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11-12 November 2008

St. Petersburg, Russia

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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
info@ices.dk

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Contents

Executive summary

The most important TOR's in the Study Group on Salmon Age Determination [SGSAD] meeting in St. Petersburg concerned the use of otoliths in age determination and the results of the scale reading blind test that had been going on amongst SGSAD members during 2008.

In a Swedish study on the usefulness of salmon otoliths, it was found that neither ground nor sawed otolith surfaces could be used in as accurate ageing of years as scales can be used in. The otolith surfaces were stained with neutral red. So far, it seems that salmon otoliths are useful in other kinds of studies such as the analysis of strontium-calcium relationship, which is related to migration patterns of fish, even as early fry stages.

In the scale reading blind test, the results of four readers were compared with the real ages of the salmon in three samples including scales from 47–48 specimens each, the samples being from three different areas: Gulf of Bothnia, Gulf of Finland, and the main basin of the Baltic Sea. The most accurate age determination results were obtained from the Gulf of Bothnia (54–92% correct), where the scales were also the most uniform and thus easiest to interpret. The most experienced reader on the salmon scales from this area was the most accurate with these scales. In the scales from the Gulf of Finland and the main basin of the Baltic Sea, there was more variation that was caused by higher number of populations from different rivers spending their sea years in these areas. The most difficult was the main basin, where the sample was a mixture of the largest number of unidentified populations. With the main basin scales, the accuracy of age determinations was 43–68%, and familiarity with the Baltic salmon did not seem to help much in improving the result.

Two of the readers estimated, whether each specimen was wild or originating in a hatchery, i.e. reared. From the sample of the Bothnian Sea, the reader with experience from this area identified 88% of the fish correctly. In other areas, the results of both readers were close to random.

The results emphasize the importance of knowledge of the features of scales from different populations as a precondition to accurate age determination of salmon. Samples, which include specimens from all parts of the Baltic Sea, are very difficult because of overlapping features expressing different things in different areas. They cannot be expected to give very accurate results in age determination.

The Study Group proposed that SGSAD would be extended in the whole distribution area of Atlantic salmon.

1 Opening of the meeting

The meeting of the **Study Group on Salmon Age Determination** (SGSAD) (Chair: J. Raitaniemi, Finland) took place from 11–12 November 2008, was opened at 10:00 am on Tuesday 11 November in the premises of the State Research Institute of Lake and River Fisheries (*GosNIORKH*), GosNIORKh 26, Makarov Embankment, RU-199053 St Petersburg, Russian Federation.

2 Adoption of the agenda

The following ToR's, mainly decided at the previous meeting of the group in 14–15 November 2006 in Riga, Latvia, were to be examined and discussed in the meeting:

a) The status of the examination of thin slice from salmon pelvic fin ray

b) The status of analysis of Baltic salmon otoliths

c) The status of the investigation on possibilities to assess post-smolt survival rate on the basis of scale growth pattern

d) the results of the scale reading blind test with scales from each part of the Baltic Sea

e) The status of the reference collection of scales as photographic images

f) The status of the preparation of a description of salmon life cycle (blue book of IBSFC)

3 TOR's of the meeting

3.1 The status of the examination of thin slice from salmon pelvic fin ray

The examination of salmon fin rays had not preceded since the previous meeting in 2006. It was decided that the work on this topic will be continued. Cut fin rays have been used in the age determination of especially some fresh-water fish species. If the cross section of salmon fin ray shows readable annual rings, it may be useful in e.g. the back-calculation of growth with specimens from which the scales have partly eroded.

3.2 The status of analysis of Baltic salmon otoliths

A working group in Sweden (Björn Ardestam, Bengt-Åke Jansson, Ingrid Holmgren, Jennie Dahlberg, Magnus Kokkin and Eva Bergstrand, Institute of Freshwater Research) studied the possibility to improve the visibility of annual rings in the otoliths of salmon. The study was carried out using both ground otoliths and sawed thin slices of otoliths. Below the results are summarized.

3.2.1 Grinding instead of sawing Baltic salmon otoliths? Does it make annuli more clear?

In the meeting of the SGSAD in Riga in 2006, results from a small Swedish study with salmon and sea trout were presented. In the study, age readings from otoliths and scales were compared. The results showed that sawed sea trout otoliths were possible to interpret, but the results on salmon were inconclusive due to small material.

In 2008, another sample of otoliths and scales from 28 salmon of known age, were collected for further studies. The material originated from reared and tagged salmon from the river Dalälven. One of the otoliths in a pair was ground along the sagittal plane (N=28), whereas the other otolith was cut in a cross section in the transverse plane by sawing (N=24; 4 of 28 samples had only one otolith). Both ground and sawed sections were etched then stained with neutral red. Several alternatives with different times for etching and staining were tried to get the best results. The 52 samples of either ground or sawed otoliths and the scales from 25 individuals (three missing), were then graded, using five criteria for how easy the samples were to interpret: quite easy to interpret (BA), acceptable (B), acceptable with hesitation (B?), not acceptable (BC), miserable (C). Summing "the accepted" (B–BA) and the "accepted including those with hesitation" (B?–BA) and the rejected (BC–C) we got the results in the accompanying table.

	Otolith ground	Otolith sawed	Scale
No	28	24	25
Graded as	%	%	%
B - BA	29	33	76
B? - BA	46	67	100
BC - C	54	33	0

Only half or two thirds of the otoliths, either ground or sawed, could be used for ageing, whereas all scales were possible to interpret, including scales accepted with hesitation. Many of the otoliths were of bad quality. Of the 28 salmon individuals, 64% had otoliths of the abnormal crystal morph called vaterite. Either one of a pair (from 12 individuals) or both otoliths (from 6 individuals), were vaterite, instead of the normal aragonite morph. The vaterite morph is less suitable for ageing, as the whole otolith is more or less translucent and growth zones do not appear clearly. Among the sawed otoliths, annuli could be seen in some of the vaterite otoliths, although most were graded as BC or B?, but in the ground samples, all vaterite otoliths were graded as rejected (BC–C). The samples prepared by the sawing method had a little higher figure for "accepted", because of the few accepted vaterite otoliths. Generally, vaterite otoliths were of bad quality independent of the method of preparation. When comparing vaterite otoliths with normal morphs, it was found that normal otoliths were easier to age, but compared with scales, the scales were still easier to interpret.

