Report of the

Study Group on Salmon Scale Reading Problems

Helsinki, Finland
12–14 November 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

https://doi.org/10.17895/ices.pub.9176

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1 INTRODUCTION

1.1 Main tasks

The **Study Group on Salmon Scale Reading Problems** (SGSSR) (Chair: E. Ikonen, Finland) met in the premises of the Finnish Game and Fisheries Research Institute in Helsinki, from 12–14 November 2001.

The Terms of References are as follows:

a) review and discuss the progress in Baltic salmon scale interpretation;

b) review the results from the Workshop on Usefulness of Scale Growth Analyses and Other Measures of Condition in Salmon (WKUS- C.Res.1998/2:60);

c) select material for the evaluation of the accuracy in scale reading.

SGSSR will report by 10 December 2001 for the attention of the Baltic Committee.

1.2 Participants

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Viilman M-L.	Estonia

Addresses of the participants are given in Appendix 1.

2 THE PRESENT SITUATION AND PROGRESS IN BALTIC SALMON SCALE INTERPRETATION

Denmark

The Danish salmon fishery is an open sea fishery, and all salmon catches are landed at two companies in Rønne at the west coast of Bornholm. All landings are from long line and drift net fishing in the Main Basin. In the year 2000 were salmon landed at Bornholm by countries as follows:

- Danish vessels 400 tonnes
- Swedish 150 tonnes
- Finnish 40 tonnes
- Polish, etc. few

The salmon landed are recorded by weight groups, and the weight groups are divided as follows; 1.5–2.5, 2.5–3, 3–4, 4–5, 5–7 7–9, 9–11 and more than 11 kilos. Scale samples are collected only from the weight groups 3kg upwards. Sampling is stratified temporally so that about 30 scale samples are collected per each weight group in each month during the fishing season from October to June. In total about 1000 samples have been collected annually. There are no salmon rivers in Denmark and therefore neither parr nor smolt samples exist.

Practically all reading of salmon scales is carried out by one person working at the Danish institute for Fisheries Research in Charlottenlund. Only sea age of the fish has been determined. No special equipment is used, but the age is

determined visually directly from the scales by a microscope. Distances of the annuli are measured for the back calculation of length and for the growth analysis. Samples have a large variation in terms of origin, due to the well-known fact that all Baltic salmon populations are represented in the Danish catches. This makes the age determination of the samples very demanding.

Estonia

Reading of the salmon scales takes place in two laboratories: Institute of Animal Science at Tarto University and in Estonian Marine Institute in Tallinn. Sampling of adult salmon has been 100–200 specimen annually in the last few years and they have been collected mainly from the brood stock fishery. Number of parr samples has been about 100–250 fish per year. Majority of the samples are from the Gulf of Finland area and the minor part is from the Gulf of Riga.

The persons carrying out the scale reading has changed during the course of the years. Today the work is conducted mainly by three persons. No special equipment is used, but the age is determined visually directly from the scales by a microscope.

Finland

In Finland, the scale reading of salmon samples takes place in Finnish Game and Fisheries Research Institute where the work is carried out by four persons, two of them ageing Baltic Salmon and the other two the salmon from rivers flowing to the Arctic Ocean. The amounts of Baltic salmon scales read are presented in Table 1.

Table 1. Amount of read salmon scale samples in Finland in 1999–2001.

Adults:

	Gulf of Finland	Gulf of Bothnia	River Tornionjoki	Other
1999	300	1000	1200	150
2000	170	2500	500	-
2001	Not aged yet	Not aged yet	600	-

River Tornionjoki:

	Smolts	Parr (older than 0+)
1999	1200	800
2000	1000	2500
2001	1700	1700

Sampling of salmon scales in the rivers Teno and Näätämö flowing to the Arctic Ocean has been carried out since 1970s. During the last three years 5,000–10,000 scale samples have been taken annually and age and growth increments have been analysed. Norwegian scientists have taken about half of the samples but analyses have been carried out in Finland.

The scales of adult salmon were read from the polycarbonate impressions. Smolt and parr age were read from the glass-mounted scales.

The age readings have been done visually either with microfiche reading equipment or with stereomicroscope. The salmon were interpreted as wild or hatchery-reared. From the wild fish both the smolt age and sea age was determined. Of fish interpreted as reared only the sea age was determined. Also the possible previous spawnings were noted.

