller proportion when it is larger. This is of course, the wrong way round since the TAC would unduly restrict fishers' activity when the stock was large, and may fail to protect the stock adequately when it is small. Total allowable catches are thus a far more effective form of management if they can be modified periodically to accord to the size of the stock. However, if the exploitation rate is low and/or the stock is not very variable, then this may not need to be done annually. However, more commonly TACs will need to be adjusted annually.

Having set a total allowable catch there is a need to control the fishery so the TAC is not exceeded. A number of approaches are possible, which include:

[1] Precautionary in the sense that they are adopted as a default and certainly not to be confused with the ideas of precautionary management.

- free fishing until the total allowable catch is taken and then shutting the fishery down;
- allocating catch by period and then shutting down the fishery for the remainder of each period when the allocation is caught;
- allocating proportions of the TAC to various sectors and leaving them to manage their own share themselves;
- allocating proportions of the TAC to individuals or individual vessels.

Allowing free fishing until the total allowable catch is taken is the simplest way to administer a total allowable catch since it is only necessary to keep a running total of the overall catch and then to stop the fishery when it is exceeded. However, such a fishery will encourage an intense race to catch fish before the total allowable catch is taken. It will thus encourage excessive capacity and a poor economic performance in the fishery. The classic example of this form of management was in the earlier management of the Pacific halibut fishery where the annual season progressively reduced to a very short period before the season closed. Such intensive races may exclude some fishers who are otherwise engaged during the short open season. On the plus side such management may suffer less from discarding practices because fishers probably find it better to land everything. However, an intense race to fish is likely to make fish quality a secondary consideration to landing fish quickly. In short, such a system does not have much beyond simplicity to recommend it.

Options for TAC management

Allocating catch by period and allowing free fishing during each period has some of the advantages of simplicity of the previous approach, in particular the need only to monitor overall catch. It would still encourage a series of races to fish but it would have some advantages in that fish would be landed throughout the year. Indeed the period chosen for opening might be aligned with times when fish quality or fish prices were best. It is however still likely to encourage excessive fishing capacity to develop and thus to be economically inefficient.

Allocating proportions of the TAC to various sectors that manage the catch uptake themselves may encourage a more orderly uptake of the fish. To what extent this occurs will depend upon the sector's ability to govern itself. In some cases producer organisations or co-operative organisations can manage fish uptake between their members very successfully. In other cases where the allocation is to an industry sector such an allocation may just engender a within-sector race to fish. A problem for management is that catch statistics will have to be collected separately for all sectors and moreover sectoral allocations would give each sector some incentive to under-report catch if they feel that they could get away with it or if they suspected other sectors were also cheating. A further problem may be to decide how to handle a case where one sector is found to have exceeded its allocation. Should management take it from the next years allocation of that sector? Alternatively, should they penalise the transgressors but balance the excess catch by reducing the remaining in-year allocations of other sectors? If the TAC is shared between several countries the latter course may be the only one to take but will be deeply unpopular with the other sectors. In better managed sectors there may be a tendency to try to improve quality and price but this may also encourage high grading. This is the practice of discarding lower valued catch in favour of its higher valued portions. Since there are often differential prices by size and since at times fish may be caught in poor quality (for example from having been too long in a gill net) there is considerable temptation for this practice to arise if fishers have a known allocation of catch.

Allocating proportions of the TAC to individuals or individual vessels has the virtues ascribed to the previous approach. It is more likely to lead to an orderly uptake of the TAC and in a fashion likely to be economically efficient. However, such a scheme is particularly vulnerable to administrative drawbacks. Statistics obviously have to be kept at an individual fisher or vessel level and the temptation and the opportunity to misreport increases as the allocations are more finely divided. Such problems of reporting often lead governments to develop rather draconian measures to ensure compliance by individuals. Problems of high grading are also likely to be exacerbated when quotas are organised at an individual level.