	Otolith vaterite	Otolith normal	Scale
No	23	29	25
Graded as	%	%	%
B – BA	17	41	76
B? – BA	39	69	100
BC – C	61	31	0

There was no apparent correlation between the quality of otoliths and scales in a fish. It could have good otoliths and/or scales, independent of each other. Furthermore, the smoltification phase was not as easy to distinguish in otoliths as in scales. This makes it difficult to estimate the size of growth zones of otoliths in the fresh water and marine phase. As the smoltification phase is of great importance in salmon and sea trout, this is an important drawback when considering use of otoliths for ageing.

The limit between the marine and fresh-water phase is of great interest in many cases. For instance, chemical analysis of strontium: calcium ratios in otoliths are sometimes used to estimate where the fish has spent different parts of its life cycle. In the Baltic Sea, this may be of particular interest, as it seems that at least trout may leave streams in early summer after hatching and still survive to adulthood in the brackish Baltic Sea. This would make it possible for trout to inhabit streams with seasonally unsuitable conditions due to for instance high water temperatures or low water flows.

3.2.2 Other matters

There was discussion on other methods in preparing otoliths for analysis, e.g. the possibility to test the same method with the salmon from the Baltic Sea as what is used with Pacific salmon species in Russia.

Another thing of interest concerns the early migration behaviour of fry soon after hatching (even May) from rivers to the sea, which has been observed in Sweden. Does it happen elsewhere, as well?

So far, it looks that the otoliths of Baltic salmon are the most useful in chemical studies like those of strontium-calcium relationship and in marking salmon with alizarin in early life stages such as egg or fry.

3.3 The status of the investigation on possibilities to assess post-smolt survival rate on the basis of scale growth pattern

In the Baltic, it has been found difficult so far to try to assess post-smolt survival rate on the basis of scale growth pattern. It was stated that the SGSAD is interested in the experience outside the Baltic Sea.

3.4 The results of the scale reading blind test with scales from each part of the Baltic Sea

3.4.1 The scale material and the readers in the blind test

In age reading blind tests, one major problem is usually the fact that calcified structures from known aged specimens of fish are not available. However, salmon in the Baltic Sea is one of the exceptions. During several decades, smolts of both reared and wild origin have been tagged with Carlin tag and released in the Baltic Sea. Of the specimens that have been caught later, the time that they have spent in the sea after tagging is known accurately. However, still unknown is the time that the wild specimens spent in their home rivers before being caught as smolt in the river mouth and being tagged.

For this scale reading blind test, three samples of known aged salmon scales were collected from the available material. Each of the samples consists of scales from 47–48 specimens from one Baltic area. The three areas were the Baltic main basin, Gulf of Finland, and Gulf of Bothnia. The fish had been recaptured by fishers in most of the countries around the Baltic Sea, and scale samples had been usually taken by the fishers. Because of the scales being sampled by non-professionals, they have been taken from different parts of the salmon body and thus vary of their shape. In the test, there were scales from specimens caught during several decades, the earliest being from 1967 and the last ones from 2007. The images of the scales were pressed in pieces of transparent polycarbonate plate to make the images clearer, and these pressed pieces, hereafter called scales, were used in the age determination test.

The scales were circulated among readers, and the results of four readers were presented as well as especially difficult scales examined together in the SGSAD meeting in St. Petersburg. Of the readers, three ones were from the coastal countries of the Baltic Sea, one from the outside of the Baltic area. The readers are hereafter called A, B, C, and D.

In the reading, there were two basic assumptions in things where there are often different practices used in different laboratories:

- birthday of salmon is 1 January

- '+' can be added to the age, if the new year's growth is visible in the scale (look at the catch date)

3.4.2 Results from the blind test

3.4.2.1 Age determinations

3.4.2.2 Accuracy of age determination

The results differed between the three different areas (Tables 1–3). The salmon caught from the Gulf of Bothnia are the most uniform in the Baltic Sea, as their first sea year in the sea is seen fairly similarly in the scale. Wild specimens have usually spent a longer time in the river than reared specimens in the hatchery. Of the readers, the one with earlier experience from the Gulf of Bothnia got the highest accuracy: 92% of the determinations were correct.

	Reader, % correct			
Area	A	B	C	D
Gulf of Bothnia	77	56	92	54
Gulf of Finland	67	71	79	71
Baltic main basin	64	55	68	43

In the Gulf of Finland, there are commonly found salmon from the populations of both the Gulf of Bothnia and the Gulf of Finland. The structures in the scales differ between these areas, and thus the scale material of the salmon caught from the Gulf of Finland is more variable. In this area, the results were the most even (67–79%), and the reader with experience from salmon scales from the Atlantic Ocean succeeded as well as readers experienced with Baltic salmon.

The main basin of the Baltic Sea is the main feeding and growing area of the salmon from rivers in all parts of the Baltic Sea. Thus the variability of the bands and zones in the scales is also largest, and as could be expected, the age reading results were poorest in this area (43–68%).

Generally there are differences in smolt size between hatcheries and years. In the Gulf of Finland, for example, the smolts are larger at release. The river stage in scales of the wild salmon from the southern rivers of the Baltic Sea is often very similar to reared salmon from northern areas. 1-summer-old and 2-summer-old wild fish are larger in the south than in the north. There are more circuli in the scales and less obvious winter zones in both southern wild salmon and northern reared salmon. In the southern rivers of the Baltic Sea, 1 or 2 years in river is typical before running to the Sea, in the north (Kalix, Tornionjoki, Simojoki), 3 or 4 years is typical in the range of 2–5 years. In the river Simojoki and some Swedish rivers in the Bothnian Bay (SD 31), 2-year-olds are common in some years. In more south, i.e. the southern part of the Bothnian Sea (SD 30), two-year-olds are dominating in smolts. In reared fish, specimens released as 1-year-olds are increasing in the northern areas, thus they are not only from the south.

