SCRS/1973/062 (COM/1973/023) Col.Vol.Sci.Pap. ICCAT, 2: 116-125 (1974)

SOME GENERAL CONSIDERATIONS OF METHODS OF CONTROLLING THE AMOUNT OF FISHING

by

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SUMMARY

The paper discusses the general problems that have to be considered when setting regulations to control the amount of fishing. The first important step is to determine the objective of the regulation. Usually this will include a combination of biological and economic factors, and will be expressed as the attainment of a certain position on a curve relating yield to fishing mortality.

The fishing mortality is not easily measured directly, but is estimated from one or other of the more readily observed quantities of fishing effort or catch. The relation between mortality and effort will vary with the value of the catchability coefficient q, which is in turn determined by the efficiency of the fishery units concerned, the distribution of fish etc. The relation between catch and mortality depends on the abundance of the stock. Which of catch or effort measures fishing mortality the better depends on the type and nature predictability of the variations of catchability coefficient, and abundance.

Whichever measure is used, the actual control can be achieved either by a single quota - with free fishing until the limit is reached - or by some system of allocation. Though both will have the same biological consequences, the economic implication of the two systems can be substantially different.

RESUME

Le présent rapport fait état des problèmes généraux dont il faut tenir compte lors de l'établissement de réglementations visant à contrôler le volume de la pêche. Il faut tout d'abord, ce qui est important, définir le but visé par la réglementation. Ceci met généralement en jeu un ensemble de facteurs biologiques et économiques, et est représenté en termes d'une certaine position atteinte sur une courbe mettant en rapport le rendement et la mortalité due à la pêche.

Il n'est pas aisé de calculer directement la mortalité due à la pêche, mais on peut l'estimer à partir de l'une quelconque des valeurs de l'effort de pêche ou de la capture les plus évidentes. La relation entre la mortalité et l'effort variera suivant la valeur du coefficient q de disponibilité, qui est pour sa part déterminé par le degré d'efficacité des unités de pêche en jeu, de la répartition du poisson, etc. La relation entre la capture et la mortalité dépend de l'abondance du stock. Le degré de précision possible des variations du coefficient de disponibilité, ainsi que l'abondance, déterminent celui des deux éléments, capture ou effort, qui permet de mesurer plus exactement la mortalité due à la pêche.

Quelle que soit l'unité de mesure employée, le contrôle proprement dit peut être appliqué au moyen d'un quota unique - avec pêche libre à concurrence de la limite établie - ou à travers un système d'assignations. Bien que les deux méthodes entraînent les mêmes conséquences biologiques, leurs répercussions économiques pourraient différer sensiblement.

RESUMEN

El documento trata de los problemas generales que han de ser considerados a la hora de establecer unas regulaciones para el control del volumen de pesca. El primer paso importante es determinar el objetivo de la regulación. Este objetivo, por lo general, es la consecuencia de una combinación de factores biológicos y económicos, y será expresado mediante una cierta posición en una curva que ponga en correlación el rendimiento con la mortalidad de pesca.

No es fácil de medir la mortalidad de pesca directamente, pero se puede estimar a partir de alguna de las cantidades más fácilmente observadas de esfuerzo pesquero o captura. La relación entre mortalidad y esfuerzo variará con el valor del coeficiente de posibilidad de captura q, que a su vez es determinado por la eficacia de las unidades pesqueras interesadas, la distribución de los peces, etc. La relación entre captura y mortalidad depende de la abundancia del stock. La mortalidad de pesca se mide por la captura o el esfuerzo y depende de la posibilidad de predecir la naturaleza de las variaciones del coeficiente de posibilidad de captura, y la abundancia.

Cualquiera que sea la medida utilizada, el control real puede lograrse bien sea mediante un cupo de capturas único - con libertad de pesca hasta alcanzar el límite - o bien por algún sistema de asignación de cupos. Aunque ambos tendrán las mismas consecuencias biológicas, las implicaciones económicas de los dos sistemas pueden ser sustancialmente diferentes.

Introduction

The present note has been prepared to provide some background material, and basis for discussion, for the ICCAT Working Group on Yellowfin. No attempt has been made to go into the subject in as much detail as has been done in other documents (e.g. some of those of ICNAF). The intention is rather to outline the major points. In addition, since most of the detailed studies have been made with reference to cod or other long-lived demersal species, mention is made here of special considerations appropriate to tuna.