As with fishing effort management, catch management can clearly affect the outcome of the various objectives of fisheries management. The proportion of the stock it is intended to remove annually will affect the biological objectives of yield maximisation, yield stability and conservation. The proportion removed may also affect the overall profitability because the potential for achieving maximum profit will occur at exploitation rates less than those that achieve maximum yield. These are also lower than the exploitation rate where the break-even occurs between earnings and costs; the point where more fishers would be employed in an unsubsidised fishery. How the TAC is allocated to individual fishers will also impact the achievement of objectives. As an example of this, a quota might be divided into many small slices designed to provide individual fishers with a viable living. Clearly such slices should not be transferred. Such a non-transferable quota would tend to provide maximum participation in the fishery. By contrast a transferable quota would be traded and tend to aggregate into fewer but more profitable enterprises. This is the management approach that many fisheries economists advocate because they tend to believe in profit maximisation as the best objective. Notable examples of the use of Individual Transferable Quota (ITQ) management schemes are found in New Zealand and Iceland. Increasingly, analogous schemes are to be found in other countries though not always in such a clear form. For example the United Kingdom has quotas tied to producer organisations rather than vessels. By contrast Ireland and Namibia use non-transferable quotas to encourage wider employment opportunities. These approaches are discussed further in Chapter 5.

5. WHAT STRUCTURES DO YOU NEED FOR EFFORT AND CATCH MANAGEMENT?

5.1 The centralised nature of fishing effort management and catch management

By their nature, effort and catch management have to span the whole fishery (Code of Conduct, Paragraph 7.3.1). Small sized resources might be managed on a local basis but the larger, more extensive, resources have to have their management agreed centrally. Since the more important resources tend to be the extensive ones, approaches to both fishing effort management and catch management tend to be centralised command and control approaches. There is usually relatively little ability, except on small local stocks (e.g. the Thames herring), to devolve the decision-making to the districts where fishers operate. A corollary to this is that they will not work well where the central body has little control over the regions where the fisheries actually operate (see Paragraph 7.7.1 of the Code of Conduct). Moreover, their operation may often seem remote from the interested parties, and to fishers the controls may appear driven by the whims of remote bureaucrats who they perceive, sometimes with justification, as being ignorant both of the fish and the fishing industry. Any attempts to put a more human face on the operation and to increase its transparency (Jentoft and McCay, 1995) is thus to be welcomed (see Chapter 7 of the Guidebook and Paragraphs 6.13 and 7.1.9 of the Code of Conduct). A further problem is that such management tools may become the shuttlecocks of political debate. Since this may focus attention on the short rather than the long-term goals of the fishery it may work against the goals of conservation and optimal long-term use. Hence, there may be some virtue in moving the decisions and operation of effort management or catch management out of direct political control and into the care of a benign and transparent public body which is given clear objectives by politicians but is then left to do its job.

The Canadian FRCC

The Fisheries Resource Conservation Council (FRCC) was created in 1993 to form a partnership between scientific and academic expertise, and all sectors of the fishing industry. Together, Council members make public recommendations to the Minister of Fisheries and Oceans of Canada on such issues as total allowable catches (TACs) and other conservation measures for the Canadian Atlantic groundfish fishery. The Council is responsible for advising the Minister on Canada's position with respect to straddling and transboundary stocks under the jurisdiction of international bodies such as the Northwest Atlantic Fisheries Organization (NAFO). The Council also provides advice in the areas of scientific research and assessment priorities.

The Council consists of 15 members, appointed by the Minister of Fisheries and Oceans, with an appropriate balance between 'science' and 'industry'. Members are chosen on merit and standing in the community, and not as representatives of organizations, areas or interests: 'science' members are drawn from government departments, universities or international posts, and are of an appropriate mix of disciplines, including fisheries management and economics; and 'industry' members are knowledgeable of fishing and the fishing industry, and understand the operational and economic impacts of conservation decisions. Members appointed from the Department of Fisheries and Oceans serve 'ex officio'. The four Atlantic Provinces, Quebec, and Nunavut may each nominate a delegate to the Council.