Delayed release (from midsummer to September, large size at release) can cause difficulties in the interpretation of the scale. A false ring may appear at release. Delayed release is more usual with sea trout, but sometimes it has been used with salmon, as well.

In the north, there may be differences between rivers related to water temperature, nutrients, parr densities, or other factors (small and large rivers). We are lacking knowledge of many wild populations particularly in the southern parts of the Baltic Sea. More specific information from them is needed.

With increasing knowledge, the description of life cycles and following scale types in different rivers and areas of the Baltic Sea can be improved. One detail with uncertainties is spawning marks, how sure can we be about them? In males they are usually clearer than in females, sometimes even accurate ageing is impossible because of erosion in the scales. It is important to register the possible spawning marks also in the future, although age was uncertain. Identification of repeat spawning may become more important.

Table 1. The data of the specimens from the Gulf of Bothnia and the age determinations of the readers A–D in the age reading blind test.

Blind test material							number of tag	country	age at release (years)	length at release (mm)	date of release	Real age at catch	A age	B age	C age	D age	Real wild/ reared	A w/r	B w/r
number	region	sea/ river	catch date	length (mm)	weight total, gutt. (g)	gender male/ female													
GULF OF BOTHNIA																			
228	GoB	sea	8.7.2000	700	3515	male	RE5045	FI	2	213	17.5.1999	A.1	2.1+	3.1+	3.1+	2.1+	reared		w
229	GoB	sea	4.7.1995	650	3200		MU2754	FI	2	227	13.5.1994	A.1	2.1+	4.1+	A.1+	A.1+	reared		w
233	GoB	sea	14.7.1997	555	1485	male	OS3455	FI	2	183	21.5.1996	A.1	2.1+	A.0+	A.1+	2.1+	reared		R
236	GoB	sea	8.8.1998	560	2000		PC7123	FI	2	192	16.6.1997	A.1	2.1+	A.0+	A.1+	2.1+	reared		R
239	GoB	sea	28.7.2001	550	1595	male	RA6724	FI	2	164	17.5.2000	A.1	3.1+	4.1+	4.1+	2.1+	reared	w	w
243	GoB	river	29.7.2001	760	4000	female	PV1259	FI		170	8-29.6.1999	A.2	2.2+	6.1+	4.2+	2.2+	wild	r	w
253	GoB	sea	2.8.2001	580	2035	male	RH5672	FI	2	165	19.5.2000	A.1	2.2+ ?	A.0+	A.1+	2.1+	reared		R
260	GoB	sea	4.7.2001	510	1100	male	RN5903	FI		151	9-29.6.2000	A.1	3.RO+	7.1+	3.1+	2.+	wild		w
263	GoB	sea	14.7.1996	830	6300	female	MU9921	FI	2	165	17.5.1994	A.2	1.2+	2.2+	2.2+	2.2+G+	reared	r	w
269	GoB	sea	19.7.1994	450	660	male	MM0272	FI	2	169	12.5.1993	A.1	2.RO. 1+ ?	A.0+	A.1+		reared		R
276	GoB	sea	5.7.2000	620	3080	male	PX1648	FI		180	10-28.10.1998	A.2	3.1+G+	7.1+	4.3	2.+G+	wild		w
280	GoB	river	27.7.2000	790	4900	female	PX1199	FI		151	10-28.6.1998	A.2	3.2+	A.1+	3(4).2+	2.2+	wild		R
285	GoB	sea	1.7.2001	900	8250	female	PV3455	FI		160	8-29.6.1999	A.2	2.2+	4.3	3.2+	2.1+G1+	wild		w
291	GoB	river	24.8.2001	520	1315	male	RN7749	FI		147	10-29.6.2000	A.1	1 (2).1+	4.2	3.1+		wild		w
293	GoB	sea	29.7.2001	540	5400	male	RN7358	FI		155	9-29.6.2000	A.1	2.1+	4.2	3.1+	2.1+	wild		w
301	GoB	sea	13.6.1994	730	4125	female	MI3341	FI		152	28.5.-11.6.1992	A.2	3.2+	5.1+	3.2+	2.2+	wild		w
