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Annotated Bibliography of Northwest Atlantic salmon stock identification papers including tagging, morphometric and genetic studies.

by

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INTRODUCTION

A major concern in the conservation and management of Atlantic salmon (*Salmo salar*) in the Northwest Atlantic is the impact of distant-water fisheries on stocks of North American origin. These fisheries, conducted primarily off Newfoundland and West Greenland, take varying proportions of salmon of North American (USA and Canada) and European origin, from year to year. The pattern of distribution of salmon of North American origin which makes it susceptible to these distant-water fisheries has been the subject of numerous studies conducted since the 1930's. These include tagging, genetic, discriminant analysis and various other studies. This paper presents a bibliography of many of the major works reported on this subject, and includes a brief summary of the intent and results of each study. This summary is by no means complete, but includes all papers available to the author at the present time. This bibliography will be updated as additional documents become available.

BIBLIOGRAPHY

Bastien, Y. 1984. A study of the interception of mainland origin Atlantic salmon in the Newfoundland commercial fishery. Report of the Atlantic Salmon Federation, St. Andrews, N.B., 32p.

This document presents a summary of major work done on the migration of Atlantic salmon in the Northwest Atlantic during the last century. The interception of mainland origin salmon in the Newfoundland commercial fisheries has been recorded as early as the 1930's. Early tagging

studies showed that between 22% and 60% of the salmon taken in various Newfoundland fisheries were from other provinces. More recent studies indicate that annual catches of Quebec origin salmon averaged (1973-79) 13.6% of the Newfoundland total; while the Maritime Provinces contributed about 11% (1969-75 annual average); and Maine origin salmon comprised about 1% (1969-80) of the Newfoundland commercial fisheries.

Baum, E.T. 1983. Interception of Maine Atlantic salmon stocks. Presented at the Northeast Atlantic salmon Workshop, 1-3 November 1982, Moncton, N.B. Atlantic Salmon Federation , Spec. Pub. Series. p89.

Over 700,000 Atlantic salmon smolts have beeen tagged and released by the State of Maine since it began its hatchery-reared tagging program, in 1966. Overall distribution of the more than 5,000 adult recoveries was: Greenland- 29%; Canada- 22%; Homewaters- 49%. Recoveries from Canada during 1971-81 were from: Newfoundland- 72%; Labrador- 23%; Nova Scotia- 3%; New Brunswick- 2%.

Baum, E.T. and A.L. Meister. 1984. Summary of tag returns from hatchery reared Atlantic salmon smolts released in Maine, 1966-82. Rep. of Maine Atl. Sea-Run salmon Comm. 13p.

The State of Maine has released over 850,000 tagged Atlantic salmon smolts during 1966-83. A total of 1,412 tags were recovered in West Greenland. Of Canadian recovered tags, 68% were taken from the east coast of Newfoundland, 23% from off Labrador, and 6% from southern Newfoundland. The remainder of Canadian recoveries occured in miscellaneous fisheries in New Brunswick, Nova Scotia, and Quebec.

Belding, D.L. 1939. Migration of the Atlantic salmon (Salmo salar) in the Gulf of St. Lawrence as determined by tagging experiments. Trans. Am. Fish. Soc. 69:290-295.

Atlantic salmon that were tagged at Cabot Strait during 1937 and 1938 were distributed to all parts of the Gulf of St. Lawrence, except the eastern part of the north shore and the northern part of the west coast of Newfoundland. The salmon that were tagged at the eastern end of Belle Ilse Strait were recaptured in the sections unoccupied by the Cabot Strait salmon. The separate regions of distribution, the difference in the time of run and the diverse characteristics of the two groups of salmon indicate that there are two distinct stocks of salmon entering the Gulf of St. Lawrence.

Blair, A.A. 1956. Atlantic salmon tagged in East Coast of Newfoundland waters at Bonavista. J. Fish. Res. Bd. Can. 13(2): 219-232.

In 1940, between June 8 - 28, 68 salmon and 386 grilse were tagged at Bonavista on the east coast of Newfoundland. The fish used were caught by commercial fishermen in salmon traps set along the coast within 3.25 miles of the Bonavista lighthouse. The proportion of tagged salmon recaptureed during the year of tagging was 41.2% and 1.5% the following year. The 28 recaptures in 1940 were distributed as follows: Newfoundland 57.1%, mainland Canada 39.3%, and Labrador 3.6%. The greatest distance traveled was 785 miles, and the fastest apparent rate of travel was 26.2 miles per day.

