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Res. Doc. 80/12

ASSESSMENT OF THE IMPACT OF THE WEST GREENLAND FISHERY ON STOCKS AND CATCHES IN NORTH AMERICA

by

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April 1980

INTRODUCTION

Since 1966 the ICES/ICNAF Joint Working Party on North Atlantic Salmon has quantified the effects of the West Greenland salmon fishery on homewater stocks and catches (Anon. 1967, 1969, 1971, 1973, 1974). These effects were quantified on the basis of estimates of the changes in weight, through natural mortality and growth, that would have occurred to the number of salmon in the West Greenland catch had they not been caught there, and if surviving, had returned to homewater fisheries. New estimates of exploitation and natural mortality rates were derived for the 1974 Working Party Meeting from a simulation analysis of the fisheries using a range of values for growth and natural mortality between West Greenland and homewaters and exploitation in homewaters (Horsted 1980; Anon. 1974). These new estimates and the same method of calculation as in previous assessments were used by the Working Party to provide best estimates of the lower and upper limits of losses to homewater stocks and catches for different catch levels at West Greenland. An allowable catch at West Greenland of 1191 tonnes would result in direct loss to homewater stocks in North America and Europe combined of between 1070 and 1520 tonnes, and to homewater catches of between 640 and 910 tonnes (Anon. 1979).

In 1979, an ICES Working Group on North Atlantic Salmon (successor to the ICES/ICNAF Joint Working Party on North Atlantic Salmon) met to review the status of stocks in relation to fisheries in the North Atlantic, and in particular to review new information relevant to earlier assessments of the impact of the West Greenland fishery (Anon. 1979). New information brought forward at the 1979 meeting suggested that the 1974 assessment under-estimated the losses to homewater stocks and catches. The Working Group endorsed this new information which indicated that:

(i) the rate of natural mortality between West Greenland and homewaters is likely lower than assumed in earlier assessments;

(ii) incremental growth between the mid dates of the fisheries at West Greenland and in North America is greater than assumed previously; and,

(iii) previous estimates of the total fish kill at West Greenland were low because of failure to recognize and include losses categorized as noncatch fishing mortality.

The current assessment of the impact of the West Greenland fishery on stocks and catches in North America presented here is based on the same approach as earlier assessments conducted by ICES/ICNAF Joint Working Party (Anon. 1967, 1969, 1971, 1973, 1974). Use and consideration of the new information endorsed by

the 1979 ICES Working Group (Anon. 1979) has resulted in the derivation of estimates of impact which differ from those derived at the 1974 ICES/ICNAF Joint Working Party meeting (Anon. 1974).

THE MODEL

Although utilized to assess the effects of the West Greenland fishery on North American stocks and catches, the model could also be used to derive comparable estimates for salmon of European origin caught at West Greenland. Values for the parameters used to determine the effects of the West Greenland fishery on European stocks and catches would need to be specific to European salmon and the fisheries in which they are harvested.

The chief parameters upon which the assessment is dependent are:

(i) the landed catch by the fishery at West Greenland and the mean weight for all fish taken in the fishery;

(ii) the proportion of the stock harvested at West Greenland which are of North American origin;

(iii) the sea-age distribution of the North American component of the West Greenland catch;

(iv) the mean weights by sea-age class for North American salmon in the West Greenland catch;

(v) incremental growth experienced by North American salmon between West Greenland and homewaters;

(vi) rate of mortality experienced by North American salmon during their return to homewaters from West Greenland;

(vii) rates of noncatch fishing mortality in West Greenland and North American fisheries; and,

(viii) rate of exploitation in homewaters.

Sets of values for these parameters are used to calculate estimates of the losses to homewater stocks and catches that would occur with a given harvest of salmon at West Greenland. Specifically, the methods are as follows:

(1) Estimate the numbers (N) of all salmon of North American (NA) origin lost to the fishery at West Greenland (G) by:

$$N_{GNA} = \frac{Y_G}{\bar{w}_{NA+E}} \cdot P_{NA} \cdot \left(\frac{1}{1-m'}\right), \text{ where}$$

Y_G = recorded catch at West Greenland;

P_{NA} = proportion of catch determined from discriminant analysis of scales (Lear and Sandeman 1974) of North American origin;

$\bar{w}_{NA+E}$ = mean weight of all fish, including those of European origin in the West Greenland catch; and,

m' = rate of noncatch fishing mortality (Ritter et al. 1979) in West Greenland where m' expresses noncatch losses as a proportion of the total fishing mortality at West Greenland. Losses to noncatch fishing mortality are assumed to be similar to the catch with respect to continent of origin and sea-age composition.

