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## Report of the Study Group on Salmon Age Determination (SGSAD)

14-15 November 2006

Riga, Latvia



International Council for the Exploration of the Sea  
Conseil International pour l'Exploration de la Mer

**International Council for the Exploration of the Sea  
Conseil International pour l'Exploration de la Mer**

H.C. Andersens Boulevard 44-46  
DK-1553 Copenhagen V  
Denmark  
Telephone (+45) 33 38 67 00  
Telefax (+45) 33 93 42 15  
[www.ices.dk](http://www.ices.dk)  
[info@ices.dk](mailto:info@ices.dk)

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## **Executive summary**

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The meeting of the **Study Group on Salmon Age Determination** [SGSAD] (Chair: J. Raitaniemi, Finland) was held from the 14–15 November 2006 in Riga, Latvia. The main issue was to examine a sample of 50 photographic images of scales from known-aged Baltic salmon together. The photographs were projected on the screen, and each participant first read the age of each specimen, after which the scales were discussed. As the next stage, it was decided that a larger sample of scales or scale impressions, including 50 specimens from each part of the Baltic Sea, preferably of known age, will be circulated among the members in a blind test. Of both already examined scales and the new sample, a reference collection as photographs will be created.

Otoliths of salmon have been studied as an additional calcified structure. Removal of otoliths from Atlantic salmon may require opening the skull from upwards, as the first attempt to take the otoliths from downwards without leaving noticeable marks to the head failed. In neutral red stained otoliths, annual rings were detectable, but the quality of the staining was lower than with sea trout, and it was concluded that it is necessary to continue the study before conclusions can be drawn. It may also be possible to use otoliths in other purposes, e.g. in the estimation of migrations and the research on factors that affect the stocking success.

The Study Group decided that from now on, 1 January will be used as the date of the birthday of salmon in the Baltic Sea, following the general interpretation of the fish birthday. In special types of biological work, other dates can be used, and then properly described.

When continuing the work on the quality assurance of age determination of salmon, SGSAD will take into account the practices and recommendations in the other ageing groups of BSRP and the two EU projects that concentrated on improving the quality of age determination, EFAN and TACADAR. It was decided that the next meeting of SGSAD will take place in the late autumn of the year 2008.

## **1 Opening of the meeting**

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The meeting of the **Study Group on Salmon Age Determination** [SGSAD] (Chair: J. Raitaniemi, Finland) that took place from the 14–15 November 2006, was opened at 9.30 am on Tuesday 14 November in the premises of the Latvian Fish Resources Agency (LATFRA), Daugavgrivas Street 8, LV-1048 Riga.

## **2 Adoption of the agenda**

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The following ToRs, mainly decided in the previous meeting of the group in 16–17 October 2002 in Stockholm, Sweden, were to be examined and discussed in the meeting:

- a) review available image analysis systems, in particular those which are in use for age determination of salmon;
- b) evaluate the status of analysis of Baltic salmon otoliths, and in particular the possibilities to increase the resolution to facilitate interpretation of otolith microstructure;
- c) review preliminary results of an investigation which studied possibilities to assess post smolt survival rate on the basis of scale growth pattern;
- d) evaluate the results of a scale reading blind test;
- e) prepare a workplan describing the Group's cooperation with the BSRP Groups and the work required to finalise the Group's activities;
- f) discuss terminology: different dates for the birthday of salmon are in use in different laboratories;
- g) discuss opportunities for networking with EFAN/TACADAR (European Fish Ageing Network).

## **3 TOR's of the meeting**

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### **3.1 Review available image analysis systems, in particular those which are in use for age determination of salmon**

In the discussions before the meeting, it was noted that in the 6<sup>th</sup> Framework Programme of the EU, there is a project named '(STREP) Objective model-based and computer-assisted age determination technology for fish'. The objective of this project is to demonstrate and evaluate the available technology, i.e. the project concentrates on the same issues as this TOR, but with higher resources. Thus, the Study Group decided that the results of the EU project will be used when they are completed.

### **3.2 Evaluate the status of analysis of Baltic salmon otoliths, and in particular the possibilities to increase the resolution to facilitate interpretation of otolith microstructure**

Otoliths were collected from salmon in Finland and Sweden. Anna Löf presented the results from the Swedish and Jari Raitaniemi from the Finnish otoliths studies.