308	GoB	river	12.8.2001	600	2000	male	RN5219	FI		149	9-29.6.2000	A.1	2.1+	A.2	3.1+	2.1+	wild		R
309	GoB	sea	19.7.2001	510	1320	male	RN8678	FI		146	9-29.6.2000	A.1	2(3).1+	A.2	3.1+	A.+	wild		R
310	GoB	sea	11.7.2001	510	1430		RN7995	FI		177	10-29.6.2000	A.1	2.1+	5.2	4.1+	A.+	wild		w
317	GoB	sea	3.7.1996	810	7000	female	OC2356	FI	2	167	24.5.-6.6.1994	A.2	2.2+	3.2+	A.3?	A.1+G+	reared	w	w
328	GoB	sea	20.7.1997	550	1430		OS2270	FI	2	200	28.5.1996	A.1	2.0+	A.0+	A.1+	2.+	reared	w	R
341	GoB	sea	9.7.1996	640	2200	male	OM4906	FI	2	165	15.5.1995	A.1	2.1+	2.1+	A.1+	A.1+	reared		w
342	GoB	sea	1.8.1995	520	1400	male	MU5368	FI	2	173	11.5.1994	A.1	2.1+	A.1+	A.1+	2.+	reared		R
348	GoB	sea	27.6.1998	640	2420	male	PE5363	FI	2	177	23.5.1997	A.1	2.1+	A.1+	A.1+	2.1+	reared		R
349	GoB	sea	6.8.1998	540	2420	male	PE4080	FI	2	155	29.5.1997	A.1	2.1+	A.0+	3.1+	2.+	reared	w	R
350	GoB	sea	24.6.1998	840	5100		OS2328	FI	2	190	28.5.1996	A.2	2.1	A.2	A.2+	2.2+	reared	r	R
356	GoB	sea	22.7.1997	510	1000		OO9483	FI	2	166	3-4.6.1996	A.1	2.(2)1+	A.1+	A.1+	A.+	reared		R
358	GoB	sea	11.8.1997	1010	13300	female	MW0216	FI	2	222	2-6.5.1994	A.3	2.3+	A.2+	A.3+	2.1+G1+	reared	r	R
366	GoB	sea	22.7.1997	920	8800	female	OF8141	FI	2	179	4.5.1995	A.2	2.2+	A.2+	A.3+	2.2+G+	reared		R
367	GoB	sea	14.6.1998	1010	12650	female	OF8312	FI	2	176	4.5.1995	A.3	2.RO. 2+	4.3+	A.3+	2.2+G+	reared	w	W
368	GoB	sea	25.7.1995	560	1760	male	MW0859	FI	2	162	2-6.5.1994	A.1	2.1+	2.1+	2.1+	2.1+	reared		w
370	GoB	sea	13.7.1997	880	6000	female	MR9344	FI	2	221	19.5.1994	A.3	2.3+	A.3+	A.3+	2.2+	reared		R
371	GoB	sea	12.7.2001	510	1650	male	RF8487	FI	2	226	3.5.2000	A.1	1.2+?	3.1+	A.1+	2.+	reared		w
377	GoB	sea	15.7.1996	870	7370	male	MU5693	FI	2	156	11.5.1994	A.2	2.2+	3.2+	A.2+	A.2+	reared	w	w
546	GoB	sea	13.6.2004	650	2200 gutt.	female	SO6788	FI		176	29.5.-11.6.2002	A.2	3.2+	4.2+	4.2+	A.1+	wild		w
547	GoB	sea	16.6.2005	830	5200 gutt.	female	RU5696	FI	2	204	14.5.2003	A.2	2.2+	A.2+	3.2+	A.2+	reared		R
548	GoB	sea	24.6.2005	800	5000 gutt.	male	TI8250	FI		162	7-19.6.2003	A.2	2.RO.1+	A.2+	3.2+	A.2+	wild		R
549	GoB	sea	27.6.2005	730	3500 gutt.	female	TI6992	FI		172	7-19.6.2003	A.2	3.1+	3.1+	5.2+	A.2+	wild	r	w
550	GoB	sea	27.6.2005	710	3200 gutt.	male	UA2020	FI	2	254	26.5.2004	A.1	2.1+ ?	A.1+	A.1+	2.2+	reared	r	R
551	GoB	sea	11.7.2003	600	1700 gutt.	male	SM3427	FI	2	195	7.5.2002	A.1	3.1+	A.1+	A.1+	2.1+	reared	r	R
599	GoB	sea	2.5.2005	**92 *)**	9768	female	TO9671	FI	2	254	3.7.2007	A.2	2.2+	3.2+	A.2+?	A.2+G1+	reared		w
600	GoB	sea	3.7.2007	1090	14000	female	TK6989	FI	2	203	10.5.2004	A.3	2.2+G+	6.2+	A.3G+?	A.2+G1+	reared		w
601	GoB	sea	17.6.2007	750	5170	female	SW3804	FI		144	24.5.-29.6.2005	A.2	2.1+G+1+	A.1+	3.2+	2.2+	wild		R
602	GoB	sea	22.6.2007	940	9460	male	SX9095	FI		148	15.5.-17.6.2004	A.3	2.3+	3.3+	3.3	A.2+G1+	wild		w
603	GoB	river	1.7.2007	800	6050	female	TP4090	FI	2	218	10.6.2005	A.2	A.1+G+	A.2+	A.2+	A.2+	reared		R
604	GoB	sea	7.7.2007	600	1800	male	VC1936	FI	2	227	4.5.2006	A.1	A.2+	A.1+	A.1+	A.1+	reared		R
605	GoB	sea	9.7.2007	540	1400	female	VC6102	FI		149	17.5.-29.6.2006	A.1	3.1+	3.1+	3.1+	A.+	wild		w
606	GoB	river	7.8.2007	500	1100	female	VC6579	FI		154	17.5.-29.6.2006	A.1	2.0+	5.0+	3.1+	A.+	wild		w