(2) Estimate the number of each sea-age class lost to fishing at West Greenland on the basis of the known age distribution. Basic components include the 1-sea-winter salmon destined to return to homewaters as 2-sea-winter fish (NA_1), the 1-sea-winter salmon that are destined to stay at sea through the third sea-winter (NA_2), the 2-sea-winter maiden salmon (NA_3) and previous spawners that spawned initially as either 1-sea-winter salmon (NA_4) or 2-sea-winter salmon (NA_5). Hence,

$N_{GNA_i} = N_{GNA} \cdot P_{NA_i}$, where

i = sea-age classes 1 to 5;

P = the proportion of each sea-age class as determined from aging data.

(3) Estimate the weight of the North American salmon killed by the fishery at West Greenland by:

$Y_{GNA} = N_{GNA_i} \cdot \bar{w}_{NA_i}$, where

$\bar{w}_{NA_i}$ = mean weights by sea-age class for North American salmon in the West Greenland catch.

(4) Estimate the numbers of fish of North American origin, according to sea-age composition, that would have arrived in homewaters had they not been killed at West Greenland by:

$N_{HNA_i} = N_{GNA_i} \cdot S$, where

S = the survival rate between the mid days of the fisheries at West Greenland and in homewaters.

(5) Estimate the number of fish that could be harvested in homewater fisheries by:

$N_{HNA_i F} = N_{HNA_i} \cdot (1-m")$, where

$m"$ = rate of noncatch fishing mortality in homewaters.

(6) Estimate the potential loss to homewater stocks ($Y_{HNA_i S}$) and fisheries ($Y_{HNA_i F}$) by:

(i) $Y_{HNA_i S} = N_{HNA_i} \cdot \bar{w}_{NA_i} (1 + \Delta\bar{w}_i)$

(ii) $Y_{HNA_i F} = N_{HNA_i F} \cdot \bar{w}_{NA_i} (1 + \Delta\bar{w}_i)$

$\Delta\bar{w}_i$ = rates of increase in weight between West Greenland and homewaters (Reddin 1980a).

ESTIMATION OF PARAMETERS

A landed-catch (tonnes) by the fishery at West Greenland can be converted to numbers of fish by dividing the landed weight by a mean weight for all fish taken in the fishery, including those of European origin. A mean weight of 3.34 kg, derived from sampling the Canadian research vessel's catch at West Greenland in 1978 (Reddin and Burfitt 1979), was applied in the assessment.

The proportion of the stock harvested at West Greenland which was of North American origin is estimated on the basis of a discriminant function analysis of characteristics of scales collected annually during the Greenland fishery from 1969 to 1976 and 1978 (Lear and Sandeman 1974; Reddin and Burfitt 1979). While the results of these analyses indicate the North American component to range from 34% to 51%, the average of 41% was used in the assessment (Reddin and Burfitt 1979).

The North American component was subdivided by sea-age on the basis of the age composition interpreted from scales collected during the 1978 research vessel sampling program (Reddin and Burfitt 1979). The age composition observed and subsequently used was 95.5% 1-sea-winter salmon; 2.5% 2-sea-winter, 2.0% previous spawners. Two-sea-winter salmon had previously comprised 10% and 7% of the catch sampled in 1969 and 1972 respectively (Munroe and Swain 1980).

Weight increases for North American salmon between West Greenland and homewaters were derived by subtracting the average weights for the different sea-age classes caught during the research vessel sampling program from 1969 to 1976 from the average

weights for salmon of corresponding smolt year classes caught in the Newfoundland commercial fishery in the following years (Reddin 1980a). Average weights at West Greenland for 1- and 2-sea-winter salmon and previous spawners which had spawned as 1-sea-winter salmon (i.e., the majority of the previous spawners) were 2.89kg, 6.08kg and 2.96kg respectively. Resultant weight increases between West Greenland and homewaters for salmon of these respective sea-age classes were estimated at 58%, 24% and 52%.

The survival rate between West Greenland and the Sand Hill River, Labrador was estimated by the inverse weight-at-age method to range from 86% to 90% for the 10 month period between sea-age 14 and 24 months (Doubleday et al. 1979). Upper and lower rates of 90% and 85% were assumed to represent the range in survival occuring during the assumed 10 month interval between the mid points of the fisheries at West Greenland and in homewaters.