The tagged grilse returns were 36.6% in 1940, 2.6% in 1941, and 0.3% in 1942. The 140 tagged grilse recaptured in 1940 were distributed as follows: Newfoundland 92.9%, and mainland 7.1%. The greatest distance traveled by recaptured grilse was 792 miles, and the fastest apparent rate was 32.5 miles per day.

Blair, A.A. 1957a. Salmon tagging at Cape Charles, Labrador. J. Fish. Res. Bd. Can. 14(2):141-144.

Salmon from the commercial fishery at Cape Charles, southern Labrador, were tagged in 1948. During the short tagging period of June 30- July 10, 35 salmon and 24 grilse were tagged. Due to delays in reaching Labrador the peak of the salmon run was missed, and storms made it difficult to get salmon in good condition for tagging. Salmon returns consisted of 5 taken in commercial gear in Labrador and 1 angled in a west coast Newfoundland river, for a total recovery of 17.1%. Only 2 (8.3%) of the tagged grilse were recaptured, both in commercial gear in Labrador.

Blair, A.A. 1957b. Salmon tagging at Francis Harbor Bight, Labrador. J. Fish. Res. Bd. Can. 14(2):135-140.

Francis Harbour Bight, near the southern end of Labrador, was the center of tagging operations in 1950. Between June 28 and July 18, 74 salmon and 41 grilse, caught in commercial gear, were tagged. In this area, the salmon run is from about June 10 to July 31 with a peak around June 30. The grilse run is from about July 1 to August 1-5 with a peak around July 20. Therefore, tagging covered the 5end of the salmon and the beginning of the grilse runs.

There was a 15% return of tagged salmon, all taken with commercial gear, in Labrador, both north and south of the tagging site. The greatest distance traveled was 186 miles, and the fastest rate of travel was 17 miles per day. Just over 7% of the tagged grilse were recaptred,

indicative of the low fishing effort on these smaller fish. The fishermen are mainly concerned with the larger salmon taken as by-catch to the cod fishery.

Child, A.R. 1980. Identification of stocks of Atlantic salmon (Salmo salar L.) by electrophoretic analysis of serum proteins. Rapp. P.-v. Reun.Cons. int. Explor. Mer, 176:65-67.

Electrophoretic analysis of the serum proteins of Atlantic salmon was chosen to locate possible distinctive protein polymorphisms which would lead to the identification of regional stocks within a mixed population. Differences were found in the disrtibution of transferrin phenotypes within the North American population; however, the overall picture obtained illustrated the very close similarities between the North American and British Isles stocks

Cutting, R.E. and A.L. Meister. 1967. Marine migration of Atlantic salmon kelts tagged in Maine, U.S.A. ICNAF Redbook part III:58-65.

During 1962-65, the State of Maine tagged a total of 788 spawning fish in the Narraguagus River. Of those an estimated 580 fish were expected to have survived spawning. Recaptures provide information on the routes and timing of migration of these salmon. Feeding kelts apparently reach Halifax, N.S. in about 50 days and southern Newfoundland in another 10-20 days. From late summer until mid-autumn they were not seen. They were found along the Greenland coast during late autumn, and by early winter were heading back toward natal rivers, appearing in the northeastern Newfoundland fisheries, at weights of 15-20 pounds (7-9 kg).

Eisner, R.A. and J.A. Ritter. 1979. The Canadian Atlantic salmon (Salmo salar) smolt tag and its recovery system: A review. ICES C.M.1979/M:24.

A variation of the Carlin tag is being used to assess the relative survivals and contributions to fisheries of groups of hatchery-reared and wild Atlantic salmon smolts. The strengths and weaknesses of this tag are reviewed. The inherent errors of loss, differential mortality, differential growth and non-reporting are variable. However, this tag, unlike some newer tagging techniques, as coded wire tags, is useful in following the distribution and migration of salmon since they can be recovered in any area without special recovery equipment.

Elson, P.F., and K.A. Pyefinch. 1973. The International

Smolt Tagging Tests, 1959-69. ICES CM1973/M:19.