#### **3.2.1 Taking of otolith samples from salmon**

In Finland, it has been regarded important that after sampling the salmon still look clean and neat and are easy to sell in the market. This means that opening of the skull in the way that is typical when removing otoliths is not desirable, if the fish are to be sold forward as whole. It is easy to remove twenty scales without leaving clearly visible injuries to the fish, but with the otoliths of Atlantic salmon, it was not known whether this is possible.

Removal of salmon otoliths from the skull from downwards was tested with a number of salmon heads before the SGSAD meeting in Finland. The gills were partly removed and the inner ear was opened from downwards with a special drill that removed the bone beside the sacculus, i.e. the cavity where sagitta is situated. This method is easy and quick with e.g. rainbow trout (*Oncorhynchus mykiss*), but with salmon it was found to be difficult and slow with uncertain result. Thus it was concluded that at least with the presently known methods, the otoliths of salmon are most easy and quick to remove from upwards, i.e. after opening the skull. This means that the removal of otoliths leaves very clear marks to the skull of the salmon.

### **3.2.2 Age determination from salmon otoliths stained with neutral red**

#### **3.2.2.1 Swedish sample**

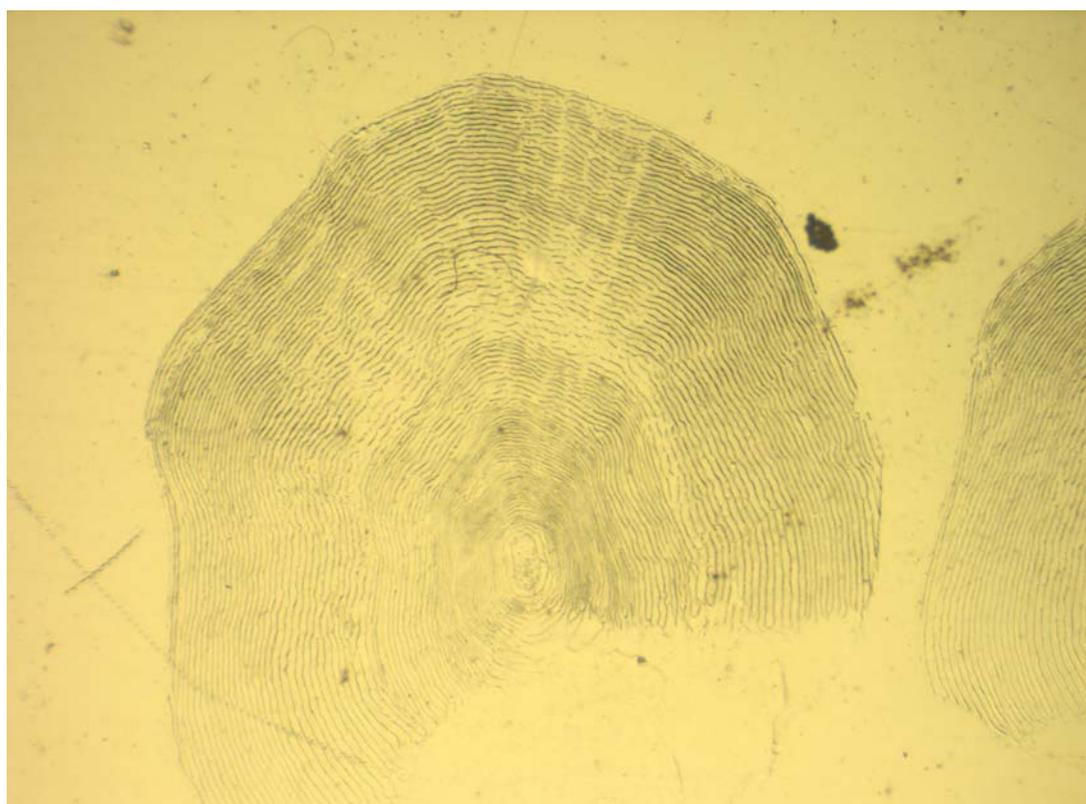
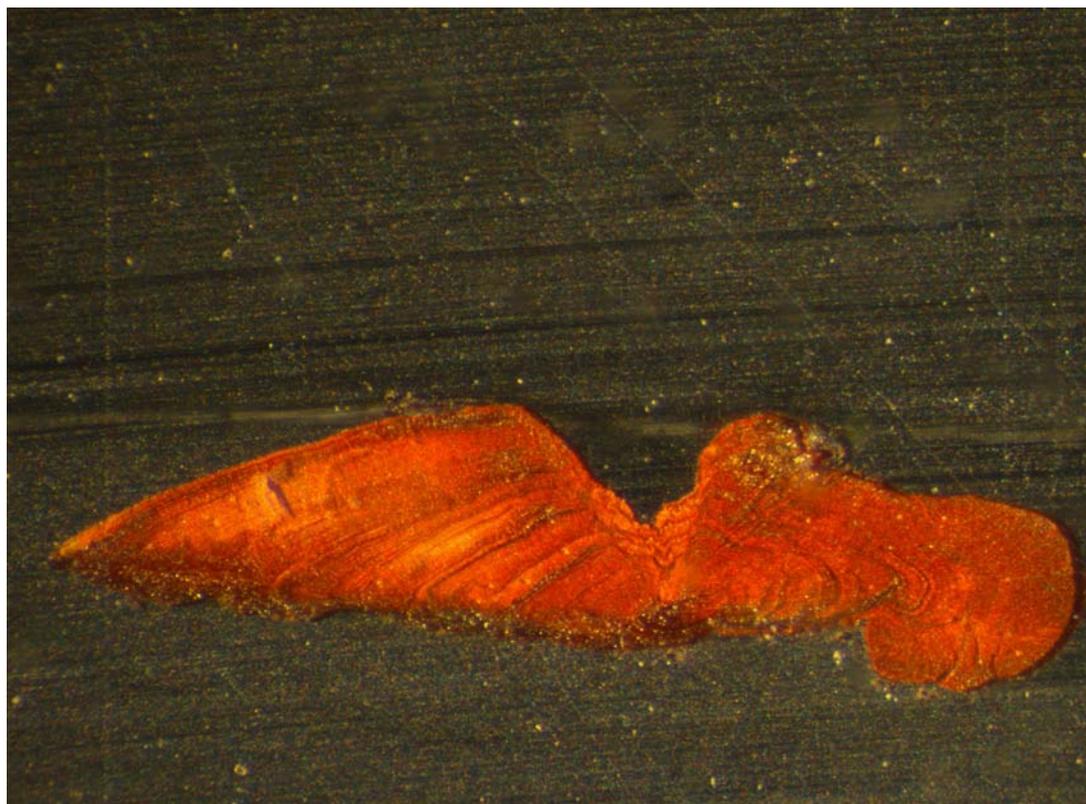