Table 2. The data of the specimens from the Gulf of Finland and the age determinations of the readers A–D in the age reading blind test.

Blind test material																				
number	region	sea/ river	catch date	length (mm)	weight total, gutt. (g)	gender male/ female	number of tag	country	age at release (years)	length at release (mm)	date of release	Real age at catch	A age	B age	C age	D age	Real wild/ reared	A w/r	B w/r
GULF OF FINLAND																			
410	GoF	sea	20.7.2002	1020	8239		HT5327	FI	2	238	3.5.1999	A.3	2.3+	A.3+	A.3+	2.3+	reared	r	R
416	GoF	sea	31.7.2001	750	4730	male	PX2416	FI	1	170	19.4.1999	A.2	2.2+	A.1+	A.2+	2.2+	reared	r	R
433	GoF	sea	28.7.2002		9900	female	RI3848	FI	2	210	2.5.2000	A.2	2(3).2+	3.2+	A.2+	2.3+	reared	w	w
440	GoF	sea	1.9.2001	670	2970	male	RN3787	FI	2	220	4.5.2000	A.1	3.1+	A.2	A.1+	3.1+	reared		R
450	GoF	sea	6.8.2002	620	2200		RR2686	FI	2	220	2.5.2001	A.1	2.1+	A.2	A.1+	3.+	reared		R
476	GoF	sea	29.6.1994	730	3900 gutt.		LF0311	FI	1	155	14.4.1992	A.2	2.2+	A.2+	2.2+	3.1+	reared		R
477	GoF	sea	22.6.1994		7700 gutt.		LF0936	FI	1	185	14.4.1992	A.2	2.1+	4.2+	2.3+	A.2+	reared		w
478	GoF	sea	10.9.1994	650	3000		MR1282	FI	1	180	7.4.1993	A.1	2.1+	A.0+	2.1+	A.1+	reared		R
479	GoF	sea	5.8.1996	610	2400 gutt.		OP6704	FI	1	185	22.5.1995	A.1	2.(0)1+	2.2	A.1+	A.1+	reared		w
480	GoF	sea	17.11.1997	750	5000 gutt.		OR4732	FI	1	203	21.5.1996	A.1	A.1+	A.1+	3(4).1+	A.2+	reared		R
533	GoF	sea	25.7.2005	750	4200 gutt.	male	UA3867	FI	2	230	26.4.2004	A.1	2.1+	2.1+	A.1+	A.2+	reared	w	w
534	GoF	sea	26.7.2005	650	2600 gutt.	male	UA3367	FI	2	217	26.4.2004	A.1	2.2+	2.1+	3.1+	A.1+	reared	w	w
535	GoF	sea	31.7.2005	790	4900 gutt.	male	TS4311	FI	2	231	27.4.2004	A.1	2.1+	2.1+	A.2	A.2+	reared	w	w
536	GoF	sea	18.7.2004	870	6500 gutt.	female	SI9118	FI	2	236	29.4.2002	A.2	2.2+	A.2+	A.2+	A.2+	reared		R
537	GoF	sea	19.7.2004	590	1800 gutt.	male	TE3958	FI	2	172	28.4.2003	A.1	2.1+	A.1+	3.1+	2.1+	reared		R
538	GoF	sea	5.6.2003	770	3800 gutt.	female	RP3297	FI	2	185	15.5.2001	A.2	2. (1)2+ ?	4.1+	2.2+	A.2+	reared		w
539	GoF	sea	11.6.2003	790	4300 gutt.	female	RP5982	FI	2	183	18.5.2001	A.2	2.2+	5.1+	A.2+	2.2+	reared		w
540	GoF	sea	6.7.2003	760	3800 gutt.	male	SP6238	FI		144	6-27.6.2001	A.2	2.2+	3.1+	3.2+	2.2+	wild	w	w
541	GoF	sea	6.8.2003	520	1200 gutt.	male	SL1003	FI	2	189	23.5.2002	A.1	2.1+	3.0+	3.1+	A.1+	reared		w
542	GoF	sea	8.8.2003	930	7700 gutt.	female	PV5709	FI	2	269	4.5.2001	A.2	2.3+	A.1+	A.3+	A.3+	reared	w	R
543	GoF	sea	30.8.2003	640	2000 gutt.	male	SH1444	FI	2	180	30.5.2002	A.1	(2). 1+	A.1+	A.1+	A.1+	reared		R
554	GoF	sea	21.10.2005	780	5100		E38723	EE	2	222	23.4.2004	A.1	2.2+	3.1+	A.2	A.2+	reared		w
555	GoF	sea	25.11.2005	850	8600		E31207	EE	2	255	30.4.2003	A.2	2.3+	A.2+	A.3+	2.2+G1+	reared		R
556	GoF	sea	3.10.2005	630	2800		E40882	EE	2	184	26.4.2004	A.1	2.2+	A.1+	A.2	3.1+	reared	w	R
557	GoF	sea	14.10.2005	760	5600		E36784	EE	1	148	4.6.2003	A.2	3.2+	3.1+	A.2+	2.2+	reared		w
558	GoF	sea	21.9.2005	630			E38677	EE	2	174	23.4.2004	A.1	3.2+	4.1+	3.1+	2+.1+	reared	w	w
561	Gof	sea	2.7.2006	710	4720		E37869	EE	1	142	11.5.2004	A.2	2.2+G+	3.2+G+	A.1+G+	2.2+	reared		w
562	GoF	sea	3.5.2006				E53719	EE	2	326	27.4.2006	A.0	2.0+	A.0+	2+		reared		R
563	GoF	sea	1.10.2005	800	6000		E38994	EE	2	222	23.4.2004	A.1	2(3).1+	3.1+	3.1+	2.2+	reared		w
574	GoF	sea	19.10.2005		2450	male	57250	RU	1	135	2004	A.1	2.1+	A.1+	4.1+	2.1+	reared		unk
580	GoF	sea	29.7.2006	700	5500		ST2632	FI	2	223	25.4.2005	A.1	3.1(2)+ ?	3.1+	3.2+	2.2+	reared		w
581	GoF	sea	20.5.2007	750	6500		ST3275	FI	2	182	25.4.2005	A.2	2.2+G+	A.2+	3.2+	A.2+	reared		R
582	GoF	sea	23.5.2007	200	100		VB1466	FI	2	192	20.4.2007	A.0	1+	1.0+	2.	2+	reared		w
583	GoF	sea	16.7.2007	960	8800	female	TR8314	FI	2	274	25.4.2005	A.2	2.3+	2.2+	2.3+	2.3+	reared		w
584	GoF	sea	22.6.2007	670	2860	male	SV2633	FI	2	196	2.5.2006	A.1	A.1+	3.1+	A.2	2+.1+	reared		w
585	GoF	sea	25.6.2007	750	7150	female	ST2480	FI	2	185	25.4.2005	A.2	2.1+G+1+	A.2+	A.2+	A.2+	reared		R
586	GoF	sea	25.6.2007	800	9350	female	TR8705	FI	2	235	25.4.2005	A.2	2.2+	A.1+G1+	2(3).2+	A.3+	reared		R
587	GoF	sea	26.6.2007	620	2530	male	UT1713	FI	2	168	8.5.2006	A.1	2.1+	A.1+	A.1+	3.1+	reared		R
588	GoF	sea	26.6.2007	650	2750	male	TN7303	FI	2	200	10.5.2006	A.1	3.1+	3.1+	3.1+	A.1+	reared		w
589	GoF	sea	28.6.2007	610	2200	male	UT1412	FI	2	182	8.5.2006	A.1	2.1+	A.1+	A.1+	A.1+	reared		R
590	GoF	sea	28.6.2007	870	8140	female	ST2368	FI	2	174	25.4.2005	A.2	2.2+	3.2+	3.2+	3.2+	reared		w
591	GoF	sea	30.6.2007	630	2530	male	UT1398	FI	2	179	8.5.2006	A.1	(2).1+	A.1+	A.1+	2.1+	reared	w	R
592	GoF	sea	30.6.2007	750	5500	female	TT3674	FI	2	202	25.5.2005	A.2	A.1+	4.1+	A.2+	2.2+	reared	w	w
593	GoF	sea	2.7.2007	630	3465	male	SV1873	FI	2	190	2.5.2006	A.1	A.2+	3.1+	3.1+	2.1+	reared	w	w
594	GoF	sea	20.7.2007	660	2860	male	UT1830	FI	2	186	8.5.2006	A.1	2.2+	A.1+	A.1+	3.1+	reared		R
595	GoF	sea	10.7.2007	570	1760	male	UT1210	FI	2	156	8.5.2006	A.1	A.1+	A.1+	2.1+	2.1+	reared		R
596	GoF	sea	11.7.2007	700	3520	male	UT1027	FI	2	174	8.5.2006	A.1	2.1+	A.1+	A.1+	3.1+	reared		R
598	GoF	sea	15.7.2007	920	9020	female	TR8423	FI	2	245	25.4.2005	A.2	A.3+ ?	A.2+	3.3+	3.2+	reared		R

