The Management of Tropical Multispecies Fisheries

J. A. GULLAND

Marine Resources Service
Fishery Resources and Environmental Division
Fisheries Department
FAO of the United Nations
Via delle Terme di Caracalla
00100 Rome, Italy

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Abstract

A brief review is presented of some of the measures taken to manage tropical multispecies fisheries in different parts of the world. An examination is also made of other government decisions, e.g., on investment, that can affect the amount of fishing and the way in which these resources are used.

The contrast is drawn between the pattern of management that is supposed to occur in advanced countries–careful scientific research, preparation of scientific advice, decision on the desired measures, and implementation and enforcement–with what happens in practice in developing countries. It is suggested that the traditional pattern is not even working too well in developed countries (e.g., in the North Sea). The paper examines how the whole process of taking management decisions (in the wide sense) might be modified to take account of the realities of life in developing countries (particularly the smaller ones with limited research capabilities) and of the complexities and uncertainties of multispecies fisheries.

Introduction

Fishery management is often thought of only in terms of the pattern that has developed in Northern Europe and North America. A fishery, usually on a single species, is troubled by falling catch rates (and possibly also falling total catch); biological research shows that this is due to too much fishing, and further research determines what pattern of fishing would be "optimum", in some sense or other; and in due course controls (catch quotas, size limits, etc.) are applied that will move the fishery towards this optimum pattern.

Little management in this sense has been done in tropical waters for compelling reasons–the available mathematical models of the dynamics of fish populations are not immediately applicable to tropical situations; the basic information to apply any model is generally sparse; there are few scientists to carry out the necessary studies, and often there is not the administrative structure to implement and enforce the detailed restrictive measures typical of fishery management in the narrow sense.

Finally it could be argued until recently that no tropical fisheries were being "overfished" and needed management. This is certainly no longer true. It may be noted here that the same reservations can also be made about the situation in many developed countries, and there are few fisheries which are in fact being successfully managed at the present time according to the idealized pattern described here.

Nevertheless some management decisions are being made. If, as is now being generally done "fishery management" is taken to include most decisions (and all governmental decisions) affecting the amount and pattern of fishing, the number of these decisions in all countries is in fact large and growing. These decisions are often taken with little reference to any biological knowledge of the stocks. For example it is quite common for the treasury to agree to tax-free imports of engines or fuels for fishing boats in order to assist small coastal communities, but only rarely are these decisions preceded by biological analysis showing whether or not the resources can support the likely increase in fishing effort. The results have often not been happy.

The purpose of this paper is to examine ways in which biological research can lead to better management decisions (in the wide sense) being taken in respect of tropical multispecies fisheries. To do this, particular attention will be given to determining the types of biological advice needed, and the institutional and other mechanisms for making that advice available, and for ensuring it is acted upon. Attention will be given to the purely biological problems only to the extent of examining how sufficient biological knowledge can be made available to provide adequate advice. Some of the frustrations in studying multispecies fisheries for the purposes of giving management advice could be avoided by recognizing that complete knowledge of the biological system is unnecessary, as well as being almost impossible to obtain.

Types of Management Decisions

Three broad types of management decisions can be distinguished—(i) decisions on management in the most narrow sense, i.e., on the introduction of regulations such as catch quotas, minimum sizes, etc.; (ii) other actions designed more to protect the special interests of a particular group, e.g., banning trawling within a certain distance of the coast to protect the artisanal fishermen and (iii) decisions to encourage growth of the fisheries, e.g., on investment. To these should be added the social controls on fishing that have been traditional in some areas, e.g., the Pacific Islands (Johannes 1977) which kept the pattern of fishing in balance with the resource, at least until outside influences broke the system.