The box gives the example of the Canadian FRCC, which is described as an independent body, which provides advice on fisheries management. Such bodies are also well suited to educating interested parties on conservation issues as some members share some common backgrounds and experience as fishers (see Code of Conduct, Paragraphs 6.16 and 7.1.10).

Where fisheries straddle political boundaries or occur in international waters there will be the need for some intergovernmental body where fisheries management can be discussed and agreed. The Code of Conduct is particularly detailed in this area (Code of Conduct, Paragraphs 6.12, 6.15, 7.1.4, 7.3.4). There will almost certainly have to be some corresponding scientific body to provide agreed scientific advice on the management needs (see Code of Conduct, Paragraphs 7.3.4, 7.4.1). Such bodies exist for most international fisheries. For example NAFO regulates fisheries that occur wholly or partly in its convention area outside the national EEZs of the seaboards of West Greenland, Atlantic Canada, France (St Pierre, Miqelon) and the USA (New England) but multinational fisheries may also be arranged by formal or informal bilateral or multilateral bodies (e.g. Argentina Uruguay joint management of Rio de la Plata fisheries, Norwegian and European Community joint management of the North Sea).

Where fisheries are wholly national affairs they are usually the responsibility of Government Departments. While the sole ownership of the fishery resource may ease some management problems, the problems of national management are often a microcosm of the problems of international management. Regional governmental bodies often have disparate objectives and different fleets, and may well hold different viewpoints on what are the appropriate fisheries controls (Code of Conduct, Paragraphs 6.12 and 7.6.5). This can lead to disagreements both between different regions and with the central government. In these circumstances it is not uncommon for agreement to be reached for political rather than conservation reasons. This is particularly the case since the time horizon of fish stock recovery is often longer than the time for which politicians are elected. This emphasises the desirability of taking management decisions out of the political arena and allowing some involvement of interested parties in the process. What perhaps is required is a fisheries equivalent of the former Bundes Bank of the Federal Republic of Germany which might protect fish stocks and coastal resources in the same way as the latter protected the value of the German currency (see the Code of Conduct, Paragraph 10.1.3).

5.2 Monitoring, enforcement and advisory structures

However management is arranged, there will clearly be a need to collect data from the fishery in order to monitor the compliance of fishers with effort or catch restrictions and to enforce the management of the fishery in some way (see Chapter 8 for detailed discussion). This can seldom be left to the fishing industry and consequently the Government frequently has to act as the referee and to arrange for the fishery to be policed. As a result, there usually has to be some national data collection and inspection service to monitor and to control the fisheries (Code of Conduct, Sub-Article 7.4 for data and Paragraphs 7.1.7 and 7.7.3 for control and surveillance).

Monitoring and enforcement services may be combined since they need similar access to the fishery and monitoring data provide the essential information on non-compliance with fishing effort and with catch restrictions (Chapter 8, Section 1). To be effective they need to be staffed with personnel who understand the workings of and are sympathetic to the problems of the fishing industry but can deal with them fairly yet firmly when the needs arises. In many cases dockside monitoring and enforcement will not fully meet the needs of either fishing effort restrictions (gears used, areas fished and species caught may all need to be checked at sea) or catch restrictions (discarding at sea may need to be monitored or prevented). Hence monitoring and enforcement staff will usually need to be capable of working at sea and for senior staff it may be appropriate that they hold some appropriate form of mariners certification. Most of all they must be incorruptible, which argues that their income must be adequate and they must be carefully selected.

