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Origin of salmon at West Greenland

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Introduction

An inshore fishery for salmon has existed for at least sixty years on the west coast of Greenland (Shearer and Balmain, 1966). The catch was entirely used for local consumption and it was not until the mid-50's that salmon were reported from trawl catches off the coast. These accidental catches did not lead to any serious attempts to fish primarily for salmon until in 1965 when two vessels, one Norwegian and one Faroese, tried drift-netting off the west coast. At that time there existed a well-established inshore fishery which in 1964 yielded 1539 metric tons (round weight). After 1965 Danish, Faroese and Norwegian drift-netters have gradually extended the offshore fishery so that its contribution to the total catch in Greenland in 1968 was close to 50% (ICES/ICNAF, May 20-21, 1969).

Tagging data indicate that Canadian salmon make a major contribution to the Greenland fishery and significant contributions are evidently also made by salmon from the British Isles and to some degree from the U.S.A. (Maine), Iceland and Sweden.

Because of the generally heavy fishing for salmon in home waters this new concentration of fishing at one of the major feeding grounds for both West European and North American salmon implies a serious threat to the species. The absence of grilse in Greenland waters as opposed to an occurrence of 10-50% in home waters further magnifies the importance of this fishery, which, due to the at least partly hereditary grilse phenomenon, may accelerate the conversion of salmon populations to grilse runs.

From the above it is easy to see the need for some type of biological tag that enables us to distinguish between salmon of different geographic origin. Only then is it possible to estimate the effects of the Greenland fishery on individual salmon-producing areas. Tagging alone is less likely to give an accurate figure, because of our lack of knowledge which rivers contribute the most to the Greenland fishery, and because tagging salmon in all salmon-producing rivers is virtually impossible. The most promising of these so-called biological tags have been internal parasites and hereditary biochemical differences as reflected in protein or enzyme zymograms of selected tissues.

In 1965 and 1966 the author analyzed 2-year-old salmon of both Swedish and Canadian ancestry reared under close to identical environmental conditions at

the Laboratory of the Swedish Salmon Research Institute at Älvkarleö, Sweden. This controlled rearing would thus have more or less eliminated differences between the two stocks that might be caused by environmental factors. The hereditary parameters to search for would have to be qualitative differences between the various stocks, because quantitative data, for instance in the form of gene frequency differentiation, would be impossible to apply due to the complex geographic background of the Greenland salmon.

In these 2-year-olds qualitative differences were found (a) in the migration rate of one zone in the transferrin complex of the blood serum, (b) in the liver esterase zymograms and finally in a quantitative difference without overlapping in the enzymatic activity of serum esterases (Nyman, 1966). The following year (1967) the same batches of fish were examined and controls from several European salmon stocks were analyzed simultaneously. Again the same differences between the Canadian and Swedish salmon were present, although not so distinct in the liver esterase zymogram. Also, a further protein system was discovered where they differed; namely, the kidney esterases. At this time I also had access to F1 hybrids from the same populations which made possible analysis of the hereditary background of the differences. The allele governing the control of the transferrin zone (with different mobility) in Canadian salmon is evidently completely dominant over its Swedish counterpart since all hybrids displayed the migration rate of the Canadian zone. With co-dominance both bands would have been inherited in the hybrids, roughly with half the intensity of the parental bands. The opposite condition prevailed in the quantitative differences in staining intensity of the serum esterases where the 'Swedish allele' appeared to be dominant. Canadian dominance was again at hand in the kidney esterases, whereas co-dominance was indicated in the differences in the liver esterase patterns, which were now reduced to merely quantitative staining intensity differences. In the differences mentioned above, all European populations sampled displayed electropherograms identical to the Swedish patterns.

These characters have now been tested on a large scale, and at present more than 900 salmon have been analyzed. These fish originate from Canada, Ireland, Scotland, Norway, Sweden and Finland. Detailed results of these studies on parr, smolt and adult salmon which are used as a control for the analysis of Greenland salmon caught in 1969 as well as a more detailed analysis of the

