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Use of Scales to Determine Mainland Origin of Atlantic Salmon caught in Offshore Waters

by

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The Atlantic salmon (Salmo salar) is the most highly prized fish in most areas where it occurs. The fish is valuable to the commercial fisherman and to the angler on both sides of the North Atlantic Ocean. From prehistoric times this fish has been caught in coastal waters in or near its natal stream, but only recently has fishing for the Atlantic salmon been started on a commercial scale in offshore waters.

Catches of Atlantic salmon in international waters off Greenland have increased during the early and mid-1960's. In 1969, 2,144 metric tons (4,726,662 lbs) were caught. This amounted to almost one-fifth of the total commercial catch from the North Atlantic Ocean, excluding the Baltic Sea. Methods to determine the mainland origin of this fish, caught far from its natal stream, are urgently needed to assess the impact of this additional exploitation on parent populations already threatened by overfishing, pollution, and the accelerated encroachment by man on its environment.

From August through October 1970, I was detailed to the Department of Agriculture and Fisheries for Scotland on a cooperative study, financed by the Natural Environment Research Council for Britain and by the National Marine Fisheries Service (former Bureau of Commercial Fisheries) of the United States to determine if scale techniques similar to the ones I had developed for Pacific salmon (Oncorhynchus spp.) could be applied to Atlantic salmon to identify the mainland area of origin of fish taken in offshore waters.

It is my objective here to present a cursory review of my work with the collections of Atlantic salmon scales and to offer suggestions for future studies of this type. I will pay particular attention to the need for standardizing the procedures for collecting scales.

CURSORY EXAMINATION OF SCALES AND OF PROCEDURES FOR COLLECTING SCALES

There are vast collections of scales from Atlantic salmon. Just how many of these are suitable for use in stock identification studies is subject to question, however, as many of the scales were lifted from varying or even unspecified parts of the fish's body. We know for both the Atlantic and Pacific salmon that scales can vary considerably from one body location to another.

To determine which locations on an Atlantic salmon's body yield scales with fairly uniform features and which locations do not, I undertook a simple experiment. From each of two fish--a large adult and a grilse--I removed and compared scales from several different body locations. Figure 1 shows the scales from the larger fish; scales from the grilse varied similarly. As expected, the size and shape of the scales varied considerably between areas particularly for scales originating near the fins and gill opening. In fact, about the only thing that most of these scales had in common was the number of winter marks. Scales from different body locations of Atlantic salmon might be suitable, therefore, for aging purposes but not for stock identification studies.

On the other hand, the size and shape of scales taken from the sides of the fish below the dorsal fin varied considerably less. Moreover, the number of circuli in the freshwater and first ocean zones of scales from this location (scales A, B, G, and H in figure 1) did not vary substantially. Scales A, B, and H each had 27 circuli in the freshwater zone and 40 in the first ocean zone. Scale G had 26 and 42 circuli in the two zones respectively. Examination of limited numbers of other scales from these same body areas indicated that the number of circuli in the freshwater and first ocean zones do not vary substantially from the counts reflected by scales A, B, G, and H.

SUGGESTION FOR FUTURE COLLECTION OF SCALES FOR STOCK IDENTIFICATION STUDIES

The shoulder area (scale B, figure 1) has long been a preferred area from which to select scales. However, it has not been the only area that has been used. Jarvie and Menzies, (1936) for example, although they did not specify the precise location from which their scales were taken,

did point out that in their work with Finnish salmon, scales were taken from the area between the lateral line and the adipose fin. They concluded, however, that for growth studies, scales from the area immediately above the lateral line and below the dorsal fin were best. This agreed with the findings of a group of salmon and trout experts who after meeting in Poland in 1933, recommended that for growth calculations, scales should be taken between the lateral line and dorsal fin, i. e., from shoulder area (Cons. Perm. Int. Explor. Mer., 1933).

Because a good proportion of the scales collected from Atlantic salmon were destined for growth studies and as such were selected from the shoulder area, a good proportion are suitable for stock identification studies. An equally large proportion, collected for aging studies, came from locations other than the shoulder area or from areas unspecified. These scales are not suited for stock identification studies.

Because many fishery agencies now take scales from the shoulder area and because the area probably provides suitable scales, future collections should be from that area of the fish providing that they are not from the lateral line itself nor from the rows immediately below the dorsal fin. In any event, the scale analyst should know from which area of the fish's body the scale was selected. To accomplish this I suggest that an outline of a fish be printed or rubber-stamped on each scale envelope and that the field worker taking the scales indicate by an "X" on the fish outline, the position from which the scales were taken. This will identify the position for each sample and will eliminate doubt as to whether the scales are suitable for growth and racial studies or are only for age determination. A suggested fish outline is shown in figure 2.

PRELIMINARY EXAMINATION OF SCALE FEATURES

Working with scales that were known or appeared to come from the shoulder area of the fish, I have come across certain suggested trends which may ultimately be useful for determining the origin of Atlantic salmon captured at sea. My findings are summarized here.