Most fisheries management approaches need some form of scientific advice in order to make informed decisions (see Chapter 5 of this volume, and the Code of Conduct, Paragraphs 7.4.1-5 and all of Article 12). This is especially the case for fishing effort management and catch management. Both are intended to limit the proportion of the fish stocks being removed each year to a sustainable level. Ideally this requires ongoing information on what proportion of the stock is being removed each year. It also requires a reasonable knowledge of what levels of removals are likely to prove sustainable. These facts allow adjustment to be made either to the fishing effort being applied to the stock or to the catch being removed from it, so as to lead to the appropriate proportion being removed in the future. These requirements are in fact quite difficult to provide since they require the enumeration of a resource that cannot be directly seen or counted and an understanding of how it will react to exploitation.

In the case of catch management, estimates of the stock size typically need to be known rather precisely. This is because if it is wildly inaccurate the catch restriction might even be set higher than the size of the stock. At best this would cause no restriction to the fishery and at worst might endanger the stock. Input controls also will need scientific advice of a reasonable precision to set them at an appropriate level initially and to respond to changes in the efficiency of fishing effort through time. However, typically the demands of precision in population estimates for output controls are not so high as for catch management since the removal rate generated by current fishing effort levels may be judged over a series of years rather on a year by year basis. Hence some averaging out of wild results occurs. Where these dubious results do not apply it may be possible to find a measure of relative removal rate and also find what levels of this measure are sustainable. However, the commonest measure of relative removal rate is fishing effort, which is subject to trends in efficiency, which may obscure changes in the stock. Thus a certain level of fishing effort might seem sustainable, judged on the evidence of past catch-per-unit-effort levels, but increasing efficiency might be masking a decline in the stock. Therefore, fisheries independent measures of stock abundance such as scientific fishing surveys may provide a safer measure of stock status than catch rates based upon commercial fishing effort.

Advice on stock status requires some suitable source of scientific advice (Chapter 5). This might possibly be acquired on an ad hoc basis from university departments but if advice is more than minimal it will probably require either a dedicated scientific agency or the ability to commission appropriate scientific advice. The provision of advice also typically requires some scientific as opposed to management data collection since scientific assessment of a stock typically requires a more detailed understanding than is required for routine monitoring, control and surveillance.

In addition to the biological advice which underpins the setting of limits it will also be wise to have advice on the likely economic and social effects of the fishery. Since these may well give conflicting signals, such advice is best integrated so that the trade-offs between each effect can be clearly seen (See Code of Conduct 7.4.5).

6. WHAT PROBLEMS EXIST WITH THE APPLICATION OF EFFORT MANAGEMENT AND CATCH MANAGEMENT AND HOW MIGHT THEY BE CIRCUMVENTED?

6.1 The problem of effort management

A major problem of effort management is defining a reasonable unit measure of fishing effort. For example, for towed fishing gears (i.e. otter trawls, dredges, beam trawls) some combination of vessel tonnage and engine power often seems appropriate as a measure of the ability to catch a proportion of the stock**.** As an example of this, the European Community effort management system (called the Multi-annual Guidance Programme) uses both tonnage and also engine power to define alternative measures of fishing power, both of which must decrease through time to agreed schedules (for a simple general description of the Common Fisheries Policy, which uses both effort management and catch management, see European Commission, 1994). For static gear fishing methods other effort measures might be more appropriate as a consistent indicator of fishing power but for some methods no such consistent measure exists. This is because a major requirement of any input control is that a given amount of the input regulated should correspond to a constant ability to exploit fish. This tends to be the case for demersal towed gear fisheries. However, for fisheries on schooling pelagic species the proportion of the fish stock caught by a given unit of fishing effort may vary depending on the size of the stock. If the number of schools of fish diminish as the stock size diminishes then it will become progressively easier to take larger proportions of the stock as its abundance declines. Such stocks are clearly not suited to management by input controls.