Objectives

The objectives of controlling the amount of fishing are best seen with reference to the curves relating the total catch (and the catch per unit effort) to the amount of fishing (Figure 1; see also Figure 1 of the 1972 report of the Standing Committee on Research and Statistics, p.50 of the 1972 Council proceedings). In general discussion these curves are often referred to as relating catch to the "amount of fishing", or "fishing effort". It should be stressed that strictly these curves are derived from the biological characteristics of the stock, and that therefore the quantity along the x-axis is the fishing mortality (or fishing mortality coefficient) i.e. the proportion of the stock that is caught per unit time. Usually the distinction is not important, and the curves relating catch to fishing effort will have the same form. The distinction can be important when the objective of management is to ensure that the fishery is kept at or moved to a particular point or region on the curve.

The catch-fishing mortality curve for yellowfin and the present position of the fishery on this curve, are not known precisely, as is shown by the variety of alternatives given in Figure 1 of the 1972 SCRS report, although there is no doubt that the fishery has reached the point at which further increases in fishing mortality will give little or no increase in sustained yield, and may cause a substantial decrease. If the yield curve has a sharp peak, as in the case of the "Generalized model" of the SCRS Figure 1 (broken line) it is most important that the fishing mortality be kept close to the value giving the maximum sustained yield (for economic reasons it may be desired to exert a slightly lower fishing mortality, but the difference is not great). Alternatively, the yield curve may be flatter, with no marked peak. The yield per recruit curve shown in the SCRS figure (crosses) is probably extreme, and a curve that is less improbable as the true relation between fishing mortality and yield in the Atlantic yellowfin is shown in Figure 1 (full line). This curve is fairly flat, which has two important consequences. First it is in practice difficult to determine the precise value of the fishing mortality that corresponds to the maximum in the yield curve. Second, the main differences between fisheries exerting different mortalities over the range are in the input (mortality, effort and costs) rather than output (catch in weight or value). If the biological background to the fishery is well described by this curve, the objective in terms of the chosen value of the fishing mortality is likely to be to exert a mortality towards the left shoulder of the curve, ie where the yield is high, though not necessarily a maximum, and where the mortality (and hence potentially the costs) is moderately low. Another important reason for preforming the left hand shoulder, rather than the estimated position of the absolute maximum is to minimize risk. Even when the population dynamics of a fish stock are believed to be well understood - and this is far from being the case for the Atlantic yellowfin tuna - the actual events in the stock may differ from what is expected. For example, though it may appear from all available evidence that the maximum sustainable yield will be taken at quite high fishing rates, these high rates might possibly weaken the ability of the stock to withstand unusual environmental conditions and lead to a sharp fall in stock and catch. This risk of instability and possible sustained declines in the stock cannot be quantified, but may be real, and will certainly be reduced at lower values of fishing mortality.

In brief, therefore, the objective of the Commission, in setting controls on the amount of fishing, will, so far as the effect on the stock is concerned, be to maintain the fishing mortality at some specified value. This value will be chosen on a combination of the maintainence of a high yield, reduction of the risk of unexpected disasters, and opportunities for reductions in cost. Acceptance of the third point implies also that the implementation of the control of fishing mortality should allow the chosen mortality to be achieved efficiently, at a low cost even if not necessarily at minimum costs.

To achieve the desired level of mortality two decisions need to be taken - how to measure the mortality (either by catch or by effort) and how to impose a limit (either by allowing free fishing by all participants, up to a certain date, or by allowing fishing for all or most of the year by a limited number of participants).

Measurement of mortality

Since fishing mortality cannot be measured or recorded directly some other quantity that can be observed and controlled must be used as an indirect measure. The catch, and some index of fishing effort (number of vessels, total days spent on the fishing grounds) are those most commonly used. As the relation between the chosen measure and the fishing mortality will not be exact, account should be taken of the results of failure to achieve the target fishery mortality. These errors may be of several types - random errors affecting all participants (countries, users of different gear, etc.) equally; random errors affecting participants differentially, and long-term trends affecting some or all participants. The basic equations describing the relations between mortality and catch or effort are:

for effort $F = qf$ .....(1)

or $F_i = q_i f_i$ .....(2)

where F = fishing mortality

q = catchability coefficient

f = fishing effort

and the subscript i describes the mortality and effort exerted by a particular segment of the fishery e.g. French bait-boats

and for catch

$F = C/\bar{B}$ .....(3)

or $F_i = C_i/B$ .....(4)

where C = catch in weight

$\bar{B}$ = average population size (biomass) during the year

The success of control of effort or catch in achieving a target level of mortality therefore depends on the degree to which the catchability or population biomass varies. The similarity between the two paris of equations are obvious, though it may be noted that whereas in (2) q_i is different for each gear or other segment of the fishery, $\bar{B}$ is the same for all. (Strictly the value of $\bar{B}$ to be used for a particular gear is obtained as the weighted average population throughout the year, weighted in accordance with the catch taken in each period. The difference will only be important if there are big changes in true population size during the year, and big differences in the seasonal distribution of catches by different gears.)