Table 3. The data of the specimens from the main basin of the Baltic Sea and the age determinations of the readers A–D in the age reading blind test.

Blind test material																					
number	region	sea/ river	catch date	length (mm)	weight total, gutt. (g)	gender male/ female	number of tag	country	age at release (years)	length at release (mm)	date of release	Real age at catch	A age	B age	C age	D age		Real wild/ reared	A w/r	B w/r	C w/r
MAIN BASIN																					
147	MainB	sea	18.11.1989	750	3900		SE05 / 1480	SE	1		25.5.1988	A.1	2.1+	2.1+	A.1+	2.2+		reared		w	R
151	MainB	sea	11.9.1989	910	9400		SE41 / 0612	SE	1		27.5.1987	A.2	3. 2+	A.1+	A.2+	3.2+G1+		reared		R	R
154	MainB	sea	21.1.1967	640	2100	male	SE103 / 367	SE			1965	A.2	(3).1+	3.1	2.1+	3.1.		wild		w	W
156	MainB	sea	15.6.1967	780	4400		SE101 / 367	SE			1965	A.2	2.2+	4.1+	3.2+	3.1+		wild		w	W
158	MainB	sea	5.4.1967	800	3900	male	SE112 / 367	SE			1965	A.2	2.1+	A.2+	2.2	3.2+		wild	w	R	W
161	MainB	sea	18.10.1986	820	6600	female	SE22 / 8460	SE	2		31.5.1985	A.1	3.2+	A.1+	A.1+	3.1+G+		reared	w	R	R
163	MainB	sea	18.5.1987	780	5700	female	SE30 / 8463	SE	2		31.5.1985	A.2	2.2+	3.2+	A.2+	3.1+G+		reared	w	w	R
178	MainB	sea	20.2.1990		5000		SE19 / 1489	SE	1		25.5.1988	A.2	2.2+	A.2	A.2	A.1+G+		reared	r	R	R
181	MainB	sea	17.5.1991	1050	16000	female	SE02 / 1488	SE	1		25.5.1988	A.3	2.(3) +	A.2	3.3+	3.2+G1+		reared	w	R	W
188	MainB	sea	9.9.1967	890	6800		SE116 / 367	SE			1965	A.2	2.2+	2.2+	2.2	3.2		wild	w	w	W
189	MainB	river	14.11.1966	1060	7700	female	SE70 / 3572	SE			1963	A.3	2.2+	4.1+G	2.3+	3.2+G		wild	w	w	W
198	MainB	sea	31.3.1968		8800	female	SE100 / 367	SE			1965	A.3	2.2+	5.2	2.3+	A.2+G+		wild	w	w	W
204	MainB	sea	29.7.1966	600	2600		SE88 / 3675	SE			1965	A.1	A.RO.1+	A.1+	1.1+	2.1+		wild		R	W
211	MainB	sea	00.6.1967	730	3400		SE109 / 367	SE			1965	A.2	3.2+	A.2+	3(4).2+	2.1+		wild		R	W
213	MainB	sea	1.10.1966	640	2600		SE115 / 367	SE			1965	A.1	2.1+	A.1+	2.2+	2.1+		wild		R	W
215	MainB	sea	11.8.1989	800	6200	female	SE43 / 0610	SE	1		27.5.1987	A.2	2. 2+	A.1+	3(4).2+	3.2+		reared		R	W
217	MainB	sea	4.5.1990	670	4000		SE14 / 1486	SE	1		25.5.1988	A.2	2.1+	A.1+	A.2+	3.1+		reared		R	R
218	MainB	sea	24.3.1987	700	3700	female	SE25 / 8462	SE	2		31.5.1985	A.2	2.2+	A.2	A.2+	3.1+		reared		R	R
219	MainB	sea	10.1.1967	710	3400		SE97 / 3674	SE			1965	A.2	2.1+	2.2	3.2	2.1		wild	w	w	W
222	MainB	sea	21.11.1988	690	3600		SE45 / 0617	SE	1		27.5.1987	A.1	2.(O)1+	A.0+	A.1+	2.1+		reared		R	R
254	MainB	sea	29.9.2000	760	4450		PU5408	FI		159	23.5.-21.6.1999	A.1	3.1+	3.1+	3.1+	2.2+		wild	w	w	W
268	MainB	sea	31.1.2001		6270		PX1478	FI		146	10-28.6.1998	A.3	2.2+	3.3	2.3	2.3+		wild	w	w	W
271	MainB	sea	9.3.1997	750	4200		OF3533	FI	2	172	15.6.1995	A.2	2.2+	A.3	A.2	2.2+		reared	w	R	R
303	MainB	sea	31.5.2001	870	7040		PN9282	FI	2	194	29.5.-19.6.1999	A.2	2.2+	A.2+	A.2+	2.2+		reared		R	R
336	MainB	sea	18.5.1998	890			OF7653	FI	2	195	18.5.1995	A.3	2.3+	A.2+	4.2+	2.2+G1		reared	w	R	W
347	MainB	sea	24.4.1998		3000		OU1893	FI	2	168	11.6.1996	A.2	2.2+	A.1	2.2+	2.1+		reared		R	W
501	MainB	sea	2.6.1992	870	7800 gutt.		48061	DK	1	150	4.5.1990	A.2	3.2+ ?	A.2+	3.3+	2.3+G+		reared		R	W
502	MainB	sea	20.9.1991	750	5000 gutt.		48182	DK	1	150	4.5.1990	A.1	2.RO.1+	4.1+	2.1+	2.2+		reared	w	w	W
503	MainB	sea	4.8.1993	960	10100 gutt.		48269	DK	1	150	4.5.1990	A.3	3.2+	5.3+	3.3+	2.2+G1+		reared		w	W
505	MainB	sea	8.10.1991	600	1800 gutt.		48246	DK	1	160	4.5.1990	A.1	2.2+	6.1+	2.2+	2.1+		reared		w	W
506	MainB	sea	27.5.1991	540	2400 gutt.		48756	DK	1	165	4.5.1990	A.1	2.1+	3.1	2.1+	2.1+		reared		w	W
507	MainB	sea	15.11.1991	810	7100 gutt.		48778	DK	1	155	4.5.1990	A.1	2.2+	A.1+	3.2+	2.2+		reared		R	W
508	MainB	sea	22.5.1994	840	9400 gutt.		53615	DK	1	150	24.4.1991	A.3	2.2+	A.2	3.3+	2.2+G+		reared		R	W
509	MainB	sea	24.4.1993	980	11500 gutt.		53669	DK	1	150	24.4.1991	A.2	2.2+	3.3	2(3).3	2.2+G1+		reared		w	W
510	MainB	sea	9.12.1992	800	7600 gutt.		16517	DK	1+	295	10.9.1991	A.1	2.2+ ?	4.2+	3.2+	2.2+G		reared		w	W
512	MainB	sea	13.6.1993	1000	15200 gutt.		16716	DK		300	10.9.1991	A.2	2.2+	A.3	4.3	2.2+G1+		reared	w	R	W
518	MainB	sea	13.5.1995	1080	18200 gutt.		72572	DK	1+	320	3.9.1992	A.3	2.4+	A.3	3.4+	3.2+G1+		reared	w	R	W
545	MainB	sea	12.5.2005	865	6250 gutt.		RU6703	FI	2	209	18.5.2003	A.2	2.2+ ?	A.3	2.2+	2.2+G1+		reared		R	W
553	MainB	sea	22.2.2005	620	2500		E39880	EE	2	262	28.4.2004	A.1	2.1+	A.0+	A.1+	2.1+		reared		R	R
560	MainB	sea	20.12.2003	850	4700		E28756	EE	2	233	24.4.2002	A.1	2.2+	A.1+	3.2+	A.2+G		reared		R	W
566	MainB	sea	4.10.2001	770	5100	female	29490	LV	1		19.5.1999	A.2	3.2+	A.2+	4.2+	A.2+G		reared		R	W
567	MainB	sea	6.11.1999	1000	12519		10725	LV			00.05.1995	A.4	2.3+	A.1+	3.3+	2.2+G1+G		**wild **)**		R	W
568	MainB	sea	5.2.1997	305	240		14827	LV	1		22.5.1996	A.1	3.0+	A.0+	3.+	A.+		reared		R	W
576	MainB	sea	22.10.2006	720	3200		VC1342	FI	2	244	4.5.2006	A.0	2.0+	2.0+	2.1+	2.1+		reared		w	W
577	MainB	sea	25.3.2007	810	6380	female	KI6082	FI	2	238	26.5.2005	A.2	2.2+	3.2	3.3+	A.2+		reared		w	W
578	MainB	sea	31.3.2007	860	7300		TO3699	FI		144	15.5.-17.6.2004	A.3	3.3+	5.2	3.3	2.2+G+		wild		w	W
579	MainB	sea	15.8.2007	210	100		UV2913	FI	2	183	27.4.2007	A.0	2.0+	1.0+	3.	2+		reared		w	W