Rates for noncatch fishing mortality in West Greenland and homewater fisheries were suggested by Ritter et al. (1979) as being of the magnitude of 40% of the total fishing mortality at West Greenland, 25% in homewater coastal fisheries harvesting salmon both temporarily and spatially distant from the fish's river of origin and 12.5% in coastal and estuarial fisheries harvesting salmon ready to ascend their home river. These rates were based on estimates made for Pacific salmon fisheries and an analogy of the similarities of the fisheries for Pacific salmon and North Atlantic salmon. Reporting on noncatch fishing mortality in the 1979 salmon fisheries at West Greenland and in Newfoundland-Labrador, Reddin (1980b) suggested rates of 22% to 42% for the fishery at West Greenland and 7% to 13% in homewaters. These rates were derived by combining separate estimates of noncatch losses categorized as escapement mortality (Doubleday and Reddin 1980), dropouts, fallouts, discards and local consumption. Estimates were based on measurements and observations made in the fisheries and consideration of values reported in the literature. Rates of 42% and 13% were paired and assumed to represent the upper limits for noncatch fishing mortality at West Greenland and in homewaters, respectively and 22% and 7% the conservative or lower limits.

Exploitation rates in homewaters are based on the assumption that the homewater catches will equal returns to homewaters from West Greenland reduced only by the associated losses to noncatch fishing mortality in homewater fisheries. This assumption is in accord with the conclusion of the 1979 ICES Working Group on North Atlantic salmon that "estimated changes in the quantity of salmon returning to homewaters, with changes in the West Greenland catch, provide a more appropriate indication of effects on homewater fisheries than the estimates of changes in homewater catches, using a constant value of exploitation rate" (Anon. 1979). This conclusion was based on recognition that a main principle in managing salmon stocks is to limit harvests to permit optimal spawning escapement.

THE ASSESSMENT

The assessment depicts a general situation for the North American component of the salmon catch at West Greenland. It is estimated that for every 100 tonnes of North American salmon caught at West Greenland, the loss to homewater stocks ranges from 170 to 242 tonnes, depending upon the assumed rates for survival and noncatch fishing mortality (Fig. 1). By the same comparison the projected losses to homewater catches range from 158 to 211 tonnes (Fig. 2). The yield increase to all fisheries that would result with any reduction in catch of North American salmon at Greenland is estimated to range from 58% to 111%. The assessment supports the suggestion made by the ICES Working Group on North Atlantic Salmon that exploitation of salmon when they are growing rapidly, as is the situation at West Greenland, will result in a reduced yield per recruit (Anon. 1979). Accordingly a catch at West Greenland, equal to the quota of 1191 tonnes, results in a loss of potential yield to North American fisheries of between 687 and 916 tonnes. The annual Canadian catch between 1974 and 1977 averaged roughly 2500 tonnes.

The recent shift to earlier starting and closing dates of the fisheries at West Greenland (Anon. 1979) also influences the magnitude of the losses to North American fisheries. The effects of this change were estimated by considering the 78% average increase in weight between 1-sea-winter salmon sampled on and before September 7, 1969 to 1976 in West Greenland (approximate closure date in 1976 to 1979) and 2-sea-winter salmon caught in the Newfoundland fishery in the following year (Reddin, 1980a). The 58% estimate of weight increase between West Greenland and homewaters for 1-sea-winter salmon used in this assessment reflects the inclusion of heavier fish from the September-October segment of the fishery and would therefore have caused an underestimate of the impact of the current fishery at West Greenland on North American catches.

Assuming the growth rates for the other 4.5% of 2-sea-winter and older salmon (Reddin and Burfitt 1979) of North American origin taken at West Greenland are the same as for the 1-sea-winter salmon (Reddin 1980a), and that the proportion of the catch consisting of North American origin remains constant regardless of the time of the fishery, a shift from a 2.89kg mean weight for 1-sea-winter salmon to that of 2.63kg, the revised estimate for the current fishery (Reddin op. cit.), would require that approximately 10% more North American salmon be taken at West Greenland to fill a fixed quota. Since the yield lost to homewater fisheries is almost directly proportional to the additional number of fish killed at West Greenland it can be concluded that the current assessment of the general situation (i.e., a later season fishery), underestimated the effects of the present West Greenland fishery on North American catches by roughly 10%.

