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PROGRESS REPORT

1. PARTICIPANTS

Members of Working Group

Nominated by ICNAF

R. J. H. Beverton	U. K. Convenor
L. M. Dickie	Canada
V. Hodder	Canada
S. J. Holt	F. A. O.
B. B. Parrish	U. K.
G. Sætersdal	Norway
R. R. Silliman	U. S. A.

Coopted or nominated by their country

E. Cadima	Portugal
J. A. Gulland	U. K.
R. Jones	U. K. (Part time)
V. I. Travin	U. S. S. R.
L. G. Nazarova	U. S. S. R.

2. GROUND COVERED BY THE GROUP

(a) The Group reviewed the available research and statistical data for the various areas and agreed on the tabulation needed for stock assessment having regard to that given in ICNAF publikations. This tabulation has been prepared for some but not all areas.

(b) The methods of assessing the effect of a change in mesh size were discussed at length, and agreement was reached on a suitable method, of which a brief account is given in Appendix I.

(c) The Group reached provisional conclusions concerning the influence of fishing on some of the stocks; while the extent varied, for all stocks for which adequate data was available there was a detectable effect of fishing.

(d) Some provisional assessments of immediate and long-term effects of change in mesh size up to 6" were made during the meeting. On catches of cod the immediate effect of meshes up to 5" is small - a loss of around 5 %, but the immediate loss with a 6" mesh in some areas may be considerable. Time did not permit the estimates for the long term benefits to be examined critically by the group as a whole, but the provisional estimates suggest long-term benefits from both 5" and 6" meshes, of up to 10 % in the more heavily fished areas, such as 4T, but elsewhere benefits will be smaller, or there may be some loss. The initial loss for haddock would be considerable for a 5" and still more for a 6" mesh. In sub-area 5 there may be a long-term benefit from meshes up to 6", but elsewhere, at the present levels of fishing, there is not likely to be a gain from meshes greater than $4\frac{1}{2}$".

The immediate effect of meshes larger than 4" on redfish catches would be considerable. The group found great difficulty in obtaining any good estimate of the effect of fishing on redfish stocks, and before making any estimate of the long term effects wished to examine critically all data referring to effect of fishing on any redfish stock, not only those in the ICNAF area (see paragraph 3.C.). These assessments have all been made in terms of yield per recruit and are for current effort levels.

(e) The selectivity data used in the assessments were not examined by the Group. Values for cod, haddock and redfish in Sub-areas 3, 4 and 5 were taken from Clark, McCracken and Templeman (ICNAF Proceedings Vol. 8).

(f) The proposals of the Group concerning the provision of a report to the Research and Statistics Committee at the Bergen Meeting are set out below.

3. Proposals for work to be done before Bergen Meeting

During the course of the meeting it was agreed that a number of tasks needed to be undertaken in order that a report could be presented to the Research and Statistics Committee which deals adequately with the findings of the Group concerning the effects of fishing on the stocks and assessments of increase of mesh size. Accordingly, the following list of assignments was drawn up:-

A. COD

(1) Sub-area 1
- (a) Complete long-term assessments. (Gulland)
- (b) Further examination of age composition data (Gulland) (Add age compositions to tabulated data). (Gulland)

(2) Sub-area 2
- (a) Examine age composition data. (Gulland)
- (b) Stock sub-division between sub-areas 2 and 3 and inshore-offshore divisions in sub-area 2. (Hodder or Gulland).

(3) Sub-area 3
- (a) Tabulation of statistical data. (Hodder)
- (b) Length-age compositions of inshore and offshore cod fishereis in sub-divisions 3 - K. L. (Hodder)

(4) Sub-area 4
- (a) Tabulation of statistical data. (Dickie)
- (b) Further work on effort-mortality relationships (Dickie)

(5) Sub-area 5
- (a) Tabulation of statistical data. (Silliman)
- (b) Catch and catch/effort relationships. (Silliman)

B. HADDOCK

(1) Sub-area 3
- (a) Tabulation of statistical data. (Hodder)
- (b) Study of trends in haddock fishery on St. Pierre Bank and comparison between fishing mortalities there and on Georges Bank. (Hodder and Silliman)
- (c) Research vessel age and length data for Grand Bank in earlier years. (Hodder)

(2) Sub-area 4
- (a) Tabulation of statistical data. (Dickie)
- (b) Catch per unit effort and effort regressions for haddock fishery. (Dickie)
- (c) Fishing power data for sub-divisions 4 V and W, for comparison with 3 P effort data. (Dickie)

(3) Sub-area 5
- (a) Tabulation of statistical data. (Silliman)
- (b) Relation between catch per unit effort and effort (Silliman).
- (c) Description of arithmetic method of analysis. (Silliman)

C. REDFISH

(1) Sub-area 3
- (a) Tabulation of statistical data. (Hodder).
- (b) Examination of length compositions for period before fishery started. (Hodder)

(2) Sub-area 4 (R, S, T.)
- (a) Tabulation of statistical data. (Hodder)
- (b) Length compositions before fishery started (Hodder)

(3) Sub-area 4 (V and W)
- (a) Tabulation of statistical data. (Silliman)
- (b) Examine length frequencies of different periods to detect changes in F and M. (Silliman)

Sub-area 5
- (c) Data for fisheries in small areas. (Silliman)
- (d) Similarities between Redfish stocks in 4 V and W and 3 - 0, N and P. (Hodder)

(4) Other areas — Examine evidence relevant to exploitatinn of isolated Redfish concentrations in N.E. Atlantic - especially Russian statistics in Barents Sea. (Sætersdal)

D. HALIBUT — Statistical and biological data of halibut fisheries in sub-areas to be sent to Mr. Sætersdal for further processing.