Most fish taken off Greenland (August to November) have spent 1 winter in the sea (age .1). These would then become the age .2 fish (2 winters at sea) in mainland streams if they returned to spawn the

following year. Scales of most of the fish that have more than 1 winter zone in these offshore areas have spawning checks. These are caused by resorption of the scale margin upon the approach of spawning. Resorption may be very severe (especially in the males) and destroy many of the marginal circuli. When the fish returns to the ocean, the irregular margins of the scales are repaired and definite scars are formed. These can be counted to determine the number of times the fish has spawned. Since the resorption may in some cases eliminate all circuli of a winter mark, only the circuli of the first year's growth in the ocean are undisturbed.

Consequently for the first phase of this study, I determined the freshwater, ocean, and total age of the individual fish. I then counted and tabulated the number of circuli in the first ocean zone of the age .2 fish from the following areas:

Scotland - Tay River

Tweed River

Norway - Lofoten Islands

Canada - Carleton and Bona Vista, Newfoundland[1/]

U.S.A. - Maine[2/]

Small numbers of scales from Sweden and Greenland

Typical scales from fish of each area with various freshwater growth patterns and ages were photographed to document the variations noted.[3/]

Frequencies of the number of circuli in the first ocean zone of the age .2 fish from these areas are shown in Table 1. It appears that the mean number of circuli varies between some areas and that, on the average, scales from fish taken in northern spawning regions have more circuli than scales from fish taken in the southern spawning regions. The data suggest that the number of circuli in the first ocean zone could be used to determine area of origin of some salmon taken at sea.

I also searched for consistent patterns in the spacing of circuli in the first ocean zone of fish originating in different areas. In sockeye salmon from the Pacific Ocean, for example, circuli spacing in the first ocean zone varies considerably and consistently depending on the mainland origin of the fish. On scales of sockeye from Bristol Bay, Alaska, the first few circuli of the first ocean zone are usually widely

spaced, while on scales of sockeye from most other areas, the first few circuli are closely spaced with wider spaced circuli often occurring near the first winter zone.

In the present study I examined the spacing of the circuli in the first ocean zone of scales from the areas listed in Table 1. None of these samples, however, reflected a consistently unique pattern of circuli spacing. In most instances the circuli were widely and evenly spaced over the whole summer portion of the growth zone.

Numerous tabulations of the freshwater age of Atlantic salmon from various areas are available in the literature. A tendency has been noted for fish to migrate to sea at a younger age in the more southerly areas. In the samples that I examined, this tendency was also evident.

SUMMARY AND CONCLUSIONS

1. For racial studies, scales should be taken from a "standard" position on the body, preferably from the shoulder area. Body position from which the scale was taken should be recorded for each scale.

2. Studies should be expanded to include additional mainland areas.

3. My analyses suggest that a method of determining the mainland area of origin of Atlantic salmon taken in offshore waters might be found by using: (a) the number of circuli in the first ocean zone, (b) the freshwater age of the fish, and (c) the general appearance of specified portions of the scales (such as the freshwater zone and/or the ocean zone). Additional samples, however, must be obtained to confirm these preliminary findings.

4. As additional material is made avialable to me, I plan to include them in my studies. The final report on this project will appear as "An Atlas of Atlantic Salmon Scales" patterned after similar atlases (now under technical review) on sockeye, pink, chum and coho salmon. In the atlas, variations of the scales by area will be shown by photographs, and greater detail will be presented regarding a technique to determine the areas of origin by means of scales.

Table 1 Number of circuli in the first ocean zone of age .2 Atlantic salmon. (Percentage frequencies, smoothed by threes.)

No. of circuli	Ireland	Scotland River Tay	Scotland River Tweed	Norway Lofoten Islands	Greenland 1/ Spawners	Canada Bona Vista	Canada Carleton	USA Maine
12				0.1				
13				0.4				
14				0.6				
15				1.7				
16				4.2				
17				7.1				
18				9.3*				
19				8.8	2.8			
20				6.9	7.2			
21				6.1	11.1	0.5		
22				5.3	18.3	2.8		0.2
23				4.6	23.3*	6.2	1.1	0.8
24				4.2	18.9	7.7	4.8	2.9
25				3.8	11.1	8.0	9.9	5.6
26				3.8	5.6	10.3	13.6	8.1
27		0.2	0.2	4.4	1.7	12.9*	15.5	11.6
28		1.7	1.0	5.1		11.3	15.5*	15.8
29	0.1	5.6	3.1	5.6		9.5	14.7	17.8*
30	0.4	9.7	6.3	5.7*		9.3	13.6	15.1
31	0.4	12.1	10.2	4.4		6.7	8.5	10.8
32	0.8	14.6	14.1	2.6		4.9	2.6	7.3
33	1.6	16.0*	15.6*	1.9		4.9	0.4	3.3
34	2.7	14.7	14.6	1.7		3.1		0.6
35	5.0	11.8	12.5	0.8		0.8		
36	7.2	8.0	9.0	0.3		0.3		
37	8.8	4.0	5.7	0.1		0.5		
38	9.8	1.3	3.9			0.3		
39	10.4	0.2	2.4	0.1				
40	11.6*		0.9	0.3				
41	11.3		0.3	0.1				
42	8.5		0.1					
43	6.6							
44	5.8							
45	4.1							
46	2.5							
47	2.3							
48	0.6							
49	0.4							
50	0.1							
Total number	212	204	319	180	45	97	68	157
Average	39.72	32.86	33.61	23.46	22.91	27.85	27.82	28.69