Where effort management approaches are appropriate then the main problems centre around the increases in technical efficiency that tend to occur as time goes on. The problem of capital stuffing has already been mentioned. It is rather obvious that if fishers cannot expand a profitable operation by increasing the size or number of their vessels they may try to do so by spending more on capital improvements designed to increase its efficiency. Whether there is an upper limit to possible efficiency improvements is a moot point. However, if there is a theoretical upper limit it is clear that it has not yet been reached since efficiency still tends to increase. Certainly fishing gear technology has advanced inexorably over the last century and with it the ability of a given size of vessel to kill a greater proportion of the fish available. Consequently restricting other outlets for fishers' investment by effort management is likely to make technical improvements in vessel efficiency very tempting. Either removing super normal profits by fiscal measures or progressively reducing the fleet capacity seem the most appropriate responses to this. The alternative of specifying fishing vessel characteristics as tightly as those of a class of racing yachts seems inappropriate and stifling of innovation. Moreover given the ingenuity of mankind it is unlikely to work since fishers will find ways to improve any unregulated dimensions of the inputs. Thus it is most important to anticipate that such efficiency improvements will occur and to anticipate how they will be handled when they do.

A particular problem is that licences may frequently specify engine power. Engines may readily have their power output derated by minor technical modifications. Such engines can thus be certified to comply with a licence requirement but after certification their performance may be subsequently subtly upgraded! Periodic certification and inspection may be needed to close this loophole.

Other problems concern non-licensed fishing. This may be a particular problem for fisheries in international waters where fleets flagged in countries that are not part of the relevant international organisation may feel inclined to disregard its decisions. They most certainly should not do so and the Code of Conduct is very clear on this point (see Paragraphs 6.1, 7.1.5, and 8.2.6). The FAO Compliance Agreement and the IPOA on Illegal, Unregulated and Unreported Fishing (Chapter 1 Table 2) both address this important matter.

In multi-species fisheries there is an obvious risk that fishing effort may switch between the various available fish stocks depending on which is currently the most profitable. To some extent this might be beneficial since fishing effort might tend to move off of stocks which are at low abundance and move onto ones which are at high abundance. However, there remains the risk that the more valuable species will tend to attract more of the fishing pressure than less valuable species. Moreover, scarcity might cause particularly valuable species to increase in unit price sufficiently to continue to attract effort even when they are over-exploited and at low abundance. Such problems might best be addressed by also imposing technical conservation measures designed to protect the more valuable and more vulnerable species of an assemblage.

A further problem may occur where several different fisheries coexist. In such cases it may be difficult to ensure that a vessel licensed to participate in one fishery is not in fact participating in another.

6.2 Problems with catch management

As discussed earlier with simple output control approaches, (when the fishery is closed just as soon as the quota is taken) a race to fish is almost bound to develop and may be associated with over capacity, poor economic performance, poor fish product price and quality, and only seasonal employment (see the Code of Conduct, Paragraph 6.7). Moreover, a rush to catch fish may cause the safety of crews to be compromised. With more orderly management of quotas with allocations made to groups or individuals these problems are less likely to occur. The major problem with such a form of output control is the frequent non-compliance or circumvention of the regulation. In many fisheries there is bound to be an economic temptation for fishers to land more fish than their allocations allow. Such illegal landings are often called "black landings" (Alverson *et al*, 1994). If they are extensive they may undermine faith in the management process (see box on Faeroes fisheries management). Moreover, the distortion of catch statistics that they may create may also make it difficult for fisheries scientists to provide accurate estimates of future catches. The reduced ability of scientists to predict catches may lead to a further lack of faith in the management system. The obvious remedy is tighter enforcement coupled with an education program to make fishers realise that they are cheating fellow fishers rather than the Government. This is likely to be facilitated by a more open system of governance that is not too close to that of Central Government and has industry representatives as members.

A more subtle form of non-compliance is reporting one quota species as another species or reporting a species as coming from another management area. Such forms of non-compliance are sometimes referred to as "grey landings". The consequences of grey landings in terms of reduced faith in the system can be as pernicious as those of "black landings". Indeed they may be worse since they foul the statistics of at least two stocks. Again proper regulation and education are the appropriate responses to prevent this happening.