The result of a small Swedish study concerning an otolith-scale comparison was presented at the meeting. Otoliths and scale samples were collected from salmon and sea trout caught at the broodstock fishery in River Dalälven, southern Bothnian Sea. Unfortunately the number of salmon was too low to allow clear-cut conclusions for salmon (Table 3.2.1).

Otoliths were sawn and stained with neutral red before reading by an expert on non-salmonids (no division of freshwater and sea phase). Impressions of scales were made on plastics before reading by persons experienced in salmonid age determination. Only fish size and catch date was known when interpreting the otoliths and scales (Figures 3.2-1 and 3.2-2).

Of the specimens of five salmon and 17 sea trout, one was incorrectly aged by otolith reading. When reading scales, freshwater age wasn't determined for reared fish, which lead to small material for comparison of methods. None of the fish was incorrectly aged by scale reading (one uncertain). For sea trout, reading of otoliths was simpler and gave more accurate results than scale reading. It also led to considerably fewer fish with no result from age determination when compared with scale reading. This was partly due to poor scale quality as the scales in some cases were collected quite close to the spawning season.

For salmon, reading of otoliths seemed more difficult, particularly with small fish. The small material prevented well-founded conclusions but the comparative advantage of otoliths to scales for age determination seemed smaller than for sea trout.

As the number of salmon otoliths was quite low, it seems necessary to continue the study and collect more material before any firm conclusions can be drawn.



