EFFECTS OF ENVIRONMENTAL FACTORS AND
FISHING ON STOCKS OF BRITISH COLUMBIA HERRING

Prepared
By The
Fisheries Research Board of Canada
Biological Station, Nanaimo, B. C.

For Presentation To
The Scientific Sub-Committee
of
The Ad Hoc Committee on Abstention
INPFC

October, 1970
EFFECTS OF ENVIRONMENTAL FACTORS AND FISHING ON STOCKS OF BRITISH COLUMBIA HERRING

At the 1969 meeting of the Ad Hoc Committee on Abstention the Japanese National Section presented comments (Doc. 1250) on a review of the British Columbia herring fishery, research results and management actions during the period 1955-1967 (Doc. 996). In essence the Japanese remarks consisted of (i) a conviction that recent regulatory measures lacked scientific basis, (ii) criticism of assumptions respecting the analysis of stock-recruitment relationships and (iii) criticism of the Canadian research program particularly in respect to adequacy of investigation of effects of environmental factors at the egg to larval stages.

The most crucial subject of contention revolves around the interpretation of the recent collapse of the British Columbia herring stocks. By 1965 spawning escapements from the most important single population of herring (Lower east coast of Vancouver Island) had reached a record low level (to about 20% of the long-term average). By the following year, spawnings by three other populations in the Vancouver Island area had likewise shown declines to record low levels or at least to levels which were far below the long-term average.

In Document 996, it was stated that the recruitment resulting from these exceptionally low spawnings would become known between 1968 and 1970. An expanded research program during the last two years has given much valuable data relative to the causes of the decline and to the present level of recruitment. Analysis is now proceeding, but until it is completed, no useful purpose would be served by pursuing the argument further in detail. It is hoped that a report soon will be available, perhaps by the time of the 1971 meeting.

In the meantime, there are other points contained in Document 1250 which deserve immediate comment if only for the purpose of clarifying the Canadian position as expressed in Document 996 and in INPFC Bulletin no. 4.

1. Level of exploitation of British Columbia herring stocks.

In the original Canadian report (INPFC Bull. no. 4, paper no. 1, p. 5) it was concluded on the basis of information available to 1955, that the total mortality rate in most stocks was in the vicinity of 82% ($Z = 1.71$). The annual natural mortality rate was estimated to range from 32% to 57% depending on age ($M = 0.39$ to $0.85$); with 50% ($M = 0.70$) being the average for the fishable age range and 54% ($M = 0.78$) being the best estimate of the rate between ages 5+ and 6+. The average annual fishing mortality rate between these ages was accordingly estimated to be about 60% ($F = 0.92$).

In considering the theoretical consequences of more intensive fishing, it was further concluded, assuming recruitment and natural mortality remained unchanged, that an increase in total mortality rate to 90% ($Z = 2.31$) would produce only a 13% increase in sustainable yield, and that a total mortality rate of 95% ($Z = 3.00$) would produce a 20% increase in yield. However, it was noted that such an increase in yield would necessitate a reduction of the spawning escapement by as much as 78%.

Independent theoretical computations by Japanese scientists (Bull. 4 paper no. 10) corroborated the Canadian Section's general conclusion that increased fishing would result in "some increase" in the sustainable yield, given
that there were no changes in the parameters of recruitment and natural mortality. There was also agreement that there would be a reduction in the size of the spawning stock.

The essential difference in the Canadian and Japanese positions can be stated as follows:

(1) As of 1955, the Canadian Section considered that the increase in yield to be expected from more intensive fishing was not worth the risk of reducing the spawning population to the point where it failed to produce the maximum number of recruits under average environmental conditions -- conditions which are admittedly subject to considerable variability.

(2) In contrast, the Japanese Section has contended that Canada had failed to provide proof that British Columbia herring stocks ever had been, or could be, reduced to the point where recruitment would be adversely affected.

2. Effects of increased rate of exploitation.

Apparently the Japanese Section does not dispute the Canadian contention, as presented in Doc. 996, that increased fishing efficiency coupled with relaxation of regulatory measures in the early to middle 1960's resulted in an increase in catch from the major stocks of herring, and that this level of catch could not be sustained and abundance declined rapidly to record or near record low levels.

In the Canadian view, the increase in total mortality rate to approximately 90% (from former levels of about 80%) was a reflection largely of increased fishing efficiency. Using an estimate of 50% for natural mortality rate (M = 0.70), the fishing mortality rate apparently increased from 60% to about 76%. (F = 0.90 to F = 1.43, respectively).

Contrary to the Japanese comments (Doc. 1250), the Canadian preliminary conclusions on the cause of the decline in abundance and the regulatory measures taken to restore the stocks, were not based solely on the view that spawning escapement had fallen below the critical point where it had adversely affected recruitment.

Document 996 clearly acknowledges: (a) the inconsistency of evidence and difficulty of interpreting information on the relationship between spawning stock size and recruitment, and (b) the possibility that a series of consecutively poor year-classes resulted from adverse environmental conditions.