Management actions, in the narrow sense, have been scarce in tropical demersal fisheries. Very little has been done to control directly the total amount of fishing through catch quotas, or limits on the licenses issued, even when, e.g., in the Gulf of Thailand trawl fishery, it has been generally accepted for some time that the fishing effort is too high. Limits have been set on the number of licensed trawlers in parts of Malaysia, but there seems to have been a corresponding increase in the number of unlicensed vessels. The main exceptions to this lack of effective control on effort have been a few shrimp fisheries, particularly those operated by large industrial enterprises. Thus the Indonesian Government has kept the growth of the shrimp fishery in West Irian under control by limiting the licenses issued to the numbers which assessments showed to be reasonable. However, once such measures have been successful in maintaining or increasing the economic return from the fishery, the pressures to increase the number of licenses can be too powerful for a fisheries department (which is often politically weak) to withstand (see Marr, this vol.).

Regulations to control the sizes caught have been more frequent, and many countries have legislation setting the minimum sizes of trawl meshes. Actions to enforce these mesh sizes are much less common, and without this, or an understanding by the fishermen of why the general use of larger meshes would be to their advantage, the actual meshes used are often well below the legal minimum. For example, Jones (1976) reported that around the South China Sea the legal requirements were not being followed, and it is not believed that the situation has greatly improved since the time of his study. This is not just a problem of developing countries. Around the Mediterranean, for example, studies showed that while most countries have regulations that require a minimum mesh of 40 mm, the actual sizes used by most trawlers in the Mediterranean were much smaller. These regulations seem generally not to have been based on any biological assessment of the effects, but rather on a belief that a mesh regulation would be, in principle, a good thing. Much of the failure to implement measures is due to a past lack of communication between administrators, fishermen and scientists, of which the absence of an assessment is one aspect.

Regulations to protect the interests of particular groups of fishermen seem to have been better obeyed, presumably because there has been an identifiable group who believe the rules are in their interest, and who will complain to the authorities if they are not complied with. The commonest of these rules are those prohibiting the use of certain gears or types of vessel–particularly trawlers–within a certain distance of the coast or within a certain depth zone. These measures are probably effective in reducing or eliminating physical interference and direct conflict, but in most cases there is not enough information on the distribution and movements of the various species of fish caught by the different gears to say whether they reduce or eliminate the competition for the same stocks of fish. Decisions to introduce such measures are usually based more on the desire to keep potentially competing fishermen out of each other's way, and so far as possible out of each other's sight, than on a biological study of the effects of these and other alternative measures.

A great variety of government actions are taken to encourage the development of fisheries. These range from very direct involvement, e.g., investment in a government-owned fleet of new vessels, though encouragement of private investment, e.g., by the provision of low-interest loans, technical assistance and advice on the use of more effective gears, to the provision of shore facilities, or improved communication between landing places and the main markets. The effect of any individual action is often difficult to judge and the biggest changes in the fishery may result from minor actions. For example, the growth of the Thai trawl fishery started with a small technical assistance program which introduced single-boat trawling. Once the economic advantages of this type of fishery had been demonstrated, the fishery grew without much direct government involvement.

Overall, though, the effect of development actions of one sort or another on the fisheries is large, and probably much larger than the effects of management actions. The role of stock assessment and biological advice in reaching the decisions has in the past been minimal. Where advice has been sought it has been concerned with immediate questions, such as the catch rates to be expected from a new vessel. Very little information has been paid to the long-term effects, and the possible impact on the stocks of, say, the increased fishing effort to be expected along a hitherto isolated coast after the construction of an all-weather access road. This situation is now changing. In particular the regional development banks are becoming increasingly interested in the potential value of large-scale investment in fishery development and recognize the importance of having good resource assessments before starting on such investments.

Advice Required

Each type of management decision requires a different type of advice. The following section examines the advice needed for each type of decision and gives special attention to where single-species analyses are not adequate. The first type—management regulations in the narrow sense—appears in principle to require the most detailed advice. If there were adequate administrative machinery to apply complicated regulations, e.g., separate catch quotas for each species in each of a number of different areas, then correspondingly complex advice would be required. However, few tropical countries could enforce such complicated measures. It may indeed be questioned whether such measures could be enforced even in the most advanced countries. Simpler and more easily enforced measures must be used for which less complex advice may be sufficient.