**Figure 3.2-1. An otolith (above) and a scale (below) from a female known-aged salmon (nr 42) caught on 22 June 2006 from River Dahlälven. The length of the salmon was 88 cm, weight 8.0 kg, and age 2.2+. Of its origin, the fish was reared.**



**Figure 3.2-2.** An otolith (above) and a scale (below) from a female known-aged trout caught on 17 July 2006 from River Dahlälven. The length of the trout was 74 cm, weight 5.2 kg, and age 2.3+. Of its origin, the fish was reared.

Table 3.2.1. The trout used in the Swedish otolith study.

| Otolithes and nosetags from trouts, River Dalälven ,prepared in -06 |            |            |        |     |     |               |           |
|---------------------------------------------------------------------|------------|------------|--------|-----|-----|---------------|-----------|
| Otolithe nr                                                         | Released   | Catchdate  | Length | WT  | Sex | Fullage       | Known age |
| 1                                                                   | 2004-05-04 | 2004-08-28 | 41     | 0,8 | F   | 2+            | 2+        |
| 2                                                                   | 2004-05-04 | 2004-09-07 | 36     | 0,4 | F   | <i>broken</i> | 2+        |
| 3                                                                   | 2004-05-04 | 2004-09-24 | 38     | 0,7 | F   | 2+            | 2+        |
| 4                                                                   | 2004-05-04 | 2005-11-03 | 55     | 2,3 | M   | 3+            | 2.1+      |
| 5                                                                   | 2004-05-04 | 2005-11-03 | 52     | 1,9 | M   | 3+            | 2.1+      |
| 6                                                                   | 2004-05-04 | 2005-10-20 | 53     | 1,9 | F   | 3+            | 2.1+      |
| 7                                                                   | 2004-05-04 | 2005-11-03 | 53     | 2,1 | M   | 3+            | 2.1+      |
| 8                                                                   | 2004-05-04 | 2005-10-27 | 52     | 1,8 | F   | 3+            | 2.1+      |
| 9                                                                   | 2004-05-04 | 2005-08-02 | 51     | 2,2 | F   | 3+            | 2.1+      |
| 10                                                                  | 2004-05-04 | 2005-10-20 | 55     | 2,5 | M   | 3+            | 2.1+      |
| 11                                                                  | 2004-05-04 | 2005-11-04 | 55     | 2,5 | M   | 3+            | 2.1+      |
| 12                                                                  | 2004-05-04 | 2005-10-27 | 51     | 1,8 | F   | 3+            | 2.1+      |
| 13                                                                  | 2004-05-04 | 2005-10-27 | 58     | 2,9 | M   | 3+            | 2.1+      |
| 14                                                                  | 2004-05-04 | 2005-10-27 | 56     | 2,4 | M   | 3+            | 2.1+      |
| 15                                                                  | 2004-05-04 | 2005-10-27 | 54     | 2,5 | F   | 3+            | 2.1+      |
| 16                                                                  | 2004-05-04 | 2005-08-02 | 56     | 2,3 | F   | 3+            | 2.1+      |
| 18                                                                  | 2004-05-04 | 2005-08-02 | 54     | 1,9 | F   | 3+            | 2.1+      |
| 19                                                                  | 2004-05-04 | 2005-08-02 | 50     | 1,6 | M   | 3+            | 2.1+      |
| 17                                                                  | 2004-05-04 | 2005-10-27 | 54     | 2,1 | F   | 3+            | 2.1+      |
| 20                                                                  | 2004-05-04 | 2005-08-08 | 55     | 2,4 | F   | 3+            | 2.1+      |

### **3.2.2.2 Finnish sample**

A sample of otoliths from about 20 specimens of salmon was burned down in the fire of the laboratory building in the research station of FGFRI in Rymättylä in November 2006. Only one otolith that was used to test the staining method was spared. In this otolith, annual rings were detectable, but the quality of the staining was not regarded satisfactory in routine use.

### **3.2.3 Possibilities to utilize the microstructures of salmon otoliths**

In the research of Baltic salmon populations and indirectly as a way to support salmon stock assessments, microstructures of salmon otoliths can possibly be utilized in some ways that are in plans to be studied in the near future.