The principles to correct interpretation of salmon scales are achieved by comparing the scales to scales from tagged material. Both wild and hatchery-reared tagged material from several sea areas and rivers is available. However, difficulties are met now and then. Part of released parr in the rivers of the Gulf of Bothnia are not marked with adipose fin clipping and some of these may be interpreted as wild because of similar freshwater zone growth pattern compared

to the wild salmon. In some cases the salmon with two freshwater years are difficult to interpret as wild or reared but these form only a minor proportion of all. Sometimes the age of spawners, especially males, caught in the river are impossible to read because of severely eroded scales.

One of the greatest difficulties was met with the samples from the Gulf of Finland. Among the bulk of samples from reared salmon there are occasionally scales which origin is difficult to determine. The freshwater zone of the scales refers to wild origin but with only sparse reference material this cannot be confirmed. However, it would be important to identify the wild salmon in the catch samples of the Gulf of Finland to estimate the proportion of wild salmon originating from the rivers flowing into the Gulf of Finland. Also by this way it would be possible to follow their migration routes and plan the fishery in the way to avoid the wild salmon as far as possible.

Sweden

Reading of salmon scales in Sweden does normally take place only at the National Board of Fisheries. For the Baltic the purposes centre upon age determination in electro fishing surveys, studies of population structure in index rivers, monitoring of the proportion of wild fish at a few long-term coastal fishing sites and also monitoring at coastal problem spots where wild and reared fish from different stocks are caught in the fishery. No regular sampling is taken from the offshore fishery, but offshore samples are often collected in connection with special projects. As salmon falls into the group of fish species where EU demands a base monitoring of the entire catch, offshore sampling will be extended in the future and perhaps other sampling as well.

During electro fishing surveys in northern Sweden, samples are taken from about 700 parr annually for age determination in order to get proper length-age keys. Samples from about 1,000–1,500 adults are read annually for the other purposes mentioned above. One person is working about 40% of full-time with scale reading and two persons are working more occasional with scale reading.

Russia

Reading of the salmon scales is carried out in State Research Institute of Lake and River Fisheries, St.-Petersburg. Salmon scale samples has been collected from the brood stock fisheries from rivers Neva, Luga and Narva flowing into the Gulf of Finland. Also parr and smolt sampling has been conducted in from these populations, which mainly are of reared origin. Some scale samples of parr of natural origin were collected in the Luga River during electro fishing studies. Scale patterns of salmon from these rivers have special character. Central part of the scale is often eroded indicating the hatchery origin (in the case of Narova and Neva Rivers). After river period there is a transitive zone indicating a gradual transition of salmon from freshwater environment to the marine feeding areas. The transition zone in scales corresponds to a life history near the river mount. Therefore, scale patterns of these three populations can probably be separated from the other populations in the Gulf of Finland. However, the ageing of these salmon is difficult due to frequent pseudoannuli in the transition zone.

In the Kaliningrad area in southeast Main Basin there are no salmon populations and therefore no population samples exists.

Latvia

Not present in the meeting.

Lithuania

Not present in the meeting

Poland

Not present in the meeting.

The data sets concerning salmon scale samples collected and analysed in different countries are presented in Appendix 2.

2.1 Possibilities to utilise image analysis in scale reading

A short review on development and possibilities to utilise image analysis tools was presented to the Group. Image analysis methods have been applied in some of the fisheries research laboratories, however no extensive review on the state of the art was available.

Image analysis tools, which are used in industrial automation routinely, could be applicable also in scale reading. Standard image analysis tools are capable to distinguish accurately and reliably the edge, focus and circuli of the scale image. For example the distances between the circuli are possible to measure and record automatically for the growth analysis. However, to determine the location of annuli by image analysis is unsolved at present and requires an unpredictable amount of development work. Traditionally the criteria for annulus are specified descriptively in handbooks. To utilise image analysis in age determination the criteria for annulus should be specified mathematically. One potential approach could to be to determine the set of rules combining image analysis measurements (location of focus, circuli and edge) with additional information (size of the fish, year and area of catching, known characteristics of various populations). If mathematical specification were solved, the age determination from scales would be more transparent and would make knowledge more transferable between laboratories worldwide.

The Group concluded that image analysis methodology gives promising views. The development of the technology should be followed and a more extensive review on the subject should be carried out for the next meeting.

3 REVIEW THE RESULTS FROM THE WORKSHOP ON USEFULNESS OF SCALE GROWTH ANALYSES AND OTHER MEASURES OF CONDITION IN SALMON

The Group discussed on the report of the Workshop on Usefulness of Scale Growth Analyses and Other Measures of Condition in Salmon and found the following points of interest, which could be useful also in the work with salmon in the Baltic Sea.