The other difference between the equations is that the catchability coefficient q is unaffected by the values of f or F, so that, for a particular year and a particular gear, the relation between the two is directly proportional. The average biomass $\bar{B}$ is affected by the amount of fishing, so that there will, in a given year, be a curvilinear relation between catch and mortality.

Effort as a measure of mortality

The immediate practical problem in controlling mortality through effort in the yellowfin fishery is the determination of the appropriate values of q_i, the catchability coefficient for each gear. Though a number of theoretical methods for comparing the relative efforts - in effect the catchability coefficients - of different gears have been discussed, based for example on the size of nets used, the only way that seems practicable for the yellowfin fishery at present is by considering the relative catches by the different gears in some base year or years. This is therefore to some extent control by catch rather than by effort and if there were no changes in the system there would be no difference. Changes in population between the base period and the year in which management measures are to be introduced will not affect the mortality exerted, but changes in catchability during this period will be important.

Some changes, of a random and transient nature, can be expected from year-to-year changes in natural factors - ocean currents, etc. - which may make the fish particularly accessible, to, for example, small purse-seiners operating off the Ivory Coast. This is not serious, except in so far as all gears are unlikely to be affected equally.

More serious problems can arise from the strong incentive to increase the catchability i.e. the mortality caused by a nominal unit of gear e.g. a day on the grounds of a given size-class of purse-seiner. Economically justified improvements are of course desirable, and should not be discouraged by the management system, but unless adjustments are made to the target level of nominal effort the target fishing mortality will be exceeded. Further, unless each group of fishermen improves their efficiency to the same extent their relative shares of the total catch will change. In a multi-national fishery this may not be acceptable for more than a short period, and could probably require regular re-calculation of the effort units on the basis of relative catches.

Catch as a measure of mortality

The use of catch as a measure of mortality avoids most of the problems of comparison between countries. Apart from the non-negligible question of conversion from landed weight (whole, gutted, gutted heads off, etc.) a ton of fish is the same anywhere. Difficulties arise because the catch does not bear a constant proportional relation to the mortality caused. Within any one year the relation between catch and mortality will be a curved line similar to those shown in Figure 2. This has been drawn on the supposition that the fishery has been, for some time, in the state indicated by point A in Figure 1. Because heavy fishing will reduce the stock the line curves

downwards, but not to the same extent as in the long-term relations shown in Figure 1 (For a fish such as the yellowfin, which may remain in the fishery for two or three years, one year is not long enough for the full effects of different levels of fishing to be apparent, in addition there may be longer-term effects on recruitment.) Equally if fishing is reduced, the catch will be greater than expected by the relative decrease in fishing mortality, but will be less than the long-term catch from that mortality.

Though the Atlantic yellowfin stock is not as highly variable as some other stocks, there are distinct variations in year-class strength (poor in 1967, 1968, good in 1969). Due to these, and other environmental factors, as well as to possible variation in fishing (e.g. a regulation to reduce the amount of fishing) there will be year to year changes in abundance. This means that the catch quota for each year will probable have to be modified in accordance with the expected population abundance (cf the lines in Figure 2 for high and low stocks). Annual modifications may not be essential if the variations in stock are not large, and if the effects on the stock of variations in fishing mortality about the target level are not significant (i.e. if the yield curve is of the flat-topped type in Figure 1, rather than sharply peaked).

Unless these conditions are satisfied, annual adjustments to the target catch will be needed, and in any case regular adjustment must be done, even if not done annually. These adjustments require estimates or forecasts of the stock abundance in the forthcoming period. Fortunately small yellowfin appear in the catches, particularly of some gears, e.g. bait-boats, at least a year before they make their biggest contribution to the catches as a whole. Thus some prediction can be made of at least the more drastic fluctuations in abundance, from the detailed examination of the size, and quantities of fish caught, and this may be sufficient for an initial, first order, control of fishing mortality through control of catch. However, if this measure of mortality is adopted, considerable study will be required into the best method of getting early and accurate predictions of stock abundance.