One of these possibilities is by means of strontium-calcium relationships in the otoliths. In sea water, strontium content is practically constant, whereas in fresh water there are usually only small amounts of strontium. In the formation of an otolith, strontium easily replaces calcium. It is known that the history of a fish can be read from its otolith when salinity is concerned (e.g. Limburg *et al.*, 2001). As the salinity of the Baltic Sea is higher in the southern part of the sea than in the northern Baltic Sea, it may be possible to use the analysis of this relationship in an otolith not only to estimate the migration patterns between rivers and the sea, but also to find out whether a salmon from a river in the northern Baltic Sea has migrated to the southern Baltic Sea to feed or whether it has stayed more north in the Bothnian Sea, for instance.

Another possibility is in alizarin that can be used to mark salmon fry or even late egg stages, i.e. developmental stages in which otoliths have started to appear in the embryos. Thus, even specimens that have been marked with alizarin and released in rivers as roe can be later identified as stocked fish (Niva *et al.*, 2005).

So far, daily ring counts have not been carried out in the laboratories of the Study Group.

## **3.3 Review preliminary results of an investigation which studied possibilities to assess post smolt survival rate on the basis of scale growth pattern**

In the investigation, the idea was to measure the distances between striae in post-smolt stage to assess post smolt survival correspondingly to Friedland *et al.* (1993; 2000): the longer distances, the better growth and survival.

However, the investigation in Finland faced a practical problem that has not been solved, yet. In order to have comparable scales in the measuring, the scales from different specimens must be similar, i.e. from the same place in the salmon skin. In Finland the scales are picked up by fishermen, and thus they tend to be from different places and of different form. With these, no clear results have been obtained so far.

## **3.4 Evaluate the results of a scale reading blind test**

In order to achieve as reliable results as possible, the Study Group collected scales from known-aged salmon to arrange a scale reading blind test. After overcoming the problem of low quality in the known-aged scales, usually picked by fishermen, a sample of scales and scale impressions from 290 specimens of known-aged salmon was ready in Helsinki in the autumn of 2006. The sample consisted of scales from the salmon samples from Finland, Sweden, Denmark, Estonia, Latvia, and Russia.

Because of the short time to the meeting of the Study Group and thus no time to a thorough circulation of scales before the meeting, a new two-phase arrangement with two ageing rounds was created: For the meeting, a sample of scale images from 50 known-aged specimens was

photographed in Finland with the aim to gather scales from as many areas as available. In the meeting, the Study Group examined together these photographs that were projected on the screen. At first, each member aged each scale and then the scales were discussed about (Figure 3.4). It was also decided that this sample of photographs would be the first stage of a reference collection of scale images from known-aged Baltic salmon, available to all.

In some specimens, there seemed to be difficulties such as spawning ring like structures that, according to the age data, should not have been spawning rings. This needed more examining; error in identification of specimens was also regarded possible. It was also stated that a photograph image collection could be more useful, if it included more than one scale from each specimen. An important thing in the interpretation of age is the birthday of the fish, because there have been different dates in use. In the scale material, marking and/or stocking date is thus as important as catching date.

It was decided that in the second phase, the scale samples (scales or impressions) of a larger number of specimens will be circulated among the laboratories of the Study Group, and this circulation will also include a scale reading blind test that will be analyzed statistically. The scale circulation is to include 50 scales from each part of the Baltic Sea. Scales of known age will be used if they are available. Mainly, the principles stated in earlier meetings in 2000 and 2002 will be followed in the implementation of the blind test. The results of the blind test will be discussed and the scales will be examined together in the next meeting. The scales from these specimens will be also photographed to be a part of the reference collection on Baltic salmon.

The meeting recommended that tagging programmes on wild fish should be carried out in areas where information on known-aged salmon is lacking: in particularly Southern Sweden and Latvia, but also Poland and Lithuania.



Figure 3.4: An example of the scale photographs in the collection from 50 specimens. A scale from the known-aged salmon that was reared and released in May 1996 into the river mouth of Kemijoki, northern Gulf of Bothnia, and caught on 19 September 1998.