Three smolt tagging tests were carried out to meet the recommendations of ICES regarding experiments on the comparitive values of various types of tags and methods of tagging for Atlantic salmon. The first experiment (1959-63) involved teams from England, Ireland, Norway, Scotland and Sweden visiting tagging operations in each country; while the other two tests involved observations in the host country (Sweden in 1966 and Canada in 1969). Overall participation involved representation from Canada, England, France, Ireland, Norway, Scotland, Sweden and the USA. The results from the first series of tests were inconclusive, though proportionate recaptures were much higher in the Baltic than in other areas and there was a tendency for higher proportionate recaptures of wild than hatchery-reared fish. The results of the second two tests indicated that: there was no difference in the two anaesthetics used; that stainless steel wire attachments were more effective than silver wire but as effective as polyethylene; that the conspicuousness of the tag is important; and that the skill of the tagger probably has an important effect on the proportionate recapture of tags.

Fournier, D.A., T.D. Beacham, B.E. Riddell, and C.A. Busack. 1984. Estimating stock composition in mixed stock fisheries using morphometric, meristic, and electrophoretic characteristics. Can. J. Fish. Aquat. Sci. (41):400-408.

A conditional maximum likelihood procedure for estimating stock composition in a mixed-stock fishery, provided that samples can be collected from the contributing stocks in isolation from each other and that characters exist that differ significantly between stocks, is described. The procedure presented can use discrete (electrophoretic, meristic) or continuous (morphometric) data or any combination of these data. The procedurewas tested by simulations and is used to estimate stock compositions of chum salmon sampled in a test fishery near Vancouver Island, B.C., in 1981. The estimated composition in the test fishery agreed closely with the results of previous tagging studies in the same area.

Gray, R.W. 1973. Preliminary assessment of the contribution of hatchery-reared smolts (Salmo salar L.) relaesed in 1970-71 in the Saint John River, New Brunswick, to various fisheries and the spawning escapement. ICES, CM1973/M:25, 17p.

A total of 94,565 hatchery-reared smolts were released in the St. John River in 1970 and 1971 to assess their contribution to the various fisheries, and to spawning escapement. From the 1970 smolt release, 1.99 adult

recaptures per 1,000 smolts were recorded, while for 1971 the return rate was 6.56 per 1,000 released. Major exploitation on these stocks occured in distant fisheries, especially in ICNAF Area 1, off West Greenland. Homing precision of hatchery-reared salmon to their rivers of release was high, although they had a lower tendency to home to a specific site than wild salmon.

Huntsman, A.G. 1938. Sea movements of Canadian Atlantic salmon kelts. J. Fish. Res. Bd. Canada. 4(2):96-135.

Salmon related to various rivers of eastern Canada were tagged and liberated after spawning in various years from 1913-1936. Analysis of recaptures showed varied movements, between rivers and for a given river between years, due to differences in the environment. For rivers with a distinct zone of influence in the sea, as the St. John river of New Brunswick, salmon tend to remain near the river mouth. For rivers with indistinct zones of influence, more of the salmon tend to wander to other regions, largely in correspondence with water movements. Unusally pronounced movements of water masses in a given year may be the primary reason for differences in the proportion of distant movements of salmon, from their rivers of origin. The length of time between successive spawnings was found to correspond with the time between the smolt stage and first spawning and to be related to sea temperature during the spring and summer.

Jessop, B.M. 1976. Distribution and timing of tag recoveries from native and non-native Atlantic salmon (Salmo salar) released into Big Salmon River, New Brunswick. J. Fish. Res. Board Can. 33:829-833.

Recaptures of tagged Atlantic salmon released as smolts into the Big Salmon River varied between annaula releases with no differences found between native and non-native origin. Distant water fisheries off Newfoundland and Greenland take few salmon from the Big Salmon River. Most recoveries occurred in the Bay of Fundy.

Lear, W.H. and E.J. Sandeman. 1980. Use of scale characteristics and a discriminant function for identifying continental origin af Atlantic salmon. In ICES/ICNAF Joint Investigations on North American Salmon. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 176:68-75.

Discriminant function analysis was applied to scale characteristics of Atlantic salmon to classify continent of origin of salmon caught off West Greenland. The North American:European ratio during 1969 was 46:54, or

approximately 50:50. During 1970 the contribution of North American origin salmon, based on this analysis, dropped to 34%. In 1972 the estimated percentage of North American origin salmon was 35%. These estimates were generally similar to those determined by tagging and serum transferrin polymorphisms studies. Comparative analyses of scale characteristics and serum electrophoresis based on samples collected from 1,033 salmon at West Greenland during 1974 and 1975 suggested that both methods yielded similar estimates of continental proportions.