Method of control

Whatever measure of mortality is used, once the target value of mortality - and hence of catch (or effort) - has been decided, then there is a choice of methods of ensuring that this target value is not exceeded. The main choice is between the basic I-ATTC scheme - free fishing until the limit is reached, with thereafter no fishing, and the ICNAF scheme - division of the total between participants. There are potentially a number of other methods - closed areas, predetermined close season, set without explicit reference to a particular target figure of catch or effort, restrictions on the type of gear used etc. These are generally only successful in limiting the fishing mortality to the extent that they reduce the efficiency of the fishery. They are therefore not usually desirable except when reduction in fishing mortality will give a clear increase in total yield, i.e. when the catch-effort curve has a pronounced peak, and the present position of the fishery is well to the right of the peak. This is not the present position of the Atlantic yellowfin fishery.

The I-ATTC, single quota system raises two immediate, and one longer-term difficulty. One immediate problem is to determine sufficiently quickly the mortality that has been caused (i.e. the catches taken or the effort expended), or will have been caused up to some future date, so that the closing date can be set with adequate precision. This means that (taking, for simplicity, catch as a measure of mortality, though the remarks apply with at least equal strength to an effort quota) information on the total catch must be available in Madrid with a delay of not more than a week.

The present ICCAT statistical system does not approach this level of timeliness. At their meetings in November the Research and Statistics Committee has statistics of the previous year that are (after more than ten months) in some ways still incomplete. The problem is not insoluble. I-ATTC gets up-to-date reports. The number of vessels fishing yellowfin in the Atlantic is not very large. It could however need some work at the national level to ensure the prompt reporting to ICCAT, and some strengthening of the secretariat to enable them to handle the reports.

The other immediate problem concerns the balance between countries. As pointed out in the 1972 SCRS report (paragraphs 78-80) the seasonal pattern of fishing is not the same for all countries. Therefore a single-quota system, with the consequent closed season, will affect countries differentially, depending on the timing of the closed season, i.e. the choice of starting date for calculating catch. Also countries differ in the extent to which they can alter the seasonal pattern of their fishery e.g. by bringing vessels into the Atlantic yellowfin fishery during the open season.

This means that a single, unallocated, quota for all its apparent simplicity is not in practice a non-discriminatory measure applying equally to all participants. Of course few if any measures (including for example size-limits) are entirely non-discriminatory, and some degree of discrimination may be positively desired. For example, the Indian Ocean Fishery Commission recommended, in relation to the tuna fisheries of that ocean, that management measures should "afford the opportunity to countries not yet significantly participating in Indian Ocean tuna fisheries to build up their fishery industry within a reasonable period to associate themselves effectively with programmes of rational utilization on a basis of equality". (It was implicit in those discussions that the countries concerned were the developing countries bordering the Indian Ocean.) ICCAT may or may not decide to give some preference to certain developing countries, but if it does so, it will certainly wish to do so consciously, knowing with reasonable accuracy the degree of preference being given. In relation to a single-quota scheme this implies a careful examination of the results of introducing such a scheme, with various opening dates, on the balance of catches between countries.

The long-term disadvantage of a single-quota scheme is economic. There is no direct control of the size or capacity of the fleet, which will increase

as each participant tries to maximize his share of the quota. This leads to a continuous shrinking of the season, and highly inefficient operations unless there are alternative uses for the vessels. In the medium term this may not be harmful, and may even be positively beneficial. For example the I-ATTC rules encouraged fishing to the westward of the traditional grounds, and (though this is less certain in view of the smaller distance, and hence smaller probability of eastern and western stocks being independent) a quota by ICCAT restricted to the eastern Atlantic could encourage fishing on what might be an under-exploited western stock. However, this expansion cannot continue long, and there is general agreement that, except for skipjack, the limits of tuna resources are being approached. Though the long-term difficulties of unrestricted capacity are mainly economic, the particular method of control used by I-ATTC can incur problems as the carrying capacity of the fleet approaches the allowable quota.

Allocating

These problems are largely removed by allocation to individual countries, though new problems are raised. The need for rapid statistical reporting becomes less urgent, but the need for accuracy, and confidence in, national reports of catches is increased. The degree of preference or otherwise given to each country becomes more explicit, though the need for an explicit decision on the shares or preferences for each country may make agreement on this more difficult. Finally, national allocations reduce the economic problems of harvesting a given quantity by removing them from the international to the national scene. This does not solve them, and for some countries, with for example constitutional objections to limiting access to fisheries, the problem may not be solved. However, with allocation, the absence of a solution in one country does not impede the ability of any other country to devise means of catching its share in the most efficient manner.