1/ Samples from Greenland streams obtained since returning to Seattle. Actual frequencies smoothed by formula: $\frac{a+2b+c}{2}$

where a, b, and c are the consecutive units being smoothed.

* = modes

FOOTNOTES

1/ Thanks are due to Dr. A. W. May, Fisheries Research Board of Canada, St. John's, Newfoundland, for the loan of these scale samples.

2/ Thanks are due to Dr. A. L. Meister, Atlantic Sea Run Salmon Commission, Bangor, Maine, U.S.A., for the loan of these samples.

3/ Considerable time was required to adapt photographic techniques to the scale projection equipment and photographic materials available. These scale photographs will be incorporated in an Atlas of Atlantic Salmon Scales to show the variations by locality.

LITERATURE CITED

Conseil Permanent International pour l'Exploration de la Mer.

1933. Report of the meeting of salmon and trout experts in Poland—October 1933. Cons. Perm. Int. Explor. Mer, Rapp. Proc.-Verb. Réun. 91. 3-10.

Järvi, T. H., and W. J. M. Menzies.

1936. The interpretation of the zones on scales of salmon, sea trout and brown trout. Cons. Perm. Int. Explor. Mer. Rapp. Proc.-Verb. Réun. 91: 63 p.

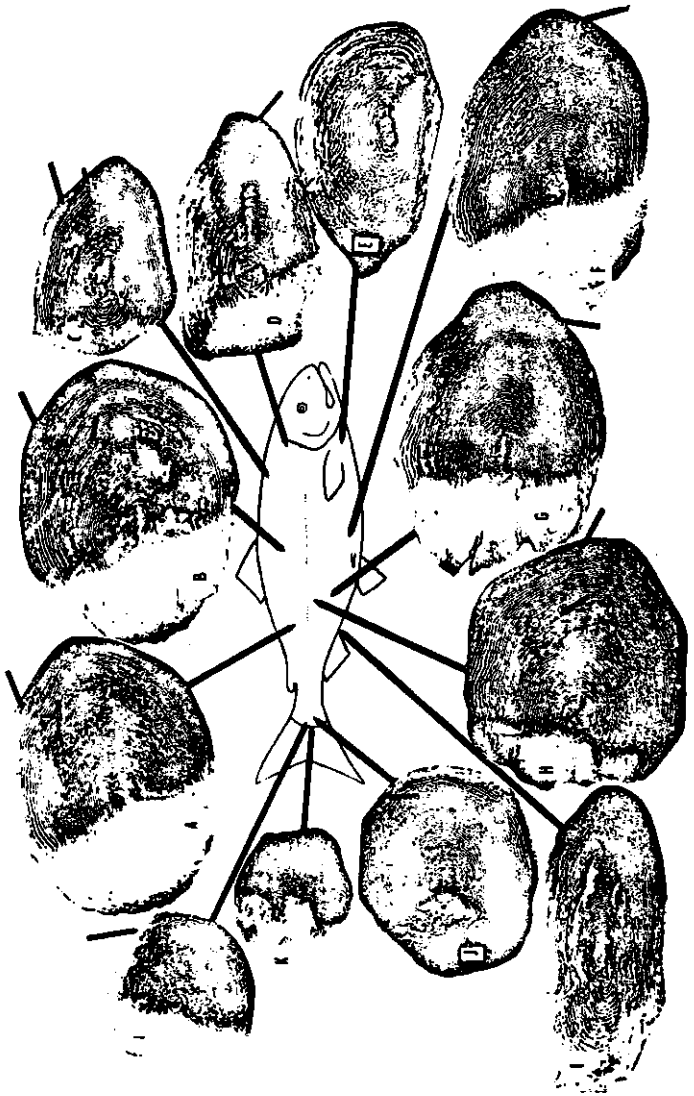

Fig. 1. Relative size, shape, and appearance of scales from various positions on the right side of the body of an Atlantic salmon. (Pointers indicate winter marks in the ocean growth zone, where evident.)

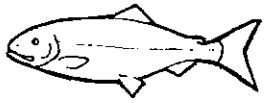

Figure 2.--Suggested fish outline for imprinting on scale envelopes.