The measures that can actually be applied will depend on the type of fishery. In small-scale fisheries it is extremely difficult to prevent anyone fishing who wants to fish from doing so, especially when there are few other jobs. Measures to control the total effort by small-scale fisheries are probably politically unacceptable, and would in any case be very difficult to enforce (virtually impossible for catch quotas); the possibilities of control on the growth of these fisheries to ensure that as far as feasible it matches the capacity of the available resources, are discussed in the following section.

In practice regulations on small-scale fisheries have to be limited to controls on the patterns of fishing–the types of gear that can be used, closed areas or seasons, or on the sizes or species that can be sold (though the last may be even more difficult to enforce than the others). Adequate advice on most of these can be provided without complex biological studies. For example the prohibited gears will be largely damaging and non-selective methods like dynamiting or poisoning. Any closed areas or seasons are likely to be chosen to protect particularly vulnerable stages of particular species, e.g., spawning runs up rivers, which could be wiped out by nets across the entrance. The need for measures of this type can be determined by straightforward single-species analyses.

Management of the larger-scale commercial fisheries presents more opportunities. Though a variety of gears are used for an even greater variety of species, the main current needs for management appear to lie in the trawl fisheries for shrimp and bottom fish. These catch a great mixture of species, with shrimp seldom accounting for more than about a quarter of the total weight caught, and usually much less. The economic importance of shrimp is much greater. In some fisheries (e.g., U. S. Gulf of Mexico, West Irian, Gulf of Carpentaria) virtually all fish are discarded, and landings are 100% shrimp. In others (e.g., the small trawlers fishing out of Cochin, India) the fishery is directed specifically at shrimp, though incidental catches of fish are landed, while others are mainly directed at fish, with shrimp making up enough of the catch to make the difference between a profitable or an unprofitable fishery. Many of these are known or believed to need management. The measures considered can, as usual, be divided into two classes—control of the total amount of fishing, and control of the pattern of fishing, i.e., the sizes and species caught.

The latter type of control is typified by the imposition of a minimum mesh size. Other approaches, e.g., by stopping fishing when or where small fish or shrimp are particularly abundant have similar effects and raise similar biological problems. The immediate extension of single-species mesh assessment to the multispecies trawl fisheries of Southeast Asia has been discussed by Jones (1976). By considering the shape of the fish and parameter ratios M/K and F/K he shows that the optimum mesh size for any species can be closely estimated as a function of the maximum size. This avoids the tedious work of carrying out selectivity experiments and yield per recruit analyses for a large number of species. The optimum mesh size for the fishery may then be estimated as an average, weighted according to the importance (weight and value) of each species in the fisheries, of the optimum mesh size for individual species—though, as Jones points out, the weighting must be done carefully because the curve of yield as a function of mesh size is strongly asymmetric, and in general, yield decreases faster above the optimum size than below.

This procedure is really the summation of many single-species assessments rather than a true multispecies assessment. The latter should take account of the possible interaction between species. Increasing the mesh size used will change the balance of fishery pressure on different species. The abundance of the larger species should increase in absolute terms, but they will still be exposed to fishing for much of their life, whereas some smaller species, with maximum sizes around the selection size for the larger mesh will hardly be fished at all. The fact that these species may become underutilized should be taken into account in simple procedure for assessing the optimum mesh size; what is not taken into account is any effects that the relative increase of these species might have on the larger species. Among adult fish this increase will presumably provide more food for the larger predators, and therefore be to their advantage, and to the advantage of the fishermen. However, there may be competition in the earlier stages between species with different maximum sizes. Particularly if they are related it can be imagined that the characteristics (food requirements, types of predators) of larval or small juvenile fish might be so similar that the density-dependent effects that determine, for example, the stock/recruitment relation apply more to groups of species taken together rather than to individual species. This would give a selective advantage to the smaller species, and hence in the long run might lead to a depletion of the preferred species, and a loss to the fishery. Checking on this hypothesis is not easy, but an examination of the biology of the younger stages of selected species might confirm or otherwise the existence of substantial overlap in needs.