Lear, W.H. and R.K. Misra. 1978. Clinal variation in scale characters of Atlantic salmon (Salmo salar) based on discriminant function analysis. J. Fish. Res. Board Can. 35:43-47.

Scales of adult Atlantic salmon were collected from 18 river systems in eastern North America, from Labrador to Maine, and at Nova Scotia, during 1968, 1973-75. Analysis of four scale characters, namely circuli in first annual river zone, circuli in second annual river zone, smolt age, and circuli in first annual marine zone, demonstrated that significant differences occurred in each of these characters between river systems and latitude. The numbers of circuli in each of the three growth zones increased from north to south, while the smolt ages decreased from north to south. A discriminant function applied to these four characters employing latitude as a "dummy" variable indicated that the discriminant function contributed significantly to the clinal trend and 73.7% of the total variation was explained by this discriminant function.

Lear, W.H. and R.H. Payne. 1973. Estimate of immediate tagging mortality of adult Atlantic salmon. ICES/ICNAF Salmon Document 15.

Marshall, T.L. 1982. Interception in Nova Scotian coastal waters of Nova Scotia salmon returning to home rivers. CAFSAC Res. Doc. 82/3. 18p.

Returns from approximately 270,000 tagged smolts released to East River, Sheet Harbour and Liscomb rivers, (1975-79) and the LaHave and Medway rivers (1971-79) were used to determine the proportional losses from southeast (Districts 16/17/19) and southwest (Districts 26-28) Nova Scotia to other district commercial fisheries in Nova Scotia and the relative importance of these intercepted stocks to landings of the other districts. Of the total projected Nova Scotia commercial harvest of stocks originating in Districts 26-28, 44.7% were taken in the "home" districts, 38.4% were landed in Districts 22/23/25 and 9.5% were caught in District 9. Of the total from Districts 16/17/19, 38.2% were taken in "home" waters,

31.4% were in Districts 22/23/25, and 20.3% in District 9. District 9 and 15 appear to be 90-94% dependent, Districts 22/23/25 41% dependent and Districts 30-32 39% dependent on salmon stocks originating from Districts 26-28 and 16/17/19, collectively.

Meister, A.L. 1972. Preliminary report of salmon tags of Maine (USA) origin recovered from fisheries in the ICNAF Convention Area during 1971. ICES/ICNAF. Salmon Doc. 72/20.

During 1971, 70% of the tags recovered from Atlantic salmon tagged in Maine were from the West Greenland fishery, with only 15% recaptured in homewaters. Most recaptures occurred during August - October off south-western Greenland, though some recoveries were reported between June and November, and throughout the west coast.

Meister, A.L. and R.D. Bond. 1975. A preliminary report on the recovery of tagged Atlantic salmon in the Newfoundland commercial fishery. Prepared for Program Working party on Atlantic anadromous fish. 14pp.

This report discusses the tag return information from Atlantic salmon tagged in Maine, USA and recovered in the Newfoundland commercial fishery during the period 1963-74. Total tag recoveries (364) by month and ICNAF division from the Newfoundland fishery reveal two distinct groups, fish caught during May-August on the south and east coasts and those taken in the September-December autumn fishery off the northeast coast. Post smolts were recaptured off the south coast as early as June 22 and as late as July 28 for releases in early May. The average rate of movement was 11.07 miles per day. Recoveries off the southeast coast occurred between July 13 and August 21 with an average rate of 11.35 miles. Two post smolts recaptured off northeast Newfoundland traveled an average of 9.8 miles per day and were taken in mid-August and early September. Salmon recovered after one or more years at large (243) were also taken along the south and east coasts of Newfoundland with peak recoveries in June - July and November - December. A total of 106 tags from fish tagged as post-kelt were also recovered, primarily during June - July off southeastern Newfoundland.

Moller, D. 1970. Transferrin Polymorphism in Atlantic salmon (Salmo salar). J. Fish. Res. Board Can. 27(9):1617-1625.

Three main patterns of transferrins, made up of two molecular types, were found by starch-agar electrophoresis in plasma of hatchery and wild Atlantic salmon. Distributions of the observed patterns from progenies of three hatchery matings agreed with expected Mendelain

distributions in offspring of known parentage, implying that the bands have their origin in two codominant alleles. In nearly all samples of the wild salmon the genetic basis of transferrin variation was demonstrated by nonsignificant differences between observed and expected distributions. Frequencies of the TfA allele differed in samples from different rivers and within the same river; the Atlantic salmon forms genetically different populations. Interchange of stocks probably influenced the values of the different gene frequencies found.