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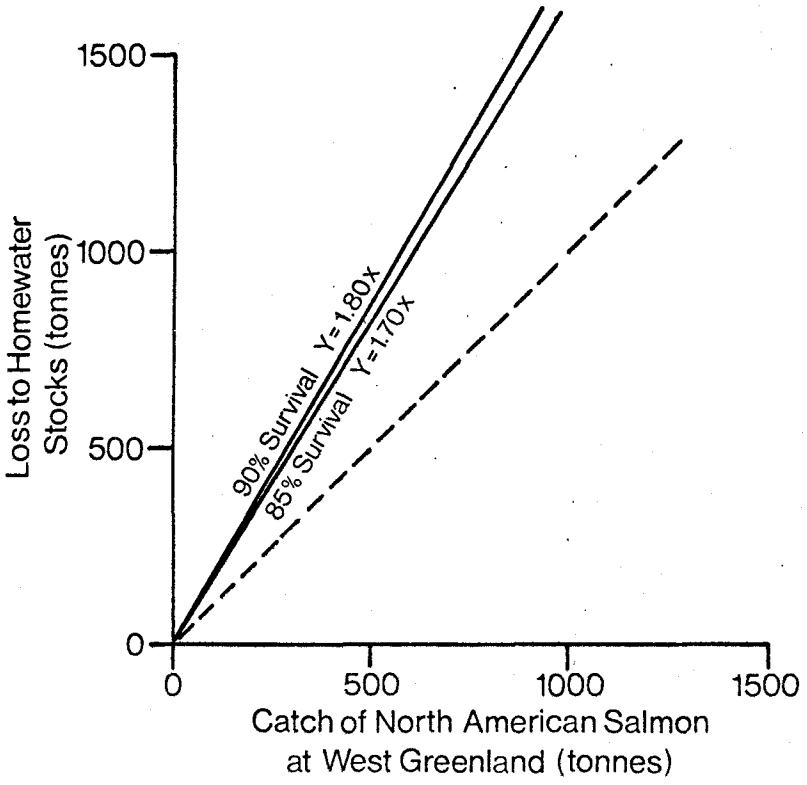
A. Rate of noncatch fishing mortality in West Greenland fishery is 22%.



B. Rate of noncatch fishing mortality in West Greenland fishery is 42%.

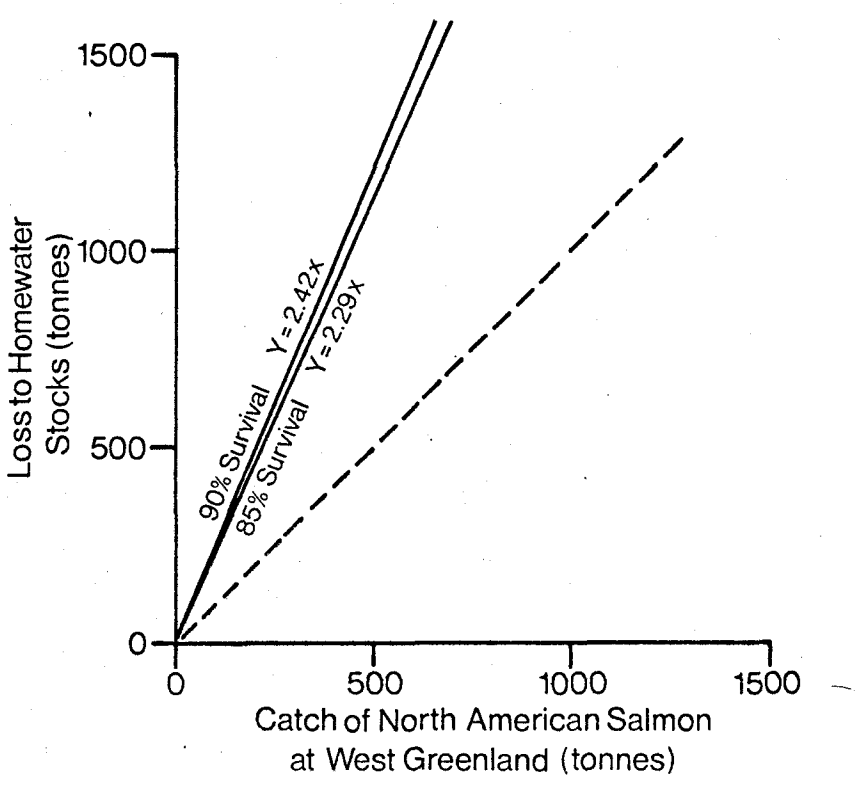
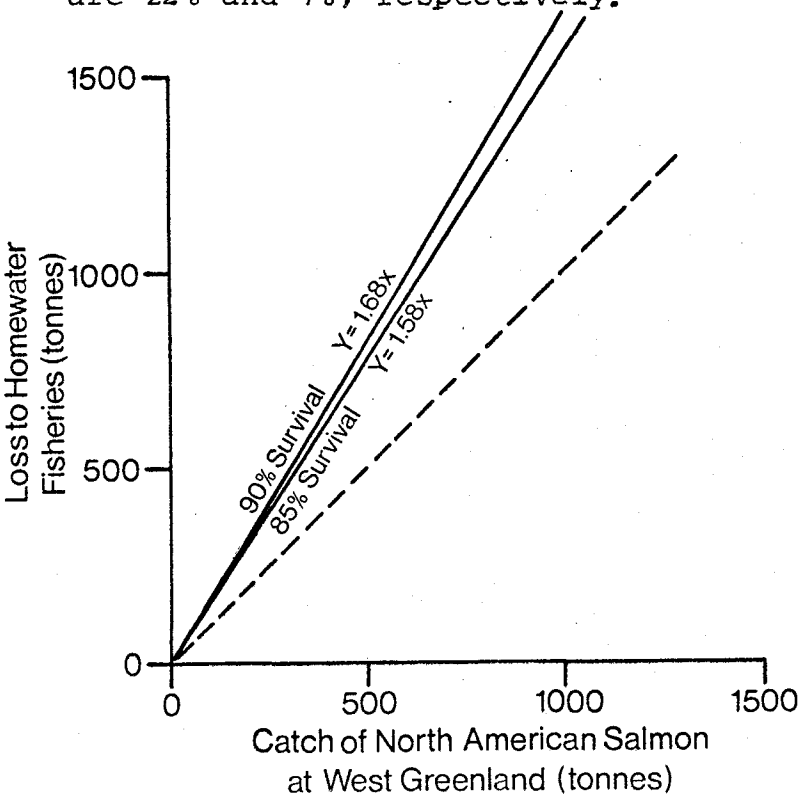