*) length in cm
**) Is this correct?

3.4.2.2.1 Age distribution

In the age distributions, the percentage of correct age determinations does not directly tell how close to reality the resulting age distribution is (Figures 1–3). Still, it can be expected that the more accurate the determinations are the higher is the probability that the age distribution is close to the real age distribution of the sample. In the χ^2-test, the accumulation of some specimens in ageing to an age group, in which there actually were very few specimens, easily caused statistical difference from the expected. However, the number of specimens in this test was so small that statistical tests in practice had a low scientific value. Instead, it must be emphasized to have a view on the possibilities of bias and biological consequences of them.

A bias in age determination may take place in even fairly accurate age determination, when one annual ring is systematically missed or a false ring is interpreted as a winter ring in the age reading of specimens from a certain population in a certain year. In practice this was found in a sample of herring from the Gulf of Finland, when two age determination methods were tested in parallel from the same specimens. The fish had grown very poorly in 2003, and one of the two ageing methods mainly missed this year in the otoliths of one year class (Raitaniemi et al. unpublished).

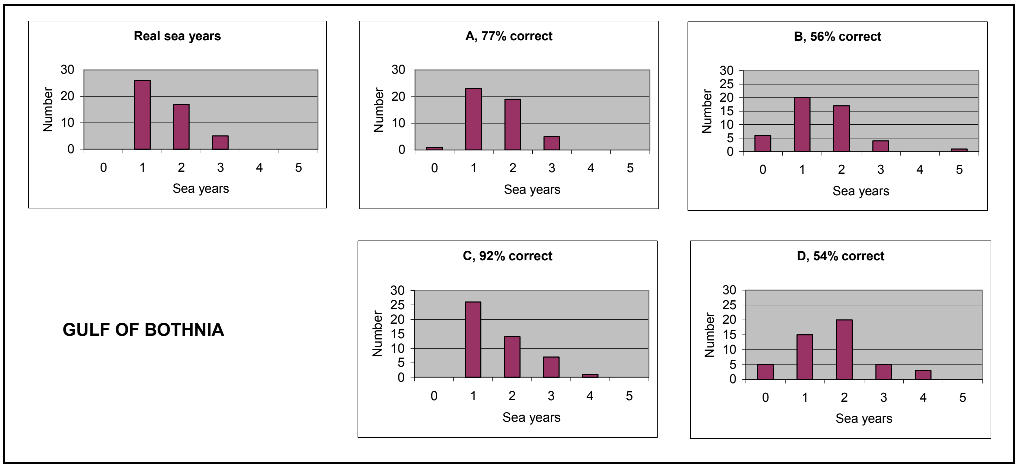

Figure 1. The age distribution in the sample from the Gulf of Bothnia (n = 48, Real sea years) and age distributions resulting from the age determinations of the readers A–D. In each figure, the percentage of correct age determinations is written after the symbol of the reader in the title.