Moller Jensen, J. 1980. Recaptures from international tagging experiments at West Greenland. Rapp. P. -V. Reun. Cons. Int. Explor. Mer. 176, p122-135.

This paper summarizes the recapture of Atlantic salmon tagged during 1965 to 1971 in the international tagging experiments at West Greenland and during the expanded ICES/ICNAF tagging program of 1972. Summaries are provided by area, gear, age and time of recapture, in both the Greenland and distant-water fisheries, during 1965-74. Of the 4657 salmon tagged at West Greenland during 1965-72, 93, or 2% were recaptured in distant waters. Most of those recaptures were taken in Ireland (65%) and Canada (30%). For the 1972 tagging experiment, 2.3% of the total number tagged were recovered, 88% of those in 1973, and 12% in 1974. Canadian recaptures accounted for 21%, Scotland for 43%, England for 16%, Ireland for 14%, France for 4% and Spain for 2% of the fish tagged during 1972.

Nyman, O.L., A.W. May, and A.L. Meister. 1971. Continental origin of Atlantic salmon from West Greenland and the Labrador Sea in 1970. ICES/ICNAF salmon Doc. 71/3, 6p.

Blood samples of 204 Atlantic salmon taken in the Labrador Sea and at West Greenland in the autumn of 1970 were analysed to determine continental origin of the individual fish. Forty-nine percent were identified as North American in origin; 51% as European. Size and age data of each group tended to support the results of the biochemical analysis.

Nyman, O.L. and J.H.C. Pippy. 1971. Techniques to identify continental origin of Atlantic salmon caught at sea. ICES/ICNAF Salmon Doc. 71/2. 21p.

Starch gel electrophoresis revealed hereditarily determined differences between the proteins of Atlantic salmon from North America and Europe. These differences could be used to classify individual fish caught at sea. Analyses of salmon samples of mixed origin caught off West Greenland indicated 43% North American fish. Collections in the southern part of the Labrador Sea indicated that salmon of European origin occur close to the Canadian

continental shelf. Division of salmon according to continental origin is supported by evidence from smolt age distribution, mean fork length and abundance of two parasites. Consistent qualitative differences in the proteins of the salmon from the two continents indicate they belong to different gene-pools and suggest that the two types are different subspecies, according to accepted definitions.

Paloheimo, J.E. and P.F. Elson. 1974. Effects of the Greenland Fishery for Atlantic salmon on Canadian Stocks. Int. Atl. Salmon Found. Spec. Pub. Ser. 5(1):33p.

Tag returns show that substantial numbers of salmon produced in the Canadian Maritimes are caught in Greenland waters. The percentage recoveries in the home river system studied (Miramichi) show a gradual decline which is significantly correlated with the gradual buildup of catches in Greenland. Detailed data collected on the Miramichi system since 1950 indicate that the onset of the Greenland fishery is one of the major, if not the most significant, changes to take place in fishing affecting Canadian Atlantic salmon since that time.

Payne, R.H. 1974. Transferrin variation in North American populations of the Atlantic salmon, Salmo salar. J. Fish. Res. Board Can. 31: 1037-1041.

A laditudinal cline was indicated by the frequency of the Tf4 transferrin allele in North American populations of the Atlantic salmon and an earlier suggestion of a major genetic discontinuity between the salmon populations of Newfoundland and those in the Canadian Maritimes is rejected.

Male one-sea-winter fish had a statistically significant deficit of heterozygotes but transferrin phenotypes of one-sea-winter females and two-sea-winter or older fish of either sex agreed closely with predicted equilibria. A comparison of anadromous and landlocked salmon populations from the same river system demonstrated that considerable genetic divergence can take place when postglacial crustal recovery produces barriers to upstream migration. The relative fitness of the transferrin phenotypes may be different for anadromous and nonanadromous life styles. In view of the demonstrated genetic divergence between anadromous and nonanadromous salmon stocks, the practice of improving salmon rivers by removing natural obstructions to upstream migration should be reconcidered in the case of rivers with large stocks of landlocked salmon.

Payne, R.H. 1980. The use of serum transferrin polymorphism to determine the stock composition of

Atlantic salmon in the West Greenland fishery. Rapp. P.-v. Reun. Cons. int. Explor. Mer, 176:60-64.