Ageing salmon with scales; this procedure is similar in both surroundings, in the Atlantic Ocean and Baltic Sea. However, in the Baltic Sea the number of reared smolt is bigger and due to that ageing of the freshwater period is often difficult. In the Atlantic area the great majority of salmon originates from natural spawning. Concerning marine phase the more regular scale pattern exists in the Atlantic area due to more stable surroundings compared to surroundings and their effects on salmon scales in the Baltic Sea.

Scales as growth indicators; the workshop stated that direct measurements of scale growth has been associated with fish growth and used it to interpret factors affecting the marine survival of salmonids. In particular, the analysis suggests with positive correlation between growth and survival rate at post-smolt phase. Measurements of circuli distances could be facilitated by image processing equipments. It was also observed that the formation of the first annuli is often different depending on river mouth surroundings. Therefore, by the growth pattern of the first marine circuli, it is possible to distinguish salmon originating from separate post-smolt feeding areas in the beginning of the marine phase. With aid of this kind of scale growth analyses salmon originating from different parts of the Baltic Sea could be separated.

Post-smolt survival varies a lot and thus affects greatly on annual recruitment of salmon to the fishing. It would give more predictive power in assessment if post-smolt survival could be forecasted through scale growth during the first winter, a year class enters the sea. Even so, if this analysis could be done from the scales of salmon entered into offshore fishing in autumn, the abundance of a year class entering for spawning migration could be available before the spawning run. Then fishing, directing to spawning migrates, could be adjusted according to the strength of run.

On the basis of tagging and scale sampling data, this analysis could be done concerning the past years. Tagging data suggests quite well survival and scale samples collected from the same fish caught with tag could give a good opportunity to test whether this method is functioning in the Baltic Sea. If so, sampling of post-smolt and 1+ feeding salmon scales would give valuable information on the strength of year class preparing to migrate for spawning.

It is believed that variable post-smolt mortality is related to climatic factors. These factors could also be interesting to check, whether different climatic parameters can be seen to affect on the changes in the scale growth pattern of the post-smolt and thus also foretell direction of changes in the post-smolt survival.

Otoliths: The workshop also found out that on the bases of Sr:Ca ratios reflect life history of salmon due to fact that ratios significantly increases as the fish enter to the marine environment. This has been detected in the oceanic

circumstances. Whether, this can be detected in the Baltic Sea area, where salinity is hardly one fifth of that met in the Atlantic is still unclear.

The other finding in relation to the otolith, is that it is possible by stable isotope analysis determine trends in food web structure.

The workshop also stated that using data collected on otoliths rather than scales gives opportunities to examine growth at daily level rather than examining circuli pairs. As a drawback, the workshop mentions that using otoliths the preparing is rather time consuming and the fish need to be sacrificed to remove otolith.

4 THE EVALUATION OF THE ACCURACY IN SCALE READING

4.1 Problems faced in general

Ageing of salmon in freshwater phase as well as in sea phase contains uncertainty, which magnitude, however, has not been identified. Also the determination of origin (wild/reared) is not infallible. The consequences to the stock assessment have not been evaluated. Nevertheless, scale reading results has been used very limited in the stock assessment for the Baltic salmon. Age compositions have mainly been derived from the tag recovery data. However, almost all taggings have consisted of the hatchery-reared fish. However, abundance of salmon of wild origin has increased considerably during the latest years and is still increasing. Therefore, importance of scale samples taken from the fishing and scale reading data are increasing also in the use of stock assessment.

4.2 Scale reading test

It was decided that a scale reading test of the Baltic salmon will be conducted in SGSSR during 2002 and if needed, continuing in 2003. Details, in which knowledge about the accuracy or precision of salmon scale reading is needed, are:

- interpretation of the fresh water phase of salmon scale – freshwater age
- interpretation of the sea phase of salmon scale – marine age
- interpretation of the origin, i.e., whether the fish is wild or originates from hatchery smolt release

The test material will consist of salmon scales from four areas in the Baltic Sea (groups):

- the Baltic Proper
- the Gulf of Riga
- the Gulf of Finland
- the Gulf of Bothnia

By the end of January 2002, the participants will send salmon scale samples representing these four different areas. The number of samples should preferably be about 100, if possible. About half of the scales in each group should be from wild and half from hatchery-reared salmon. When possible, the scales should be from known aged fish. If the age of the fish is not known, an experts opinion, i.e., an age estimate is asked. The scale bags are to be grouped according to the four areas. The scale samples should be sent to Erkki Ikonen, (Finnish Game and Fisheries Research institute).

