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DISCUSSION AND CONCLUSIONS OF THE SYMPOSIUM ON THE BIOLOGICAL BASIS OF PELAGIC FISH STOCK MANAGEMENT

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As stated in the Introduction the final session of the symposium was devoted to the presentation and discussion of a document prepared by the Planning Group, which attempted to summarize the salient points which might be drawn from the papers presented and from the critical examination of them. This paper is largely based on that document, modified to some extent by the very constructive discussion which ensued from it.

HISTORICAL REVIEWS OF EVENTS LEADING TO DEPLETION OF PELAGIC STOCKS

Perhaps the most striking conclusion to be drawn from the papers which review the development of the pelagic fisheries is that there are few pelagic stocks left in the world's oceans which have been subjected to modern fishing technology, whose current state does not give cause for alarm; for a large number it has been necessary to advise a complete prohibition of directed fishing. In all of these heavily depleted stocks the events preceding the collapse show similar features: a sharp increase in catches over a few years, followed by an even more rapid decline, resulting in either a complete cessation of fishing, or a very low level of catches below that at which the initial escalation started. In most cases the rate of decline has been augmented, in the final stages, by recruitment failure. These features are clearly evident in the papers in this volume by Dragesund, Hamre, and Ulltang; Jakobsson; Anderson and Paciorkowski; Saville and Bailey; and Molloy, amongst others. The major exception to this course of events may be the Atlantic menhaden (Schaaf, this volume), which would appear to have shown rather greater resilience to excessive fishing.

Although there are instances of demersal stocks which have reacted similarly to heavy fishing pressure, such as haddock on Georges Bank, these have been few relative to the frequency of collapse in pelagic stocks; nor would it appear that this difference in the incidence of stock collapse merely reflects differences in the fishing pressure on the two categories. North sea cod and haddock have for several years been subjected to exploitation rates and patterns similar to those which caused collapse of the North Sea and Celtic Sea herring stocks.

In some instances environmental changes may have played a part in the decline of the pelagic stocks considered in this volume, for example Japanese sardine (Kondo, this volume), but generally their influence would appear to have been minor compared with the effects of the fisheries. It has long been known that year-class strength fluctuates in response to environmental changes; the scientific advisory system must therefore be prepared to diagnose a declining trend in recruitment in good time, and advise accordingly. The management bodies must react to this advice quickly if fish stock management is to be effective. Too often the response from both parties has been to admit that the stock is declining due to reduced recruitment, allied with the maintenance of a high exploitation rate, but to postpone advising, or taking, appropriate action in the hope that a strong year class will appear in the near future. Nature is not noted for its magnanimity to the improvident!

FEATURES PECULIAR TO PELAGIC STOCKS WHICH MAY EXPLAIN THEIR VULNERABILITY TO FISHING

In the light of what has been said above regarding the higher incidence of collapse in pelagic fisheries it would seem necessary to look for factors in the reproductive biology, the ecology, or the behaviour of pelagic species which might explain their lesser resilience to fishing pressure. From the papers presented in this volume and from the discussion during the symposium the following features of pelagic fish behaviour and ecology would appear to be contributory factors of some importance in this context.

(a) There is strong evidence that as stock size decreases in pelagic fish the catchability coefficient increases; that with decreasing stock size a unit of fishing effort catches an increasing proportion of the residual stock. This is a logical outcome of the tight schooling behaviour of most pelagic species and of modern fishing technology. As the stock decreases so does the area over which it is distributed, but shoal size is probably maintained at much the same level (Ulltang; Pope; Saville and Bailey; this volume). With modern intership communication and fish-finding aids a reduced fleet can very quickly locate what remains, even of a heavily depleted stock, and take virtually the same catch from it on a time-fishing basis as from a much higher stock level. Thus a reduced nominal fishing effort can maintain, or even increase, the exploitation rate on a reduced stock. This would seem a likely explanation of the failure of major closed periods for herring fishing in the North Sea in 1971 and 1972 to have had any measurable effect in reducing the fishing mortality rate on this stock. Similarly, the events in the southern North Sea herring fisheries in the early 1960s, when the Downs stock did not recover after an apparent drastic decline in fishing effort, could be explained in the same way. The pattern may also be observed in Peruvian anchoveta where the effect of El Niño phenomena was not only to reduce the exploitable stock, by their adverse influence on recruitment, but also to confine this reduced stock to a smaller area, with a concomitant increase in the catchability coefficient (Csirke, this volume).