The other possibility is that the increase in absolute numbers of the larger fish with the bigger mesh could have an effect on the smaller fish on which they feed, particularly the recruits or pre-recruits of the more valuable species. For example, Pauly (1982) has suggested that recruitment of shrimp in the Gulf of Thailand is inversely related to the abundance of fish. This is an extension of the general stock/recruitment problem, to which there seems no easy answer.

Control of the Amount of Fishing

In temperate waters, in single-species fisheries, the scientific rationale for these controls may be based either on yield-per-recruit models of the Ricker/Beverton and Holt type, or by production models relating catch, effort and catch-per-unit-effort. Even with the limited number of species in the North Sea, for example, the extension of the first type to take account of species interactions is proving so difficult that the management decisions (e.g., on the 1981 quota for cod) are still based on single-species analysis. Given the poorer database and the much greater number of species there is little hope of the direct use of the analytical methods as the main basis for providing advice in tropical demersal fisheries.

The difficulties of applying analytical models to a great range of species are really of two kinds–operational and conceptual. Operationally the work of obtaining the estimates for the necessary parameters (F, M, K, etc.) and making the calculations has proved time-consuming for the handful of species in the North Sea (even now the estimates of M for most of the North Sea are not good), and repeating the same work for, say, the couple of hundred species in the Gulf of Thailand would be impracticable. The estimation aspect has been tackled by Pauly and others who, following and expanding on the work of Beverton and Holt (1959), have noted that there are clear patterns in the natural parameters so that usable estimates can be obtained from a few easily made observations (e.g., see Pauly, this vol.). This approach gives very quickly the form of the yield-per-recruit curve, leaving as the major estimation problem the location of the present fishery on the curve, i.e., estimating the current fishing mortality.

The conceptual problem is that this still leaves the assessment of the fishery as a whole as the sum of single yield-per-recruit curves, with no account of species interactions. This is clearly important, as shown by the differences in trends in abundance between species in the Gulf of Thailand, but incorporation of this interaction in the analytical models in a quantitative rather than a purely descriptive manner has not proved easy. In the

North Sea the effects of predation by one commercial species by another has been taken into account by the so-called "legion" or "phalanx" extension to the cohort analysis (Pope 1980) but it is difficult to see how this can be readily extended, even in a simplified form, to a large number of species. In any case some of the more important types of interaction in the North Sea seem to be those affecting recruitment—for example the outburst of high recruitment in most gadoids in the late nineteen-sixties—which are even less easy to take into account. This is not to say that analytic models are not useful in providing advice—at the very least yield-per-recruit calculations for a few selected species can give support (or otherwise) to results obtained in other ways—but it does seem likely that the main source of quantitative management advice (e.g., what would be the effect of reducing the fleet size by 10%) will have to come from production models.

The use of production models in multispecies has been met head on in the Gulf of Thailand and elsewhere, by examining the relations between total catch (usually as total weight of all species, but also as weight of marketable species, or total value), total effort, and catch-per-effort. In the Thai fishery the catch-per-effort has been obtained from research vessel data, which avoids many of the problems of possible changes in species preference involved in using commercial catch and effort data. The statistical problems of the production of a spurious correlation can also be avoided in this case by plotting catch as a function of catch-per-effort (as an index of stock biomass).