Distribution of demands of the scale samples:

The Baltic Proper: Sweden, Denmark, Poland, Lithuania, Latvia
Gulf of Riga: Estonia, Latvia
Gulf of Finland: Estonia, Finland, Russia
Gulf of Bothnia: Finland Sweden

Each scale bag is to include 5–6 good scales of the fish, if available. On each bag, the participants give the information of the fish (date of catch, site of catch, total length, total weight, sex, origin-wild or reared, known age or age estimate). A separate list of the bags including the same data, sorted according to the area, is also wished.

Of these scales, Kari Nyberg (University of Helsinki) and Jari Raitaniemi (FGFRI), who will not attend the ageing test, selected the scales for:

1) ‘Learning material’ of about 100 individuals from different areas of the Baltic Sea to be used in training. Origin of fish –wild or reared must be clear. Of a large part, these scales are from known age fish. All possible information from these fish is given.

Test material to be used in the scale reading test. The number of fish in the material will be solved when all the material has arrived in Helsinki and Lars Karlsson has calculated the minimum needs concerning statistical power. Statistical calculations from the material are to be able to answer to at least most of the questions arisen. For the training and test material scale impressions will be made in Helsinki.

4.3 The rules of the test

The scales are sent to the readers from Helsinki, one laboratory at a time. With the test sample, the readers will get the learning sample for training. Both are to be sent back to Helsinki after the determinations. For training and reading, each laboratory will have at most one month, however, a shorter period will make the test proceed faster.

The readers will be given similar information of the fish as in normal age determination:

- date of catch
- area of catch
    - ICES subdivision
    - river, coastal waters, or offshore
- total length
- total weight
- sex

When reading, the reader will write down

1) an estimate of full years of fresh water age (remember the birthday, 1st April)
2) an estimate of full years of sea age (remember the birthday, 1st April)
3) the existence of possible + growth
4) whether the fish is wild or reared

The reader can also mention, if there is doubt that fish is a repeat spawner or there are other details of the fish readable in the scale.

Example 1: The fish has been caught on the 5th of February, and it has 2 freshwater annuli, 1 marine annulus and an additional summer ring (summer ring = zone of fast growth with a lot of circuli; annulus = about the same as winter ring, i.e., practically almost no growth, few circuli). Its age is thus 2.1+ (or A.1+) and it is interpreted to be wild/reared.

Example 2: The fish has been caught on 5th April, and it has 2 freshwater annuli, 1 marine annulus and an additional summer ring. Because new + growth cannot be detected yet, it’s age is thus 2.2 (or A.2) and it is interpreted to be wild/reared.

After the test, the training material and possibly parts of the test material will form a reference collection of Baltic Salmon scales to be used in the training of age determination. Photographs of the collection will be put on Internet pages as an Atlas.

4.4 Handling of the test material and test results

The scale reading test results of the laboratories participating the test will be handled in the University of Helsinki by Kari Nyberg together with Jari Raitaniemi. The results will be presented for the Baltic Committee in the Annual Science Conference in 2003.

5 RECOMMENDATIONS

1. The group recommends that the development of the technology in the image analysis methodology should be followed and a more extensive review on the subject should be carried out for the next meeting.

2. Indications, that the scale growth pattern in the beginning of post-smolt phase could be used for pre fishery abundance estimations, should be investigated from the collected tag recovery/scale sample data.

3. It should be investigated whether the first post-smolt feeding areas result such features in to the corresponding scale pattern that on these bases sea area from where salmon originates from can be detected.

4. The Group recommends that in the next meeting, the preparation of salmon otoliths for analysing will be demonstrated. This will be done for the ageing and growth analyses purposes. Therefore, for the next meeting, the participants are asked to collect salmon otoliths in addition to scales. The otoliths taken, should be put in small plastic bags that are enclosed in the paper scale bags, this to avoid the vanishing of the otoliths (very small). The thin slice (cross-section) of salmon otolith, examined in a research microscope, may give additional information to scales, especially from the freshwater period.

5. As a very large part of the landings from the open sea fishery of salmon are landed at Bornholm (Denmark, in the year 2000 Danish landings at Bornholm were 400 tonnes, Swedish landings, 150 tonnes, and Finnish landings 40 tonnes) the Group recommends to investigate the possibilities to centralise collection of salmon scale samples caught by offshore fishing in the Main Basin to the fish harbours in Bornholm, Denmark.