Quota regulations are often specified as levels of legal landings rather than catch. So fishers may chose to discard some of the less valuable part of their catch in order to get the best earnings from the quota they have available. Such discarding is often legal and indeed fishers may be required to discard over-quota or undersized fish. Such discarding is wasteful and should be minimised (see the Code of Conduct, Paragraphs 6.7, 7.6.9 and 8.4.5). Moreover, such discarding practices may also distort the intention of the regulation and allow exploitation to be higher than the regulation intended. Again this is a practice that may undermine faith in the management system. The prevention of discarding presents a dilemma. To permit discarding allows it to be measured by scientific observers (though this is expensive), to ban it may discourage it but also may simply render it unobservable. Some countries (e.g. Norway) require all fish to be landed and some compensate fishers for the cost of landing illegal or unmarketable fish. Compensation is set at a level that encourages landing but provides no real profit to accrue to fishers from catching the fish. Other approaches involve the setting up of permanent or temporary closed areas to direct fishers away from the areas where fish that are likely to be discarded are abundant (Code of Conduct, Paragraph 7.6.9). Temporary closed areas obviously require fast footwork by managers to be effective and are thus more easily achieved when the industry is involved in the details of the management and can provide rapid intelligence. (Temporary closed areas are used, for example, in Norway and Iceland, and the pelagic fishing industry in South Africa imposes closed areas on its members as a means of reducing bycatch).

Discarding can be a particular problem in multi-species fisheries. When a quota for one species is exhausted, fishers may continue to catch it and to discard it while fishing for other species in the area. This creates a particular problem if one species is recovering from overexploitation and quotas have been set on the basis of low removal rates, while the fishery for another species allows far higher removal rates. The problem is of course exacerbated if both species are caught with the same fishing gear at the same times and in the same places. Allowing the limited landings of bycatches of the more vulnerable species may be one management approach but this may cause a fishing pattern to develop which utilises any bycatch provision to the maximum extent possible. Suitable technical measures may be another approach (Code of Conduct, Paragraph 7.6.9) but the problem may be that the vulnerable species is larger and more selected by fishing gears than the less vulnerable species.

A draconian but effective approach is to close the entire fishery once one quota is exhausted or once some specified bycatch level has been exceeded. This is practised in the USA's Bering Sea and Gulf of Alaska fisheries to protect Pacific halibut and marine mammals. It requires a dedicated observer programme for such an approach to be effective. Where observer programmes do not operate, there is a risk that some fleets might make anticipatory discards of any species with quotas or bycatch levels, which if exceeded would lead to a closure of the total fishery.

7. THE PRECAUTIONARY APPROACH AND FISHING EFFORT AND CATCH MANAGEMENT

The precautionary approach to fisheries management (FAO,1995b, FAO, 1996) can be applied at all stages of development of fisheries (Code of Conduct, Paragraphs 7.5.1 and 7.5.2). It is not particularly associated with any one management approach. However, as fish stocks become progressively more exploited it is likely they may require the reduction in exploitation rates that effort management or catch management are intended to provide. An intelligent anticipation of this need may certainly help. This could be achieved by adopting restrictive licensing schemes and detailed catch statistics before the need for them becomes acute. Such intelligent anticipation of future problems by the development of a suitable fisheries management plan (see Chapter 9 of this volume and Code of Conduct, Paragraph 7.3.3) is an integral part of the precautionary approach. More detailed interpretation of the precautionary approach becomes possible once a full range of effort management or catch management measures are in place. In particular the imposition of target and limit reference points for a fishery may be made more possible if the population dynamics of a stock are known in the detail often required by catch management (Code of Conduct, Paragraph 12.13).

Detailed scientific thinking about recovery plans compatible with the precautionary approach has been developed (ICES, 1997). These typically involve progressive reductions in fishing mortality rate as stock sizes diminish. Such detailed management probably requires effort management and/or catch management for their achievement. However, the alternative or addition of safe technical conservation measures, for example towed gear mesh sizes that give fish a chance to spawn before they are caught, or alternatively extensive no take zones might help prevent the stock becoming seriously depleted in the first place.