### **3.5 Prepare a workplan describing the Group's cooperation with the BSRP Groups and the work required to finalise the Group's activities**

In Baltic Sea Regional Project (BSRP), there have been several fish age reading workshops, e.g. with herring, perch, and flounder, with the aim to improve the reliability of age determination. Georgs Kornilovs from LATFRA presented the work in these workshops. With all these species, blind tests in age reading have been arranged at some stage. Although the age determination of salmon differs somewhat from the other species, there are common phenomena with them; e.g. it has been common that the reader most familiar with the population seems to read the ages most reliably. In the future work of SGSAD, it is recommendable to take into account the recommendations and experiences of the other age determination workshops of BSRP, and to adapt them when appropriate.

### **3.6 Discuss terminology: different dates for the birthday of salmon are in use in different laboratories**

There have been several dates used as the birthday of salmon. The Study Group decided that from now on, 1<sup>st</sup> January will be used as the date of birthday of salmon in the Baltic Sea, following the general interpretation of fish birthday (Hile, 1950). In special kind of biological work, other dates can be used, and then properly described.

### **3.7 Discuss opportunities for networking with EFAN/TACADAR (European Fish Ageing Network).**

EFAN (European Fish Ageing Network, 1997–2000) and TACADAR (Towards Accreditation and Certification of Age Determination of Aquatic Resources, 2002–2006) were EU concerted actions. Both were participated by a large number of member laboratories from EU countries, Norway, and Iceland (institutes, universities), concentrated mainly on marine fish populations.

Jari Raitaniemi, who was a participant in both projects, had a presentation of them in the meeting.

The purpose of EFAN was to 'develop, conduct and coordinate collaborative research and training, and thereby ensure that age determination becomes a reliable element of the assessments underlying the scientific management advice on fisheries and environmental resources'. Information on age determination methods was collected to the net pages of EFAN: <http://www.efan.no>. The most reliable methods in the most important species and stock were documented, and EFAN contributed to further development of age determination methods.

The overall objectives of TACADAR were to increase reliability of age estimation procedures in the EU and to increase the adoption of procedures that include quality assurance and quality control mechanisms. Information on TACADAR project is available in the net pages: <http://www.efan.no/tacadar/>.

In the future work of SGSAD, it is recommendable to take into account the recommendations and experiences of EFAN and TACADAR and to adapt them when appropriate.

## **4 The next meeting**

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### **4.1 The time and place of the next meeting**

It was decided that the next SGSAD meeting would take place in the late autumn of 2008. Maria Dolgikh promised to find out, whether the next meeting of SGSAD could be arranged in Moscow or St Petersburg in Russia. Älvkarleby in Sweden was set as a reserve option.

### **4.2 TORs for the next meeting**

For the next meeting, the Study Group set the following TORs that the participants are going to examine and prepare beforehand and consider together in the meeting:

- a) examination of thin slice from salmon pelvic fin ray;
- b) evaluation the status of analysis of Baltic salmon otoliths:
  - i) is it possible to improve neutral red staining of salmon otoliths or make the annual rings clearer?
  - ii) grinding instead of sawing? Could that make the annuli clearer in salmon?
  - iii) microstructures – another staining method or different preparation methods?
    - Russia: test with similar method as what are used with Pacific salmon species;
  - iv) wild fish – what do the river years look like, can wild fish be separated from reared fish?
- c) continuation of the investigation on possibilities to assess post smolt survival rate on the basis of scale growth pattern with a new sample from River Dahlälven:
  - i) a sample will be collected from River Dalälven to get a collection of scales from the same part of fish and thus regular, comparable form.
  - ii) The assessing will be done as cooperation between Finland (Irmeli Torvi) and Sweden.
- d) evaluation the results of a scale reading blind test with scales from each part of the Baltic Sea (scales from 50 specimens per area, preferably known aged);
- e) preparation of a reference collection of scales as photographic images, with Finland as responsible;
- f) preparation of a description of salmon life cycle, with Sweden as responsible (blue book of IBSFC).