Fig. 1. Relation between the weight of landed North American salmon at West Greenland and resultant losses to homewater stocks.

A. Rates of noncatch fishing mortality in West Greenland and homewater fisheries are 22% and 7%, respectively.



B. Rates of noncatch fishing mortality in West Greenland and homewater fisheries are 42% and 13%, respectively.

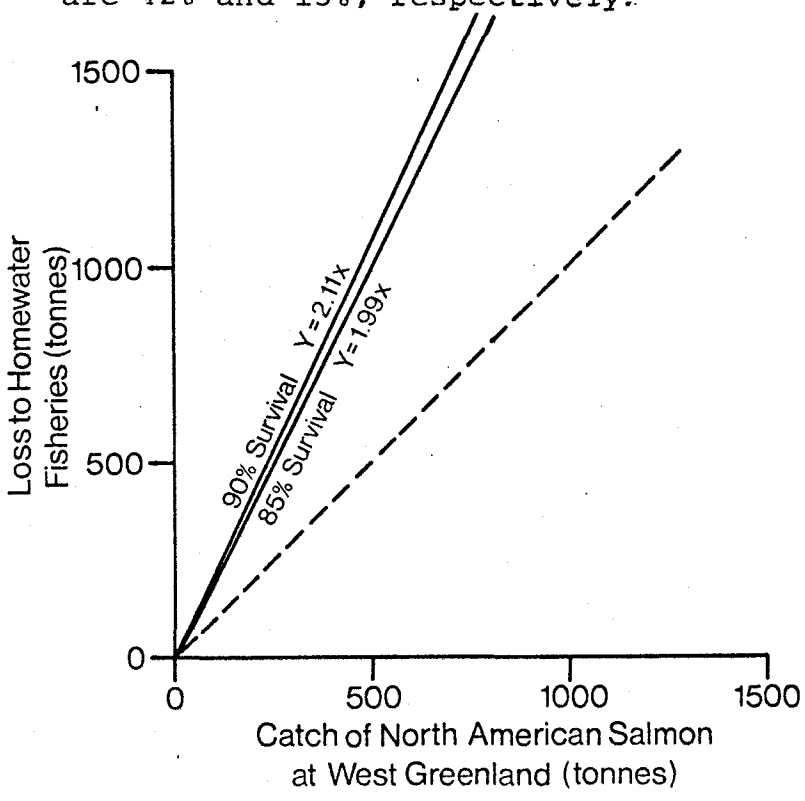


Fig. 2. Relation between the weight of landed North American salmon at West Greenland and resultant losses to homewater fisheries.