(b) The ratio of production to stock biomass is probably lower in pelagic fish than in most demersal ones. This is likely to result in their being more susceptible to collapse under excessive fishing pressure than demersal species, and would imply that they should be exploited at a lower rate.

(c) It also seems likely that the left-hand limb of the stock-recruitment curve in demersal species is steeper than in pelagic ones, which would suggest that demersal species can be subjected to a higher exploitation rate, and/or an exploitation pattern which catches a higher proportion of the stock prior to the age of first spawning for a longer period before a stock-recruitment relationship becomes established, although the resultant decline would then be more rapid.

It is also likely that stock depletion, because of its effects in reducing both the age spread in the spawning population and its distributional area, would in turn reduce both the geographic spread and range in time of larval production. This in turn would adversely affect the probability of the resulting larvae's encountering favourable environmental conditions and increase the chances of recruitment failure. There is firm evidence of a major reduction in the range of spawning sites used by North Sea herring since the stock declined (Postuma, Saville, and Wood; 1977); similar evidence may be inferred from Dragesund, Hamre, and Ulltang; and Anthony and Waring (this volume).

(d) It is possible that analogously to the mechanism noted above by which a depleted pelagic stock becomes more vulnerable to fishing, a constant stock of predators may also be capable of inflicting an increased level of predation on a depleted stock, resulting in a higher natural mortality rate. Unfortunately not enough is known about the feeding behaviour of the major predators on pelagic fish species to test and quantify this; but the paper by Laevastu and Favorite (this volume) would stress the potential importance of predator pressure if this were so.

REPLACEMENT OF DEPLETED STOCKS

It has frequently been inferred, for many parts of the oceans, that as pelagic stocks have been badly depleted their place has been taken by another species. Were this so it would be of considerable importance in the management context, both in relation to the steps which might be necessary to rebuild the depleted stock and indeed in deciding whether rebuilding were either necessary or desirable. It was therefore of some importance to review the evidence of the reality of the reported cases of "replacement". The paper by Daan (this volume) would suggest that, on any reasonably firm biological criteria, there are few, if any, instances of another fish species' filling the ecological niche vacated by a depleted stock. The question, however, must continue to be one of some importance. As pointed out by Dragesund, Hamre, and Ulltang (this volume) Atlanto-Scandian herring were formerly the main consumers of secondary production in the Northeast Atlantic and there must have been similar drastic changes in ecology in other areas where major pelagic stocks have been reduced to very low levels. It is therefore of considerable importance to know how the food they formerly consumed is now being utilized.

FACTORS WHICH HAVE INFLUENCED THE EFFECTIVENESS OF PAST ASSESSMENTS AND WHICH MUST BE TAKEN INTO ACCOUNT IN FUTURE

It would appear that for several of the stocks discussed in this volume the process of depletion has been a fairly long-term one and that the symptoms of it were diagnosed well before any effective management action was taken. The scientific advice provided to management bodies must shoulder some of the responsibility for this. For too long the major criterion governing management advice appears to have been the maximum sustainable yield per recruit on the current exploitation pattern, without any serious attempt to investigate either the repercussions of the exploitation pattern or the exploitation rate on the likely sustainable total yields (Sætersdal; Dragesund, Hamre, and Ulltang; Saville and Bailey; this volume). The inevitable effect of this delay in applying more stringent criteria in formulating management advice was that effective action, when it was advised, demanded major sacrifices in yield, measured against immediately preceding years, and not surprisingly it was difficult to persuade management bodies to accept them as being essential to recovery of the stock.