## 5 References

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**Annex 1: List of participants**

| NAME                  | ADDRESS                                                                                                                            | PHONE/FAX                                                                | EMAIL                                        |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------|
| Ryszard Bartel        | Inland Fisheries Institute,<br>Reduta Zbik 5<br>PL-80-761 Gdansk,<br>Poland                                                        | TEL: +48 58 305 7011<br>FAX: +48 58 305 7011                             | gdansk@infish.com.pl                         |
| Irena Borzecka        | Inland Fisheries Institute<br>Department of River Fisheries<br>Zabieniec / Warsaw<br>Poland                                        | TEL: +48 227 562 044                                                     | zeki@infish.com.pl<br>zabienic@infish.com.pl |
| Maria Dolgikh         | Russian Federal Res.<br>Inst. of Fisheries and Oceanography<br>(VNIRO)<br>17, Verkhne<br>Krasnoselskaya<br>Moscow 107140<br>Russia | TEL:<br>+7(495)264 88 92<br>FAX:<br>+7(495)264 95 32                     | dolgikh@vniro.ru                             |
| Frank Ivan Hansen     | Danish Institute for Fishery Research (DIFRES),<br>Charlottenlund Slot<br>DK-2920<br>Charlottenlund<br>Denmark                     | TEL: +45 3396 3363<br>FAX: +45 3396 3333                                 | fih@difres.dk                                |
| Ingrid Holmgren       | Swedish Board of Fisheries<br>Institute of Freshwater Research<br>Brobacken<br>SE-814 94<br>Älvkarleby<br>Sweden                   | TEL: +46 26 825 05<br>FAX: +46 26 825 15                                 | ingrid.holmgren@fiskeriverket.se             |
| Lars Karlsson         | Swedish Board of Fisheries<br>Institute of Freshwater Research<br>Brobacken<br>SE-814 94<br>Älvkarleby<br>Sweden                   | TEL: +46 26 825 03<br>FAX: +46 26 825 15                                 | lars.karlsson@fiskeriverket.se               |
| Martin Kesler         | Estonian Marine Institute<br>Vanemuise 46 B<br>51014 Tartu<br>Estonia                                                              | TEL: +372 56 278 606                                                     | martin.kesler@ut.ee                          |
| Anastasia Khrustaleva | Russian Federal Res.<br>Inst. of Fisheries & Oceanography<br>(VNIRO)<br>17, Verkhne<br>Krasnoselskaya<br>Moscow 107140<br>Russia   | TEL:<br>+7(495)264 91 10<br>+7(495)264 85 19<br>FAX:<br>+7(495)264 95,32 | Khrustaleva@molgen.vniro.ru                  |
| Kunnar Klaas          | Põlula Fish Rearing Centre<br>46701 Lääne-Virumaa<br>Estonia                                                                       | TEL: +372 52 78 245                                                      | qnkunn@hotmail.ee                            |

| NAME                       | ADDRESS                                                                                                                               | PHONE/FAX                                            | EMAIL                           |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------------------------|
| Anna Löf                   | Swedish Board of Fisheries, Institute of Freshwater Research Brobacken SE-814 94 Älvkarleby Sweden                                    | TEL: +46 26 825 08<br>FAX: +46 26 825 15             | anna-carin.lof@fiskeriverket.se |
| Kataryna Mizejewska        | Warmia and Mazury University in Olsztyn Dept. of Fish Biology and Pisciculture Oczapowskiego Str. 5 10-900 Olsztyn, Poland            | TEL: +48 089 523 3290                                | kataryna.mizejewska@uwm.edu.pl  |
| Wojciech Pelczarski        | Sea Fisheries Institute Gdynia ul. Kollataja 1 PL-81-332 Gdynia Poland                                                                | TEL: +48 58 735 6219<br>FAX: +48 58 735 6110         | wpelczar@mir.gdynia.pl          |
| Jari Raitaniemi<br>(Chair) | Finnish Game and Fisheries Research Institute<br>Turku Game and Fisheries Research<br>Itäinen Pitkätatu 3<br>FIN-20520 Turku, Finland | TEL:<br>+358 205 751 685<br>FAX:<br>+358 205 751 689 | jari.raitaniemi@rktl.fi         |
| Mārīte Riekstina           | Latvian Fish Resources Agency<br>Daugavgrīvasiela 8<br>Riga, LV-1048<br>Latvia                                                        | TEL: +371 761 2408                                   | marite.riekstina@latzra.lv      |
| Irmeli Torvi               | Finnish Game and Fisheries Research Institute,<br>P.O. Box 2<br>FIN-00791 Helsinki<br>Finland                                         | TEL: +358 205<br>751 313<br>FAX: +358 205751201      | irmeli.torvi@rktl.fi            |
| Elena Vedishcheva          | Russian Federal Res. Inst. of Fisheries & Oceanography (VNIRO)<br>17, Verkhne Krasnoselskaya<br>Moscow 107140<br>Russia               | TEL: +(495)264 94 54<br>FAX: +(495)264 95 32         | Vedischeva@vniro.ru             |