This procedure is attractive because it is simple and gives results that can be clearly understood by the policymaker, especially if the fishing effort is expressed in units appropriate to possible management policy, e.g., the number of trawlers of a standard size, that are operating. The method can show at once that, for example, a further increase in the number of trawlers will reduce the value of the catch, and that the greatest value would be obtained with a fleet say 80% of the present size. The question is whether the method is reliable. Might the variety of species involved and their interactions invalidate the conclusions so that increased effort actually increase the catch, or conversely that the optimum fleet size is even less than 80% of the present? It has been argued that provided the fish stocks adjust quickly to changes in the amount of fishing, the data automatically include the net results of interspecific reactions. Certainly the decline in the catch-per-effort of all species together in the Gulf of Thailand is the aggregate of very different rates of declines between species, and these differences presumably reflect interspecific effects, as well as differences in the direct response of individual species to the impact of fishing. The awkward assumption is that the system adjusts quickly to changes in fishing effort. The data set for the Gulf of Thailand is longer than for any other tropical area, but even so covers less than 20 years. Though the average life span is less than in temperate areas, some of the larger species live several years, so that the whole data series is only a few generations. Given that the intensity of fishing has been changing continuously over this period, there is clearly a probability that the stock at any one time would be in a state different from the equilibrium state corresponding to a sustained fishing effort at the current level, and a possibility that this difference could make a practical difference to the conclusion and the biological advice offered, e.g., on the optimum number of trawlers. This possibility might be tackled by examining the effects on the conclusions of considering the level of effort corresponding to the current stock as being the average effort over a varying number of years up to and including the current year. Alternatively the changes in the relative abundance of various species can be examined in order to formulate hypotheses of how these changes are induced by fishing, and therefore what sort of delays might be involved before the effects of fishing have their full effect. For example, if one major change is that species A increases because of better recruitment due to the reduction in the numbers of large individuals of species B, then there would be a delay equal to the period for fishing to have its full effect on B, plus the time for the improved recruitment to grow into the exploited stock of species A.

The other problems with the most simple-minded application of a production model is that it says nothing about the possible gains from changing the ratios of fishing mortality between different species. Pope (1979) has shown that while the data from a fishery on two or more stocks with a fixed ratio of F's on the various species will fit a production model perfectly, the greatest combined yield obtained under this restriction may be much less than that obtained by allowing the ratio of the F's to vary. Intuitively it is obvious that the production of a multispecies fishery could be improved by controlling the fishery on each species individually, perhaps by deliberately 'overfishing' undesirable species, or underexploiting those low-valued species that are the food of more valuable species. The position giving the greatest combined yield is, however, of purely theoretical interest unless there is a practical possibility of making the required adjustment to the ratios of fishing mortalities. While it is certain that in no fishery is it possible to achieve all possible ratios (two species may be so mixed on the fishing grounds that they must inevitably undergo approximately equal fishing mortalities), it is almost equally certain that in any fishery it is possible to achieve some changes in the ratio. In principle this might be done by setting catch quotas for each species (or group of species) but the experience of this system, and the associated rules on incidental catches, in developed countries does not suggest that this would work well in tropical developing countries with many more species and, generally, weaker administrative structures. A system of graduated levies or grants, such that fishing on one species would be discouraged by imposing a tax or levy on each tonne landed, while other species for which heavier fishing was desirable would attract a grant or premium has theoretical advantages, and might be easier to enforce. However, it has not been applied in practice so far. For the present the best chance of adjusting the balance of effort between species in tropical demersal species would seem to be controls on the area or season of fishing or the type of gear or vessel used.

For any given fishery the number of alternatives is strictly limited. That is, the assessment problem, which in the simple approach deals with only one degree of freedom (total amount of fishing) and for a full multispecies assessment might have 100 degrees of freedom (the F for each of 100 species) may be reduced to perhaps three or four (total effort, timing of any closed season, location of any closed areas, and perhaps specification of type of gear). This is, at least in principle, a much more feasible task.