More recently, after it was widely accepted that maximum yield per recruit for most pelagic stocks was an untenable management criterion, the deficiencies of management advice have mainly arisen from overestimation of stock size (or associated underestimation of the fishing mortality rate), in the last year for which catch data were available. The papers in this volume by Ulltang and by Pope would supply some explanation of the rather consistent tendency towards overestimation, where assessments of the terminal F were estimates of, or subjective judgements of changes in, nominal effort over the preceding few years. It would now seem apparent that nominal effort cannot be utilized in estimating terminal Fs for the majority of pelagic stocks. It is essential, therefore, for reliable assessment of the current state of stocks, and for prediction of future TACs, that much more effort be devoted to investigating the practicability of obtaining alternative measures of stock size and/or terminal F from sources independent of direct data from the fisheries. Possible approaches to this problem, such as acoustic surveys (Jakobsson), egg or larval surveys (Saville and Bailey; Lett), research-vessel surveys (Anderson and Paciorkowski; Anthony and Waring), and tagging experiments (Dragesund, Hamre, and Ulltang) are discussed in various papers in this volume. It would seem unlikely that a "best" method can be specified for all situations. Each approach should be critically examined in relation to the conditions applying to the stock under consideration. It should also be appreciated that where a zero TAC applies, such fishery data independent estimates are the only way to monitor stock recovery and to advise on when fishing can be resumed, and at what level of catch. If such methods are not applied until the fishery is stopped, it is very difficult to evaluate the resulting estimates and to ascribe confidence limits to them. It would seem highly desirable therefore to start making such estimates as early as possible so that they can be monitored against reasonably reliable estimates which have been, or can in due course be, obtained from Virtual Population Analyses.

In heavily exploited long-lived species, and in all cases for short-lived species, the predicted yield is very dependent on the estimated recruitment in the year in question (Bailey, this volume). The papers presented in this volume would suggest that over-optimistic assumptions about future recruitment to the exploited stock have been a major factor in stock depletion in many of the cases reviewed here (see Molloy; Saville and Bailey; Anthony and Waring; Anderson and Paciorkowski).

This situation would be considerably improved by reducing the proportion of the yield contributed by young fish, which in many cases would also appreciably increase the yield from the stock. The major effect in this context, however, would be that the year classes would be available for a longer period, during which their strength could be estimated more precisely before they made a major contribution to the total allowable catch. Even under these circumstances, however, more accurate estimates of the strength of recruiting year classes are, and will continue to be, badly needed.

In many cases research-vessel fishing surveys are carried out to supply estimates of year-class strength of juvenile fish before they recruit to the exploited stock; but in many cases no such estimates are available, and in most cases those that are have rather wide confidence limits on the predicted recruitment strength. Much more work is needed on this aspect, both in getting such estimates for those stocks for which they are not currently available and in refining those estimates which are. Where no method of estimating recruitment is currently available it might also be appropriate to adopt a more cautious assumption than that recruitment will be the mean for some previous period – particularly if the mean has very wide confidence limits or the spawning stock has declined appreciably from the level that applied during the period when the mean recruitment was measured.

In all cases considered during the symposium there is strong positive, or presumptive, evidence that the stock collapse was, in the final analysis, due to reduced recruitment, generated by a decline in spawning stock (see for example Jakobsson; Dragesund, Hamre, and Ulltang; Saville and Bailey). It would therefore seem evident that the first consideration in advising on stock management must be the maintenance of the spawning stock above a level at which there is a serious danger of development of a stock-recruitment relationship. Unfortunately this danger level can be specified with any degree of precision for relatively few stocks. This matter must be given much closer consideration, as it is absolutely critical to the whole management policy; but in the interim a very conservative policy should be adopted in advocating any management which might result in further reduction of the spawning stock size.

Adopting such a conservative policy may well result in short-term loss of yield and disruption of fishing activity. But this sacrifice seems worth making when one considers the draconian measures necessary, over a long period, to rebuild a stock once a clear-cut stock-recruitment relationship has been established.