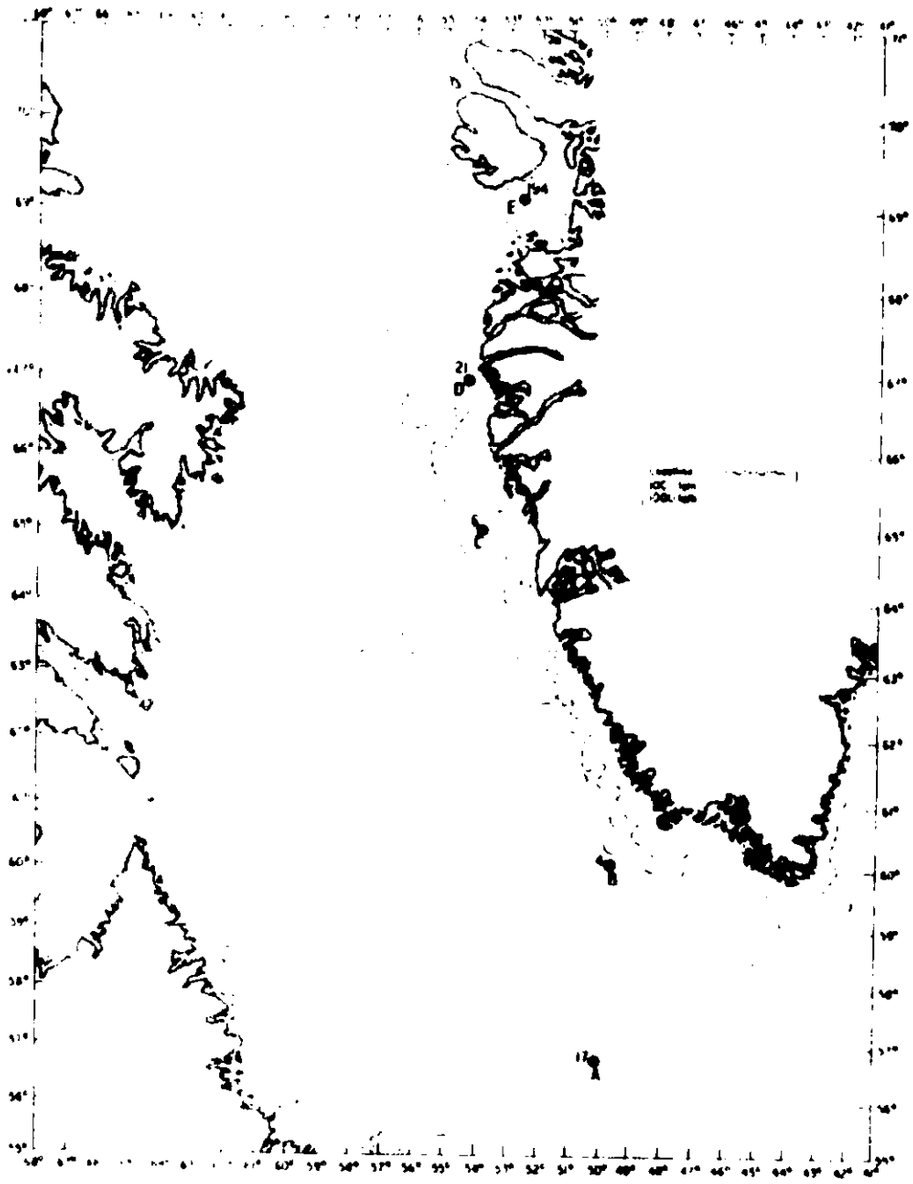
Greenland samples are being prepared for publication in the Journal of the Fisheries Research Board of Canada.

Results

Sampling of adult specimens indicated that some of the characters which were useful for separating 2- or 3-year-olds gave poor resolution mainly because of blurring of the genetic differences by a more varied environment and probably also because ontogeny correlated differences disappeared in adult, sea-going salmon. However, two independent zones in blood serum as shown by buffer modifications proved quite adequate. One is the transferrin zone mentioned above. The slight but significant difference in this zone could be magnified by employing a modification of the buffer described by Aronsson and Grönwall (1957) as modified by de Ligny (1967). Another zone where differences could be detected was revealed by employing the buffer described by Gahne (1966). This difference, also qualitative, is located in the slow alpha$_2$-globulin region.

The enzymatic activity in the fast bands of salmon liver esterase is very variable unless we are dealing with specimens reared under identical conditions including being fed the same diet. These variations are evident in sea-run fish and cause increased difficulty for typing of enzyme patterns. Roughly 20% of the Greenland salmon examined in this study could be typed according to liver esterase pattern alone, i.e. they had distinct patterns and agreed with the results of the serum typing. In only two instances was there any discrepancy from the serum typings. These two fish were grouped with the 'European' salmon, with which they agreed according to both sera patterns.

The geographic distribution of the samples obtained in 1969 by the *A. T. Cameron* is given in the figure below.



The number of salmon caught at the five major sampling areas.

The composition of the samples according to sera typing and in some instances liver esterase zymograms is shown in the table below.

Origin of salmon from the different sampling stations.

Location	Date (1969)	No. of fish analyzed	Geographic composition A = North America E = Europe		Percentage of North American origin
A. Halfway between Labrador and Greenland	6/9	17	A = 6	E = 11	35
B. Off Kap Farvel	10/9	4	1	3	25
C. Sukkertoppsbanke	15/9	6	5	1	83
D. Store Hellefiske	18/9	20	6	14	30
" "	19/9	1	-	1	-
E. Disko Bay	22/9	3	1	2	33
" "	23/9	57	26	31	46
" "	24/9	48	25	23	52
" "	26/9	41	17	24	41
" "	27/9	3	3	-	100
" "	29/9	3	1	2	33
" "	30/9	24	7	17	29
" "	1/10	15	5	10	33
	Total:	242	103	139	43

The percentage of Canadian fish is somewhat lower than figures tabulated from tagging data and mean smolt age (ICES/ICNAF, 1966). However, only continuous sampling throughout the fishing season and all along the coast will be able to compensate for seasonal and annual variation in the geographic composition of the various stocks of salmon contributing. From these data there does not seem to be any pronounced schooling of fish from the two continents, respectively, since in almost every catch where large numbers of salmon were obtained, 'European' and 'Canadian' salmon appeared to be distributed at random in the nets.

The results of this investigation are further substantiated by examination of the abundance of internal parasites, where the incidence of *Eubothrium crassum* and *Anisakis* sp. larvae differed significantly at the 99% level, between fish classified as 'European' and 'Canadian', respectively, but where the incidences were within the same range for the sample here called 'Canadian' salmon and a control of tagged Canadian salmon which were caught in Greenland waters (Pippy, 1969). These results are also presented in more detail by Nyman and Pippy (in preparation).

One of the difficulties in applying this method is the necessity of having access to fresh blood. Also deviations from these results could occur due to the lack of control fish from the United States and Iceland. Future sampling from these countries is, therefore, required.

Summary

Sera typing of salmon caught off the west coast of Greenland on *A. T. Cameron* Cruise 164 showed that 43% of the fish were of North American (Canadian) origin. However, possible seasonal and annual variations in the composition of the stocks contributing to this fishery necessitate extensive sampling throughout the fishing season to render a more accurate figure possible.

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