The normal stages involved in assessment and management might be largely reversed. Instead of making assessments of the effects of changing biological parameters (fishing mortality, size at first capture, etc.) and then considering what specific measures would have the necessary effects, the first stage might be to identify, in general terms, possible measures, and then make the assessment. Two types of identification would be needed. First, the biological data would have to be examined to see what groupings by areas/season/gear/vessel do give significant differences in species (or size) composition in the catches - unless there are differences, then controls will have no effect. Second, the operation of the fisheries and of the administration of fisheries should be examined to see what controls would be practical, in terms of such things as economic disruption to the fishermen, effectiveness of enforcement, etc. Only then need the actual assessments be made, when it can be known what combinations of fishing mortality on different species should be considered.

Protection of Special Interests

The commonest example of this type of management action are the measures taken to protect the interests of small-scale inshore fishermen against possible damage by larger enterprises. Possible interactions between different fisheries after the fish are landed are not considered here, though it must be recognized that if markets are limited, the development of an industrial fishery can reduce the prices received by the artisanal fishery – though conversely the industrial fishery may open new markets and improve prices all round. Equally, within the context of the present meeting, the problems of direct physical interference, e.g., the destruction of fixed gear by trawlers, will not be examined, though this is a major justification for restricting the activity of large vessels near the coast. The concern here is the possible impact of fishing by one group of fishermen (particularly larger industrial vessels) on the stocks of fish exploited by another group (particularly the smaller-scale fishermen). Though some indirect effects are possible, through one fishery reducing the stocks of species which interact with species that are exploited by another fishery, these effects are likely to be smaller than the direct effects, when both fisheries harvest the same species. Also the indirect effects are at least as likely to be favorable (reduction of predators or competitors) as harmful, and the main concern over possible effects is when they are, or are believed to be harmful. Thus the necessary scientific advice can be based largely on single species assessments.

Quantitatively the necessary assessments can be very simple. The policy-maker needs to know for example that introducing an offshore trawl fleet of 50 vessels will cause a significant reduction in the catches of an existing inshore fishery. However, he is not greatly concerned with the precise value of their reduction, i.e., he needs to know whether it is 50% or 5%, not whether it is 50% or 40%. The requirements for qualitative studies may be greater. While the assessments for each species can be quite simple and crude, careful attention has to be given to the exact species being assessed. Unless the two fisheries are operating on the same area (and possibly not even then), it cannot be assumed that they are exploiting the same species. In many families important to tropical demersal fisheries there are a number of similar species – some mainly found inshore, some mainly offshore, and some move between inshore and offshore. Unless the exact species composition is checked it can easily be assumed that because the two fisheries catch, say, many croakers, they must be exploiting the same stock. Also important is some knowledge of migration and dispersion. Little is known about the movements of most species of tropical demersal fish, and they may vary from being resident and localized to making movements over hundreds of miles. Without some knowledge, which might come from tagging, or from examining detailed seasonal information on distribution and size composition, it could be believed that developing an offshore fishery would have no effect on a coastal fishery 50 miles away, when in fact there was a rapid interchange of fish between the areas.

Development Planning

Action by governments to encourage the growth and development of their national fishery – obtaining loans from international development banks for new vessels, providing low-interest loans to fishermen, improving shore facilities such as cold stores, etc.—are probably much more important than the decisions concerning regulations of fishing effort, mesh size, etc. in determining the pattern of fishing, and its match with the optimum pattern as determined by national objectives. In the past many of these decisions were made with little reference to scientific evidence, other than an examination of current catch rates. There is now a growing recognition among many of the responsible organizations (regional development banks, etc.) that decisions to initiate or to expand a fishery should be preceded by analyses of the likely effects of the development on the abundance of the stocks and hence on the catch rates in the fishery concerned, and in any other fishery on the same or related stocks.

The simplest advice sought has been on the productive capacity of the stock – often expressed as a wish to know the "MSY" from the stock. This can be a dangerous over-simplification, especially when the scientific advice is interpreted as meaning that if the estimate of MSY is, say, 25,000 tonnes, and provided the projected total catch is less than 25,000 tonnes, then all will be well. Apart from the risk that the MSY might be overestimated, this attitude ignores all the changes in the stock, and in catch rates that occur as any fishery expands, and which become very important well before the MSY is reached. To be useful, and effective in preventing wrong development decisions, the biological advice must be comparable to that provided in planning management decisions. It also should be presented as early as possible in the process of planning development—all too often biologists are brought in too late, and are placed in the difficult position of objecting to an investment which most often has already been agreed upon.