E. OTHER TASKS — A brief description of the fishery and the exploited stocks to be given as an introduction to the statement prepared for each sub-area. This will be prepared by those with special responsibility for the sub-area concerned.

4. Preparation of reports on findings of the Working Group

(a) It was therefore decided that a summary report should be prepared, before the end of the Bergen Meeting, detailing the assessments summarised in paragraph 2 (d), and including data and findings arising from the tasks listed in paragraph 3.

(b) To prepare this summary report, it was agreed that it would be essential for the Working Group to meet in Bergen three days before the beginning of the meeting of the Research and Statistics Committee. It appears that all the members of the group except J.A. Gulland and R. Jones will be going to Bergen as members of their countries delegations, and it is urgently requested that funds be made available to these members of the Group also to attend for at least these three days and preferable for the whole of the Research and Statistics Committee meeting.

(c) It is requested also that a meeting room and the necessary typing facilities be provided in Bergen for the three days during which the Working Group will be meeting.

R.J.H. Beverton,
Lowestoft.
26.3.60.

APPENDIX

Methods of assessing the long-term effect of increasing cod-end-mesh size.

1. Symbols

$_1Y$ = Annual catch in weight before mesh increase

$_2Y$ = Annual catch in weight after mesh increase

Y_R = That part of $_1Y$ which would be "released" (i.e. which would never have been caught) if the larger mesh were used

Y_K = That part of $_1Y$ which would be retained (kept) if the larger mesh were used

So that $_1Y = Y_R + Y_K$

N_R and N_K = the numbers of fish in Y_R and Y_K respectively

W_K = mean weight of fish in Y_K - Y_K/N_K

F' and M' = Fishing and natural mortalities of recruited fish over the range of age (Δt) between the sizes of first liability to capture by the two meshes.

E = the fraction of the N_R "released" fish that will eventually be captured, rather than die naturally, after they have become liable to capture by the larger mesh. ("Rate of exploitation")

$E = \frac{F}{F+M}$ where F and M are respectively the fishing and natural mortality coefficients effective at ages above the size of first liability to capture by the larger mesh.

2. First Method

If the larger mesh were introduced, fish of sizes which had previously been subjected to a total mortality of (F' + M') over the period Δt would henceforth be subjected only to a mortality of M' over that age range. The numbers of fish reaching a size at which they are liable to retention by the larger mesh would therefore be expected to increase by the factor $e^{F_\Delta t}$. Thereafter they would be subjected to the same mortality rates as before, the same fraction, p, of them would be caught, at the same average weight as before, so that

$$_2Y = Y_K \, e^{F_\Delta t}$$

This is the method derived formally for the case of knife-edge selection, by Holt (1958). (ICNAF Annual Report).

3. Second Method

In a method proposed by Gulland we consider the fate of the N_R fish. They will be subjected to a natural mortality M' for a time before they become liable to capture by the larger mesh. Some of them, which would in fact have been captured by the smaller mesh almost as soon as they became liable to capture by it will, with the introduction of the larger mesh, be subject to M' for the whole period Δt. Others, which would have been captured by the smaller mesh only just before they reached a size at which they would become liable to capture by the larger mesh, will be subject to M' for an infinitesimally short time. On the average the N_R fish will therefore be subject to M' for a period of about $\Delta t/2$.

The number $N_R \, e^{-M\Delta t/2}$ will be expected to survive to become liable to capture by the larger mesh. Of these $EN_R \, e^{-M\Delta t/2}$ will eventually be caught, at an average size of $\overline{W}_K$.

The expected gross gain by using the larger mesh is therefore -

$$E N_R \; e^{-M\Delta t/2} . \bar{W}_K$$

and the expected net gain is

$$\text{Gross gain} - Y_R$$

The catch with the larger mesh is the sum of Y_K and the gross gain, i.e.

$$_2Y = Y_K + E N_R \; e^{-M\Delta t/2} . \bar{W}_K$$

But $\bar{W}_K = Y_K/N_K$

so $_2Y = Y_K(1 + E . e^{-M\Delta t/2} \; N_R/N_K)$

4. Comparison of methods

The principle of the two methods is the same, and they may be shown to be formally identical in the theoretical case with knife-edge selection, apart from the approximation involved in the second method by taking the mean time of exposure to mortality M' as $\Delta t/2$. This approximation seems however to be a very close one.