6. The Group recommends that a common database, based at the internet, with all kinds of possible information regarding, interpretation of salmon scale, would be of great help to all, and especially new readers, and should be established as soon as possible.

7. The possibility for a need to a co-meeting with the Workshop on Usefulness of Scale Growth Analyses and Other Measures of Condition in Salmon was discussed, and it was decided that the Chair makes enquires about the themes discussed there to find out how useful such a meeting would be.

8. The next meeting of the Study Group was agreed to be held in October 14–15 2002 in Stockholm, Sweden.

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APPENDIX 2 – SCALE SAMPLES AND OTHER DATA FOR SALMON STOCKS OF THE BALTIC SEA AREA

Data types = information of the salmon sample, length, weight, sex etc.
Scale preparation = how thw scale samples have been prepared; impressions, glass mountings
Analysis to Date = information recieved from the samples; age, growth etc.

Country	ICES Sub-div.	Offshore/ coastal/ river	River name	Data Types	Duration	Scale Preparation	Analysis to Date	Remarks
Finland	25-28	offshore		length, weight, sex	(1949)-1980→	impressed	age; wild/reared	
Finland	31	coastal		length, weight, sex	1971→	impressed	age; wild/reared	
Finland	31	river	Oulujoki	length, weight, sex	1947	impressed	age; wild/reared	
Finland	31	river	Simojoki	length, weight, sex	1980→	impressed	age; wild/reared	
Finland	31	river	Tornionjoki	length, weight, sex	1980→	impressed	age; wild/reared	
Finland	31	river	Kiiminkijoki	length, weight, sex	1997→	impressed	age; wild/reared	
Finland	30	coastal		length, weight, sex	1973→	impressed	age; wild/reared	
Finland	30	offshore		length, weight, sex	1973→	impressed	age; wild/reared	
Finland	30	river	Kokemäenjoki	length, weight, sex	1994-1996	impressed	age; wild/reared	
Finland	29	coastal		length, weight, sex	(1960)-1980→	impressed	age; wild/reared	
Finland	29	offshore		length, weight, sex	1980→	impressed	age; wild/reared	
Finland	32	coastal		length, weight, sex	1980→	impressed	age; wild/reared	
Finland	32	offshore		length, weight, sex	1974→	impressed	age; wild/reared	
Finland	32	river	Kymijoki	length, weight, sex	1982→	impressed	age; wild/reared	
Estonia	32	river	Kunda	length	1996→	scales	age; wild	parr
Estonia	32	river	Selja	length	1996→	scales	age; wild/reared	parr
Estonia	32	river	Selja	length, weight, sex	2000-2001	cleaned	age; wild/reared	adult
Estonia	32	river	Valgejõgi	length	1996-97; 00-01	scales	age; wild/reared	parr
Estonia	32	river	Jägaala	length	2000-01	scales	age; wild	parr
Estonia	32	river	Pirita	length	1992; 00- 01	scales	age; wild/reared	parr
Estonia	32	river	Keila	length	1996→	scales	ages; wild	parr
Estonia	32	river	Vasalema	length	1996→	scales	ages; wild	parr
Estonia	28	river	Pärnu	length	1996→	scales	ages; wild	parr
Estonia	32	river	Narva	length, weight, sex	1998-2001	cleaned	age; wild/reared	
Estonia	32	coastal		length, weight, sex	1997-2001	cleaned	age; wild/reared	
Russia	32	river	Luga	length, weight, sex*	1999→	scales	age; wild/reared	
Russia	32	river	Narova	length, weight, sex	2000→	scales	age; wild/reared	
Russia	32	river	Neva	length, weight, sex	1999→	scales	age; wild/reared	
Sweden	31	river	Luleälven	length, weight, sex	1955-2000	scales	age	
Sweden	31	river	Skellefteälven	length, weight, sex	1957-1960, 1962-2000	scales	age	
Sweden	31	river	Umeälven	length, weight, sex	1956-2000	scales	age	
Sweden	30	river	Ångermanälven	length, weight, sex	1954-2000	scales	age	
Sweden	30	river	Indalsälven	length, weight, sex	1952-2000	scales	age	
Sweden	30	river	Ljusnan	length, weight, sex	1958-2000	scales	age	
Sweden	30	river	Dalälven	length, weight, sex	1957-2000	scales	age	
Sweden	25	river	Mörrumsån	length, weight, sex	1958-1966, 1971-1993	scales	age	
Sweden	21	river	Lagan	length, weight, sex	1951-1963, 1966-2000	scales	age	