A method is developed to estimate the proportion of North American and European salmon in the feeding aggregation off West Greenland. The method uses geographical discontinuities in the distribution of alleles at the Tf-locus in home-river populations.

There are marked annual fluctuations in the proportion of North American salmon off West Greenland; 23% in 1970, 53% in 1971 and 20% in 1972. Recently the major contribution to the fishery has been from European salmon stocks; although evidence is presented which suggests thatthe North American proportions were much higher in past years.

The contribution from different salmon-producing regions in Europe and North America also fluctuates from year to year; in 1970 there was a significant contribution from southwest Europe, and in 1971 the abundance of North Amaerican salmon at West Greenland was increased by a large influx from the northern rivers of the species range.

Peet, R.F. and J.D. Pratt. 1972. Distant and local exploitation of a Labrador Atlantic salmon population by commercial fisheries. ICNAF Redbook, Part III:65-71.

Atlantic salmon smolts and adults have been tagged at Sandhill River, in southeastern Labrador, during 1969-71, as part of a program to investigate the origin of salmon being exploited by large commercial fisheries off West Greenland. A large percentage of the population was found to be 2-sea-year virgin fish, while 90 percent of the 2-sea-year fish were taken in commercial fisheries off Greenland and in homewaters. A 6- to 7-fold increase in the recapture rate off Greenland from 1970 to 1971 was attributed the record high catches off Greenland in 1971. Fish were taken from early August to late October in the Greenland fishery between Disko Bay and Cape Farewell.

Pippy, J. (Chairman). 1982. Report of the working group on the interception of mainland salmon in Newfoundland. Can. MS Rep. Fish. Aquat. Sci. 1654: 196p.

This report presents findings of the Canadian Department of Fisheries and Oceans Working Group established in 1975 to investigate the harvest of non-Newfoundland and Labrador origin Atlantic salmon in the Newfoundland and Labrador commercial fisheries. Catches are assessed on a weekly basis and seven management options are presented. This report considers salmon of Canadian origin only, and although it acknowledges that Maine origin salmon contribute to the Newfoundland fisheries, no attempt is made to estimate the impact of proposed regulations on

stocks of USA origin salmon.

Reddin, D.G. and R.F. Burfitt. 1981. Proportion of North American and European Atlantic salmon off West Greenland in 1980. CAFSAC Res. Doc. 81/29. 12p.

The proportion of salmon of North American origin in samples from commercial catches at West Greenland in 1980 was 48% and in the research vessel catch was 58%, as determined by a discriminant function developed by Lear and Sandeman (1980) using scale characters. The exploited stock at West Greenland in 1980 consisted of 59% North American origin salmon. The relative abundance of North American origin salmon at West Greenland has increased from 1978 to 1980. The proportion of salmon of North American origin decreased in the commercial samples from south to north.

Reddin, D.G. and R.F. Burfitt. 1981. Length, weight, sex and age characteristics of Atlantic salmon (Salmo salar) of North American and European origin caught at West Greenland in 1979. CAFSAC Res. Doc. 81/29. 24p.

Atlantic salmon from research vessel catches and samples of commercial catches at West Greenland in 1979 were analysed for fork length, weight and smolt age differences among fish identified to continent of origin (either North American wild or hatchery, or European origin). There were no significant differences in the fork lengths, weights, and smolt ages of male and female salmon, of salmon caught in NAFO div. 1AB and 1CD, and of salmon caught by research vessel and by commercial fishery. However, North American wild origin salmon were shorter, weighed less, and had a higher mean smolt age than did salmon of European origin. The sex ratio was 1:2.69 (males:females) in the research vessel catches. The sex-age composition in the West Greenland commercial catches was sea-age 1- 96.6%, sea-age 1- 2.1%, and previous spawners- 1.3%.

Reddin, D.G. and R.K. Misra. 1978. Multivariate analyses of Atlantic salmon (Salmo salar) caught in the Twillingate fall commercial fishery. ICES C.M.1978/M:11. 8p.

Characteristics of Atlantic salmon scales collected from the mixed stock fishery in the Twillingate, Newfoundland, area during October to December (1974-76) were analysed for area of origin using multivariate analyses. Results indicated that 2% of the sample originated from rivers in Labrador, 21% from Newfoundland, 67% from the Maritimes and 10% from the USA.