Thus if the methods are fundamentally the same, then

$$e^{F'\Delta t} = 1 + E \; e^{-M\Delta t/2} \; N_R/N_K$$

Now, for knife-edge entry to the exploited phase, we may write

$$N_R = \frac{R\,F'}{F' + M'} \left[1 - e^{-(F' + M')\Delta t}\right]$$

and $$N_K = \frac{FR \; e^{-(F' + M')\Delta t}}{F + M}$$

Putting $E = F/_{F + M}$ we have

$$E \; N_R/N_K = \frac{F'}{F' + M'} \left[e^{(F' + M')\Delta t} - 1\right]$$

Expanding the exponential term

$$= \frac{F'}{F' + M'} \left[1 + (F' + M')\Delta t + \tfrac{1}{2} \left[(F' + M')\Delta t\right]^2 + 0(\Delta t)^3 - 1\right]$$

where $0\,(\Delta t)^3$ denotes terms of the order of $(\Delta t)^3$ and smaller.

$$\therefore 1 + E \; e^{-M\Delta t/2} \frac{N_R}{N_K} = 1 + (1 - \tfrac{1}{2} M\Delta t + \tfrac{1}{2} . 1/4 \; M^2(\Delta t)^2 + 0(\Delta t)^3$$

$$\times \; F' \; (\Delta t + \tfrac{1}{2}(F' + M')(\Delta t)^2 + 0(\Delta t^3))$$

$$\doteq 1 + F'\Delta t - (\tfrac{1}{2} F'M - \tfrac{1}{2} F' \; (F' + M'))(\Delta t)^2 + 0(\Delta t)^3$$

$$\doteq 1 + F'\Delta t + \tfrac{1}{2} (F'\Delta t)^2 + 0(\Delta t)^3$$

Similarly expanding, $e^{F'\Delta t} = 1 + F'\Delta t + \tfrac{1}{2}(F'\Delta t)^2 + 0(\Delta t)^3$

Thus the two expressions are identical in the first three terms of the expansion, and will be very nearly equal if Δt is reasonably small.

The methods differ in practice in their utilization of the available data and the magnitude of errors caused by incorrect estimation of parameters. Thus the values of M and Δt have only a small effect on the results of applying the second method so long as the product $M\Delta t/2$ is not large, whereas the results of the first method depend entirely on the values of F' and Δt, and rather small changes in either of these cause quite large changes in the result. Furthermore, F' is difficult to estimate; in practice it would normally be necessary to assume it equal to F, determined usually from the size or age compositions of the N_K fish. In effect, the observed ratio N_R/N_K, from information not utilized in the first method, is used in the second method as an estimature of a function of F', M', F and M.

Trial calculations with the same values derived as described before, for a hypothetical population, using the two methods and an extended calculation of the exact result, showed as expected that the second method gave estimates of gain closer to the true gain than did the first method.

5. Estimation of Δt.

The method of estimation is to calculate values of the lengths of fish at first liability to capture by each of the two meshes, and to derive a corresponding time interval by relating these lengths to a curve of average length against age. The length at first liability to capture may be difined as the length at the 50 % point of a resultant selection ogive, the latter being obtained as the product of a recruitment ogive and a mesh selection ogive. This measure of "median selection length" is simple to obtain but has the disadvantage that two resultant selection ogives which are congruous above the 50 % point but diverge from each other below it, and which should therefore be approximated by different average length at first liability to capture, have the same 50 % points. For this reason it is perhaps preferable to calculate the "mean selection length", as the mean of the derivative of the resultant selection ogive. The difference between the mean and median could not normally have much influence on the results obtained by using the second method of assessment, but it could significantly affect the first method.

It is, strictly, necessary to know the values of F' and M' in order to determine the recruitment ogive, because this is obtained by first dividing the length frequency curve for the catch by the mesh selection ogive to obtain the length frequency of the recruited stock, and then to back calculate, using the F' and M' values, the length frequency distribution of the entire stock; finally the ratio of the length frequency curve of the recruited stock to that of the entire stock gives the required recruitment ogive.

If F' + M' is not too high the ascending, left-hand limb of the length frequency distribution for the recruitment stock gives roughly the shape of the recruitment ogive, so that the left-hand sides of the catch curves may be treated as resultant selection ogives, and the difference between the means of their derivatives is an estimate of the difference between the mean length at first liability to capture by the smaller and larger meshes. Numerical trials showed, however, that this approximation is not always close enough to permit application of the first method of assessment with reliability, though the discrepancy is not likely to affect the results of the second method. It should be noted that in a situation where the range of lengths over which mesh selection is occurring is such that most or all recruitment has already occurred, the mesh selection ogive itself is closer to the resultant selection ogive (and may even coincide with it) than is the left-hand limb of the catch curve.

The method chosen as the most suitable to apply in practice was to calculate

(a) The mean length of the N_R fish

and (b) The mean difference between lengths of equal frequency on the catch curves for the smaller and larger meshes.