The Japanese response appears to ignore these acknowledged uncertainties or to interpret them in such a way as to make it appear that Canadian management policy has been guided largely, if not entirely, by the assumption that the current low level of abundance (and poor recruitment) is due to the size of the spawning stocks. Adherence to such dogma is neither explicit nor implicit in the contents of Document 996.

Reiterating a statement in Document 996: "In general, no relationship has been certainly established between year-class strength and amount of spawn. This does not necessarily mean that none exists...." To take any other stand at the present juncture, namely, to dismiss the possibility that British Columbia herring stocks were reduced by the fishery to a level below the critical minimum requirements for maximum recruitment, would be utterly irresponsible.
The view expressed in the original Canadian abstention case that increased exploitation would reduce the spawning stocks to dangerously low levels was unacceptable to the Japanese section. However, events of the past decade appear to have confirmed the point that the risk to the welfare of the stocks was indeed out of all proportion to the small benefit theoretically to be derived by more intensive fishing.

It is unlikely that the very best of scientific investigation can ever be expected to provide absolute proof that the small size of recent year-classes was the result of near record low spawning escapements. These year-classes were the progeny of parent populations which were subjected to record high levels of exploitation. It seems to be asking a lot of coincidence to insist that the exceptionally low levels of recruitment in recent years were merely the result of exceptionally poor environmental conditions.

3. Fitting of stock-recruitment curves.

In Doc. 1250 (part 2) Japanese scientists maintain that the method of fitting curves to data relating parent stock size to recruitment is based on assumptions which cannot be supported. Doc. 996 clearly indicates Canadian recognition of environmental variation and the difficulty of separating a true parent-progeny relationship from this "background noise". The technique of averaging has recognized limitations, but is widely accepted in scientific circles as a means of suppressing inherent natural variability of the data in order to establish a generalized picture.

Nothing in the available information on the distribution pattern of spawning populations or on the "spawning ecology", suggests that the stock-recruitment relationships illustrated in Doc. 996 are without reasonable foundation. If Japanese scientists can provide more explicit advice on the development of ecologically more realistic models, Canadian scientists would welcome such guidance in further consideration of stock-recruitment relationships.

4. Investigation of environmental factors.

In Doc. 1250 (part 3) it is intimated that ecological studies on British Columbia herring are not sufficient to meet the requirements to identify the environmental factors which determine the strength of a year-class at its egg to larval stage. As acknowledged by Japanese scientists, such studies are difficult. Indeed, the present state of knowledge in respect to herring -- and for that matter, many other marine species -- is such that it is difficult to say with absolute assurance that the fate of a year-class is determined invariably during the egg to larval stage. With but a few notable exceptions, it remains a universally un-tested hypothesis.

In any case, Canadian research on the early life history of herring and of ecological factors has been intensified within the past decade and already several lines of investigation show encouraging preliminary results.

The existence of environmental effects has been clearly acknowledged. Current studies are exposing relationships between year-class strength and broad, general environmental factors which in all probability are merely associated with the real causal factors. The question of the adequacy or inadequacy of present investigations to identify the particular causal factors does not appear to be
especially relevant to the central issue, namely the stock-recruit relationship. If a sound correlation between year-class strength and associated general environmental factors can be established, it will serve just as well in development of a stock-recruitment model which takes into account environmental influence. In world fisheries literature there is a notable lack of success in identifying the particular factors which influence survival. In all probability the reason is that no single factor is responsible; that several factors work in combination; and their importance relative to one another varies from year to year.

5. Summary and conclusion.

This report is to be regarded as an interim response to the Japanese comments (Doc. 1250) on the status of British Columbia herring stocks to 1967 (Doc. 996). Because many of the data are currently in the process of re-analysis and, more important, because full reporting cannot yet be made on the size of year-classes resulting from the exceptionally poor spawning escapements in the middle 1960's, it is premature to pursue the stock-recruitment argument at this time. It is hoped that, with the acquisition of complete data pertaining to those critical years, a detailed report will be available to the Scientific Sub-Committee in the near future.

The present report has endeavoured merely to clarify certain obvious misconceptions in the interpretation of results presented in Doc. 996. There are some areas of continuing disagreement, but in general the doubts or questions raised by Japanese scientists in Doc. 1250, are identical to those expressed by Canadian scientists.

The question of stock-recruitment relationships -- particularly the possibility that it is within the capability of a marine commercial fishery to reduce adult populations to the point where they can no longer provide a maximum supply of recruits -- is attracting increasing world-wide attention, as evinced by the 1970 ICES/FAO/ICNAF Symposium on Stock and Recruitment. The problem is one of practical concern, no longer just a subject of debate in the community of fishery theorists.

It would be unrealistic to anticipate that, as a result of the acquisition of more recent data and further analysis, absolute proof of the effects of parent stock size on recruitment of British Columbia herring will be forthcoming. To provide absolute proof is a laudable objective, but something which is beyond the capabilities of fisheries science no matter where it is currently practised. What does lie within its capability is the provision of information which enables scientists to draw reasonable conclusions and provide guidelines for prudent management procedures. To insist otherwise, as a basis of developing management policy is to invite disaster and grave misuse of the world's ocean resources.