8. WHERE CAN YOU SEE EXAMPLES OF EFFORT MANAGEMENT AND CATCH MANAGEMENT IN ACTION?

Catch management, notably total allowable catch (TAC) management systems, is particularly common in fisheries where the catch is based upon fewer species. In the case of demersal (bottom living) fisheries these are more often found in higher latitudes. Most of the major demersal fisheries of the European fisheries of the North Atlantic have total allowable catches as the primary management instrument. The same is true of the demersal fisheries of Canada and much of the USA. Total allowable catch management is also practised in Argentina, Australia, Namibia, New Zealand, and South Africa. One may also find them used on pelagic fisheries which tend to be less mixed than demersal fisheries. Notably, they are used on large pelagic fisheries such as the southern bluefin tuna.

Total allowable catches have an obvious appeal when fishing opportunities have to be shared between countries, or communities or fleets since they can be allocated a constant share of the overall TAC. Such percentage shares of catch form the basis of many fisheries agreements between countries. In general it is easier for countries to agree to share catch in some proportion than to agree how to share out fishing effort. This is because fishing effort is measured in various ways for various fleets so that establishing a common currency for an agreement is technically difficult.

Moreover, it is well known that fishing effort may change in efficiency through time and changes in efficiency by one partner might well undermine any agreement. Thus percentage shares of catch (so called relative stability) form the basis of national shares of the European Community's Atlantic fisheries. It is also the basis of the share between Norway and the European Community in the North Sea and Norway and Russia in the Barents Sea and between Australia, Japan and New Zealand for the southern bluefin tuna. For these reasons total allowable catch management remains established in these areas even where its track record for achieving sustainable fisheries is anything but impressive, e.g. in the demersal fisheries of the European Community.

While the use of total allowable catch management is widespread in higher latitude demersal and pelagic fisheries, it appears to be more difficult to operate as the number of species increase in a given fishery. There are several reasons for this. Firstly, problems of bycatch are bound to increase as more species occur in the catch and it is more likely that several of the quotas managing such a fishery will be incompatible and lead to discarding or falsified landing declarations. Secondly the requirement for scientific assessments of stock sizes becomes more difficult and less cost effective when faced with many small stocks rather than one big one. This is because the amount of sampling needed to effectively sample a small stock is similar to that required for sampling a large one. The cost of scientific advice may thus tend to be lower per unit catch for a large fish stock than a small one. The same is often true of the per-unit costs of management monitoring and surveillance. Therefore, by extension, the species rich demersal fisheries of tropical regions may be virtually impossible to manage by single-species quotas. The alternative of multi-species quotas of course always carries the risk that the fishery may focus on the more valuable species and perhaps discard the less valuable species in order to maximise short-term earnings.

Effort management systems have a less systematic distribution. Clearly they may be inappropriate for managing fisheries on schooling pelagic fish whose catchability may increase as stock sizes decrease. They seem appropriate for some single-species fisheries particularly where precise scientific assessment of stock size is difficult but where a reasonable presumption of constant catchability exists. Examples of this are seen in some local shellfish fisheries.

Mozambique deep-water shrimp fishery: this fishery illustrates the potential advantages of effort management but also the problems of success. The fishery on Sofala bank catches two species of shrimp. One species has continuous recruitment while the other recruits to the fishery during November and December. An industrial trawler fishery started in the late 1970s and rapidly became the most valuable fishery in Mozambique. It was mainly fished by two joint venture fleets from which Mozambique earned licensing fees. However, the stocks became over-exploited by the early 1990s. A limited entry scheme and a total allowable catch were introduced but the latter was set at too high a total allowable catch to form a binding constraint on the fishery. The Mozambique Fisheries Research Institute (IIP) proposed a closed season for January and February both as a technical measure and also as an effort reduction. This resulted in a rapid recovery of the fishery to profitable levels. The closed season was subsequently extended to also include December. However, the profitable nature of the fishery led to the issue of additional licences and the fishery is again depressed. For details see www.mozpesca.org