Ritter, J.A. 1973. Evidence of variable tag loss among

nine groups of hatchery-reared Atlantic salmon smolts released in 1973. ICES C.M.1973/M:24.

Nine groups of hatchery reared Atlantic salmon smolts, marked with Carlin-type tags were examined to determine the likelihood of immediate tag loss. About 11 percent of spring tagged smolts had either lost tags before release or were expected to lose them shortly after release. One group of smolts was tagged in the fall. Of the fall tagged group, 95 percent had either lost, or were expected to lose the tags shortly after release.

Ritter, J.A., T.L. Marshall, D.G. Reddin, and W.G. Doubleday. 1980. Assessment of the impact of the West Greenland Atlantic salmon (Salmo salar) fishery on stocks and catches in North America. ICES C.M.1980/M:38. 10p.

Quantitative estimates of the impact of the West Greenland Atlantic salmon fishery on stocks and catches in North America were derived using a technique used in the ICES/ICNAF Joint Working Party and incorporating new estimates of natural mortality, growth, non-catch fishing mortality and continent of origin. For each ton of North American origin salmon caught at West Greenland, loss to homewater stocks is estimated at between 1.7 and 2.42 tons. Loss to homewater catches is estimated to range between 1.58 and 2.11 tons.

Ruggles, C.P., and J.A. Ritter. 1980. Review of North American Smolt tagging to assess the Atlantic salmon fishery off West Greenland. Rapp. P.-v. Reun. Cons. Int. Explor. Mer., 176:82-82.

During 1959 to 1971 1,894,000 hatchery and 259,800 wild Atlantic salmon smolts was tagged and released into various rivers in North America. This paper presents a general overview of the recaptures of these smolts in the West Greenland fishery. Hatchery-reared salmon accounted for 75 percent of the North American smolt tags recaptured in the Greenland fishery while 88% of all tagged smolts were hatchery-reared. Nineteen percent of all adult recaptures for smolt releases were returned from the West Greenland fishery. Analyses of results from the 1972 fishery indicate that smolts recaptured as two-sea-winter fish were recovered further north and earlier than the one-sea-winter salmon recaptures. North American salmon were more southern in their distribution than were the European salmon.

Saunders, R.L. 1980. Atlantic salmon (Salmo salar) stocks and management implications in the Canadian Atlantic provinces and New England, USA. Can. J. Fish. Aquat.Sci. 38:p1612-1625.

This paper discusses the diversity of Atlantic salmon stocks from the Atlantic Provinces of Canada and New England, USA. The mixed stock fisheries in Greenland and Newfoundland are considered from the point of view of interception. It is concluded that identification and management of specific stocks in the Greenland fishery are impractical at present, but that identification of North American components, using discriminant function analysis of scale growth patterns and smolt tagging should be continued. Since it is impractical now to manage the fisheries by stocks, it is suggested that it may be possible to characterize an assemblage of like stocks from given areas and to identify and manage for these in large mixed-stock fisheries.

Turner, G.E. 1973. Migration route and timing of Mirimichi River salmon (Salmo salar) as indicated from recaptures of tagged smolt and adult salmon. ICES C.M.1973/M:23.

Post-spawning adults tagged in the Mirimichi estuary were recaptured in different areas off Newfoundland than were 2-sea-year virgin salmon tagged as smolts, indicating differences in migration routes. Recaptures of salmon tagged as smolts came from the more southerly fishing areas off Greenland, early in the season. No difference was found in mean recapture dates among ICNAF Statistical areas for either 1- or 2-sea-year salmon. However, significant differences were noted between areas 3K and 3L, off Newfoundland's east coast.

Wilkins, N.P. 1972. Biochemical genetics of the Atlantic salmon Salmo salar L. I. A review of recent studies. J. Fish. Biol. 4:487-504. and II. The significance of recent studies and their application in population identification. pp 505-517.

These papers review recent studies of blood group and protein polymorphisms in Atlantic salmon conducted to indentify individuals of different spawning populations in the high seas fisheries. In general, this paper concludes that different spawning populations can not be identified in high seas fisheries using these protein characters, although it may be possible to identify the continent of origin (North America or Europe) of some individuals. The paper also discusses the contradictory evidence for proposals to assign separate sub-species to the N. American (S.s. americanus) and the European (S.s. europaeus) populations. The possible role and future direction of studies on the biochemical genetics of salmon are also outlined.