Finally, on this topic, it would appear that stocks at, or near, the distributional range of the species may be liable to greater variability in year-class strength and hence also in stock size (Jakobsson; Dragesund, Hamre, and Ulltang; this volume). This must result in such stocks' being more vulnerable to excessive fishing pressure, and management policy in these cases should be based on a lower exploitation rate than might be considered appropriate under other circumstances. Management bodies should then also be prepared to react quickly in further reducing fishing at the first signs of any adverse trend in environmental conditions. But in many long-lived pelagic species, which are not so obviously living near the limits of the distributional range for the species, for example North Sea mackerel (Hamre, this volume), the normal pattern would appear to be recruitment of very large year classes at long intervals with rather poor recruitment in intervening years. In such cases a rather low exploitation rate would also be appropriate – particularly since the recruitment of such strong year classes is, in itself, liable to attract additional fishing effort to the fishery. The policy should be to manage with an exploitation rate which will ensure that these strong year classes will continue to make an appreciable contribution to the spawning stock over a time interval equal to that which normally separates strong year classes. Under these conditions, when favourable circumstances again occur for reproduction there is a high probability that the spawning stock will be large enough to take advantage of them.

It must also be appreciated by management bodies that such recruitment patterns, of very strong year classes at long intervals with intervening periods of poor recruitment, make it very difficult for the scientists to distinguish between natural recruitment variation and recruitment failure induced by a too-small parental stock. Great caution should therefore be exercised in exploiting such stocks if the time interval since the last strong year class is longer than normal.

LESSONS TO BE LEARNT BY MANAGEMENT BODIES

Although, as has been commented on in the section above, scientific advisory bodies cannot be absolved of all blame for the present state of the majority of pelagic stocks, it is also clear from the papers presented in this volume that management action, even on receipt of satisfactory management advice, has in most cases been too little and too late. This may have resulted from the form in which the advice was given, which frequently implied some hesitation in formulating it. This hesitation was induced by the rapid development of the fisheries and inadequate information on catch levels and their compositions. Moreover it is likely that the somewhat timorous approach adopted by the scientific community during much of the history of many of these stock collapses was largely conditioned by the realization that more stringent advice would result in its rejection and simply engender delay in taking any action whilst further assessments were made. Such a reaction to past experience is understandable, if difficult to justify in terms of scientific responsibility.

In the light of what has been said above concerning the problems of pelagic fish stock assessment and management, however, it is clear that better management of these resources will demand a more effective dialogue between the scientific advisory and the management bodies, and a much greater readiness on the part of the latter to react quickly to advice, particularly in situations of adverse, unpredictable environmental changes. It should be clearly understood that any appreciable delay in reacting can only result in the necessary corrective action being more severe and unpalatable if it is to achieve the objective.

Management bodies must also accept that in any fishery, but most particularly perhaps in the case of pelagic fisheries, a stable situation is a completely hypothetical concept, and any prognosis of yield will be subject to rather wide confidence limits even when the prediction has an adequate basis of scientific research and the time between making the prediction and the period to which it applies is small. Under these circumstances, to ask for scientific advice on stock sizes and total allowable catches for a period more than one year in advance is unrealistic; the answers given can then be indicative only of likely trends and cannot be of the degree of precision required for taking firm management action.

In several of the stocks discussed in this volume there is now evidence of some recovery from a badly depleted state after a period of very severe restrictions on the fisheries (Jakobsson; Hourston; this volume). In these cases, and in other stocks where fishing has had to be prohibited owing to severe stock depletion, it would seem advisable to exercise great caution in permitting a resumption of fishing, and then initially only at a very low exploitation rate if the recovery is not to be halted, or possibly even reversed. During the initial stages of recovery stocks are likely to be very vulnerable to fishing and to have a lesser degree of stability than under normal circumstances.

As experience throughout the world during the last two decades has shown, graphically illustrated by the papers in this volume, pelagic stocks are more susceptible to collapse under excessive fishing pressure than demersal ones, so management bodies must accept that it is imperative that they be exploited at a relatively low rate of fishing mortality. This management policy would not only be a safeguard against future collapse of these stocks, but would also reduce the likelihood of excessive fluctuations in catch and the need for frequent radical changes in management action.

REFERENCE

Postuma, K. H., Saville, A., and Wood, R. J. 1977. Herring spawning grounds in the North Sea. Coop. Res. Rep. Cons. int. Explor. Mer, 61: 1–15.