Provision of development advice of this kind is both easier and more difficult than providing management advice. It is easier in the sense that less detail and reliability is required. Often it will be sufficient to know that a proposed investment will not raise the fishing effort to a level at which catch rates will drop unduly so that the investment can go ahead, or on the other hand that there are sufficient doubts about whether the resources can support additional investment, so that alternative uses for those investment funds can be sought. It is much more difficult in the sense that assessments are required of the effects of levels of fishing that have not so far been experienced, whereas management advice is usually concerned with predicting the effects of reducing effort to some level that has been experienced in the past. The latter difference becomes more significant in a multispecies fishery since the opportunities to depart from a simple extrapolation are greater. Where several fisheries, on different mixes of species occur, the expansion of one fishery may cause interaction between species (and hence between fisheries) which had previously been negligible, and undetected, to become significant and in need to be taken into account when deciding on development.

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Discussion of Dr. Gulland's Paper

Several participants noted that, in a given fishery, the value of the catch might not change in the same way as the total weight. In some fisheries, particularly in developed countries the aim of management is often to preserve some particularly desirable species or species mix. In most developing countries all species are acceptable on the market, though there are big differences in the prices received for different species. High-value species, including shrimp, may be worth ten or twenty times the trash fish (including small individuals of desirable species), which is most often used only for duck food or fish meal.

The problem of the incidental catches of fish in fisheries directed primarily at shrimp was raised as a special and urgent problem of multispecies management. The situation could be eased if it were possible to separate the exploitation of fish and shrimp. In many fisheries the high value of the shrimp catch effectively subsidizes the overexploitation of fish. However, in others it is only the presence of shrimp in the catch that allows for an economically viable exploitation of the fish.

It was pointed out that while changes in species composition can be expected as a result of exploitation, these need not always be in an undesirable direction. On the northwest shelf of Australia for example, it seems that the Taiwanese fishermen expected, and planned for, a shift in species composition towards the more valuable shrimp and squid.

It was agreed that the pattern of fishing can be as important as its total amount. Thus, for example, while there is generally little evidence from multispecies stocks of any decrease in total catch, even under extremely high levels of fishing, a drop could easily occur if fishing concentrated on very small fish. In Lake Victoria catches have fallen apparently because of intense seining of the breeding areas of tilapias. In this connection there was some discussion of the generally accepted rule that for most species of fish the smaller individuals are found inshore, and the larger ones in deeper water. While this rule is generally true, the distribution of juveniles of some of the tropical demersal species is unknown. On the northwest shelf of Australia, for example, a careful sampling of the inshore areas did not yield any juveniles of the main commercial species.

The question of the stability of unexploited stock was raised. It was stressed that there is no reason to expect that, in the absence of any interference by man, the stock should remain constant in total abundance or species composition. Some fluctuation may be expected and these could make interpretation of changes after the beginning of fishing difficult, especially since there is an obvious tendency for a fishery on a given stock or species to develop when it is particularly abundant.

The use of catch quotas as a method of controlling a fishery was raised. It was pointed out that though quotas are widely used in temperate waters, they have several disadvantages when applied to tropical areas. Few countries are in a position to enforce them; calculation of the appropriate quota for a short lived species whose abundance might be rapidly changing is difficult, and more especially single-species quotas in a multispecies fishery could lead to a highly undesirable situation; for example a quota on shrimp could lead to severe overexploitation of many fish species.

While there is some pessimism about the immediate possibilities of implementing and enforcing any restrictive management measure in most tropical areas, there are still many other opportunities for influencing the way in which the fisheries in these areas develop, especially if action is taken before a large overcapacity has grown up.