Effort management seems appropriate for multi-species trawl fisheries where the ability of the fleets to move their attentions to the most abundant species may help reduce pressure on depleted stocks. However, this is not an automatic benefit. It would certainly depend upon the fleets not being so large that they exhausted one stock before the rested stock recovered. It would also depend upon how separate the distributions of the different fish were and how their relative prices adapted to scarcity or abundance.

Effort management is also used as a backstop for fisheries predominantly managed by TAC. An example is the Atlantic fisheries of the European Community (see European Commission, 1994 for a broad outline of the Common Fisheries Policy and the Lassen Report, 1996 for the specifics of over capacity) where the capacity of the fleet is out of balance with the resources and needs to be reduced. In the case of the European Community an effort management programme called the Multi-annual Guidance Programme has been in place for some time. However, it has suffered in that the annual reductions that European Community countries could agree are insufficient to stem the typical increases in the efficiency of fishing effort that may be expected.

Experience suggests that single tools seldom suffice to achieve fisheries management. Moreover, where multiple objectives exist, multiple management tools will certainly be required (Pope, 1983 and Chapter 5 of this volume). However, it is also true that the historical problems with both fishing effort management and catch restrictions were that concerns for short-term goals often clouded the achievement of long term goals. Consequently fishing effort and catch management have not historically been applied with sufficient vigour or with sufficient regard to the precautionary approach to achieve long-term sustainability. Achieving long-term goals by input and output controls or other methods will require an appropriate focus and considerable political will.

9. REFERENCES

Alverson, D. L., Freeberg, M. H., Murawski, S. A., and Pope, J.G. 1994. A global assessment of fisheries bycatch and discards. *FAO Fisheries Technical Paper*, **339**. FAO, Rome. 233pp.

European Commission. 1994. *The New Common Fisheries Policy*. Office for Official Publications of the European Communities, Luxembourg. 46pp.

FAO. 1993. Report of the Expert Consultation on the regulation of fishing effort (fishing mortality). A preparatory meeting for the FAO World Conference on fisheries management and development. Rome, 17-26 January 1983. *FAO Fisheries Report* **R289**. FAO, Rome. 34pp.

FAO. 1995a. *Code of Conduct for Responsible Fisheries*. FAO, Rome. 41pp.

FAO. 1995b. Precautionary Approach to Fisheries. Part 1: Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions. *FAO Fisheries Technical Paper* **350**/1. FAO, Rome. 52pp.

FAO. 1996. *FAO Technical Guidelines for Responsible Fisheries No. 2. Precautionary Approach to Capture Fisheries*. FAO, Rome. 54pp.

ICES. 1997. Report of the Study Group on the Precautionary Approach to Fisheries Management, ICES Headquarters, 5-11 February 1997.ICES CM 1997/Assess:7. 41pp.

Jentoft, S and McCay, B. 1995 User Participation in Fisheries Management: Lessons drawn from international experiences. *Marine Policy*, **19**: 227-246.

Lassen Report. 1996. Report of a Group of Independent Experts to advise the European Commission on the Fourth Generation of Multi-annual Guidance Programmes, Commission of the European Communities. DG XIV Brussels.

McGoodwin, J.R. 1990. *Crisis in the World's Fisheries: People , Problems and Policies*. Stanford University Press, Stanford.

Pope, J. G., 1983. Fisheries Resource Management Theory and Practice. In: Taylor, J. L. and Baird, G. G. (Eds.) *New Zealand finfish Fisheries: the Resources and their Management*. Trade Publications, Auckland. p. 56-62

Townsend, R.E. 1998. Beyond ITQs: Property Rights as a Management Tool. *Fisheries Research,* **37**. 203-210.