Discussion

Any method to control the fishing mortality on Atlantic yellowfin raises significant problems, and the choice of method, and the means to overcome the problems incurred with that method will need careful study by ICCAT and member countries.

Examination of trends in other commissions, e.g. ICNAF, suggest that the method that may be chosen could be national allocation of a catch quota. This would seem to offer good chances of realizing most of the economic benefits that can arise from management. At the same time two major problems need to be tackled - agreement on allocation, and less obvious but equally vital, improvement in national statistics so that national reports of yellowfin catches are on time, correct and seen and accepted to be correct. It is not the intent of this note to discuss principles that might be followed in making

allocations . These have been discussed at length by ICNAF and other bodies. Any allocation of a yellowfin quota would presumably have to take some account, inter alia, of present and past shares of the catch, any special interests of current participants and interests of new participants including non-members of ICCAT, possibly due to the transfer of vessels from countries already engaged in the yellowfin fishery.

Figure Legends

Figure 1 (above) Possible sustained (steady state) relations between fishing mortality and catch or catch per unit effort in the Atlantic yellowfin.

Figure 2 (below) Relation between the fishing mortality exerted in one year and the catch taken during that year, for different initial stock sizes.

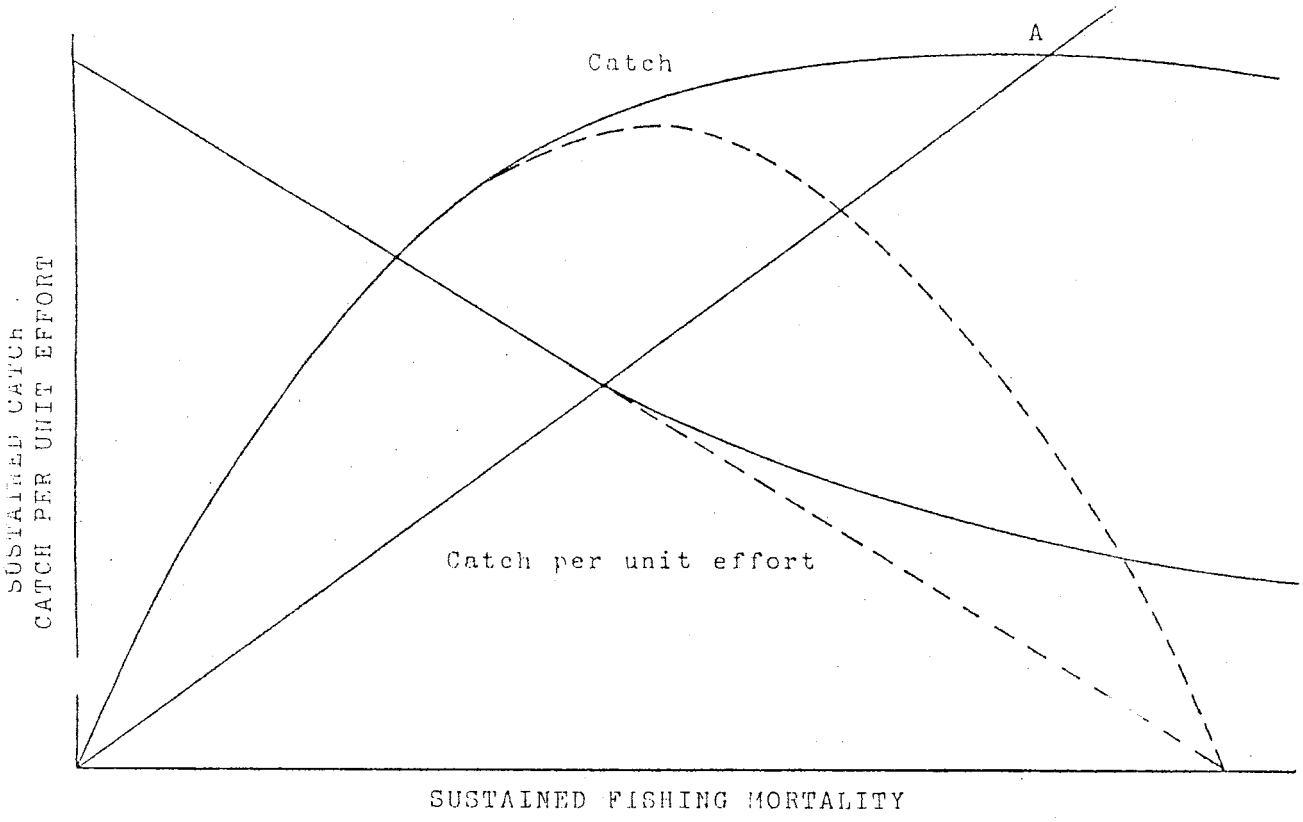
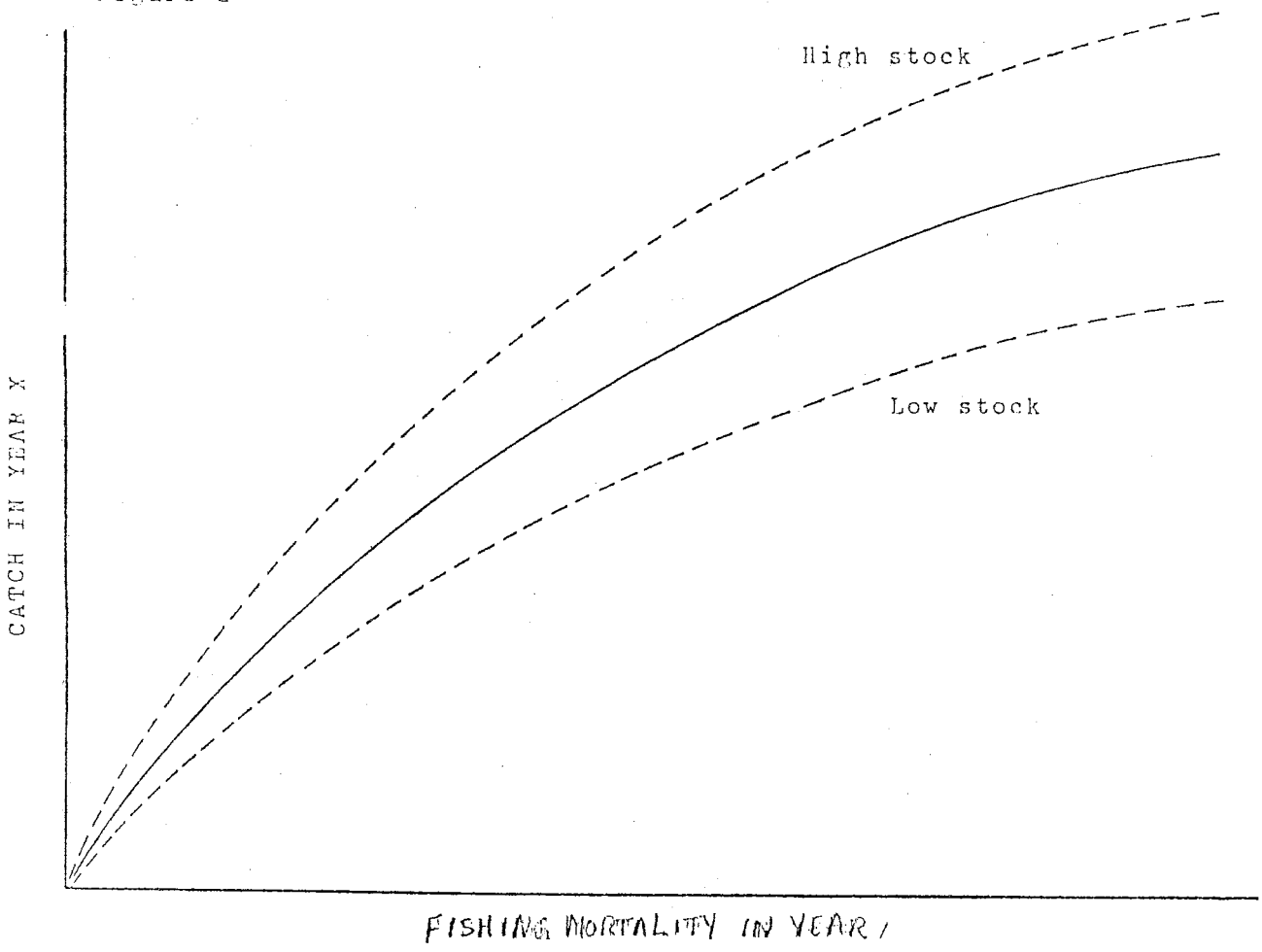

A
Catch
Catch per unit effort
SUSTAINED CATCH
CATCH PER UNIT EFFORT
SUSTAINED FISHING MORTALITY

Figure 2


High stock
Low stock
CATCH IN YEAR X
FISHING MORTALITY IN YEAR /