## **Annex 2: Agenda**

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### *Tuesday 14 November*

- 9:30 Start of the meeting  
Introduction. View on the schedule, proceeding and tasks of the meeting.
- 9:45 d) scale reading blind test, first stage  
Reading of scale images from the screen scale by scale
- 11:00 or after Coffee  
Reading of scale images continues
- 12:30 Lunch  
Continuation of scale reading blind test, discussion and examination together scale by scale
- 14:30 Coffee
- 14:45 a) Image analysis systems  
b) Evaluation the status of analysis of Baltic salmon otoliths  
c) possibilities to assess post smolt survival rate on the basis of scale growth pattern  
e) workplan describing the Group's cooperation with the BSRP Groups; presentation of the work in BSRP groups by Georgs Kornilovs
- 18:00 End of the day's work

### *Wednesday 15 November*

- 9:00 f) terminology: what to use as the birthday of salmon? The group decided that in the assessment work 1 January will be used. In special kind of biological work, other dates can be used, and then properly described.  
g) EFAN/TACADAR (European Fish Ageing Network / Towards Accreditation and Certification of Age Determination of Aquatic Resources)  
TORs for the next meeting
- 12:00 Lunch
- 13:00 Place and date of the next meeting  
Continuation of work with scale images
- 16:00 Closing of the meeting.

### **Annex 3: SGSAD Terms of Reference for the next meeting**

The **Study Group on Salmon Age Determination** [SGSAD] (Chair: J. Raitaniemi, Finland) will meet in Moscow or St Petersburg, Russia in late autumn of 2008 to:

- a) evaluate the status of the examination of thin slice from salmon pelvic fin ray;
- b) evaluate the status of analysis of Baltic salmon otoliths;
- c) evaluate the status of the investigation on possibilities to assess post smolt survival rate on the basis of scale growth pattern;
- d) evaluate the results of a scale reading blind test with scales from each part of the Baltic Sea;
- e) evaluate the status of the preparation of a reference collection of scales as photographic images;
- f) evaluate the status of the preparation of a description of salmon life cycle.

SGSAD will report by 1 June 2009 to the attention of Diadromous Fish Committee and Baltic Committee.

#### **Supporting Information**

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|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PRIORITY:</b>                                             | The highest priority of SGSAD is to increase and maintain a high level of reliability of age determination of salmon as a basis for the stock assessment and other research concerning salmon.                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:</b> | In the age determination of fish, quality assurance is a vital part to ensure the reliability of age determinations. With the Baltic populations of salmon, cooperation of age readers from different countries and laboratories can be used as a tool to improve and validate the age determinations and to maintain high quality.<br>In addition to age determination, SGSAD contributes the use of scientific methods that utilize calcified structures, especially scales and otoliths.<br>Stock assessment of salmon and other research on salmon are benefited from the work of SGSAD. |
| <b>RESOURCE REQUIREMENTS:</b>                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>PARTICIPANTS:</b>                                         | The Group is normally attended by some 10–20 members and guests.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>SECRETARIAT FACILITIES:</b>                               | None.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>FINANCIAL:</b>                                            | BSRP has supported the work of SGSAD by means of travelling expenses of the participants from countries that get funding from BSRP.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>LINKAGES TO ADVISORY COMMITTEES:</b>                      | There are no obvious direct linkages with the advisory committees.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>LINKAGES TO OTHER COMMITTEES OR GROUPS:</b>               | There are linkages with Diadromous Fish Committee, Baltic Committee, and Baltic Salmon and Trout Working Group.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>LINKAGES TO OTHER ORGANIZATIONS:</b>                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>SECRETARIAT MARGINAL COST SHARE:</b>                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

## Annex 4: Recommendations

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| RECOMMENDATION                                                                                                                                                                                                               | ACTION                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| 1. The meeting recommended that tagging programmes on wild fish should be carried out in areas where information on known-aged salmon is lacking: in particularly southern Sweden and Latvia, but also Poland and Lithuania. | National research institutes. |