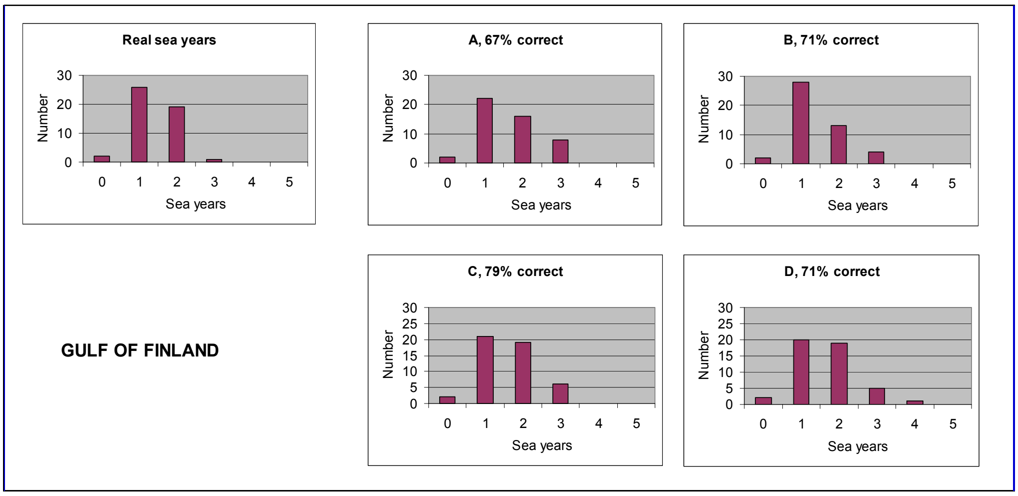

Figure 2. The age distribution in the sample from the Gulf of Finland (n = 48, Real sea years) and age distributions resulting from the age determinations of the readers A–D. In each figure, the percentage of correct age determinations is written after the symbol of the reader in the title.

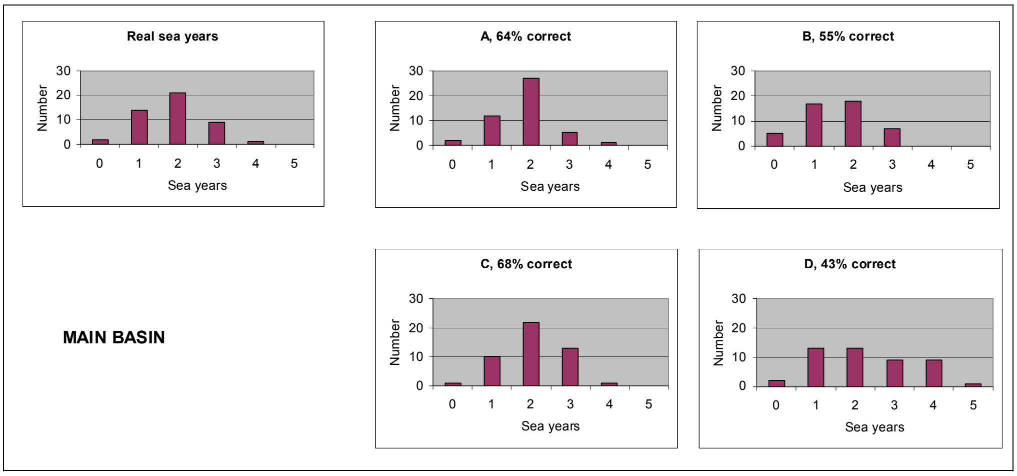

Figure 3. The age distribution in the sample from the main basin of the Baltic Sea (n = 47, Real sea years) and age distributions resulting from the age determinations of the readers A–D. In each figure, the percentage of correct age determinations is written after the symbol of the reader in the title.

3.4.2.3 The identification of wild and reared specimens

Two of the four readers took part in the estimation of the origin of each specimen, i.e. of whether each fish had grown its river years as wild in a river (wild) or in a hatchery (reared). The best result, 88% correct, was obtained from the Gulf of Bothnia by the reader who had earlier experience from the salmon of the Gulf of Bothnia. In the samples that were mixtures from the populations of rivers around the Baltic Sea as well as hatcheries around the Baltic Sea, the results were fairly close to random with both readers.

	Reader, % correct	
Area	B	C
Gulf of Bothnia	65	88
Gulf of Finland	52	60
Baltic main basin	66	51

The Gulf of Bothnia is also easier than more southern areas, because the difference between the river stage in the scales of wild and reared specimens is larger there. The scale of a wild specimen from the central or southern Baltic Sea may look like that of a reared specimen from the Gulf of Bothnia.

3.5 The status of the reference collection of scales as photographic images

Several scales were photographed by Ruth Haas-Castro from each specimen included in the scale reading blind test. Together the scale images form a collection of known aged reference scales of salmon from the Baltic Sea. From the meeting till the end of the year 2008, the scale collection was also available in the Internet, and present and former members of SGSAD were informed of the possibility to download the images.

3.6 The status of the preparation of a description of salmon life cycle (blue book of IBSFC)

The work has not proceeded so far. The salmon life cycles in the Baltic Sea vary somewhat between different populations, which could benefit the interpretation of scales. The description could include quantitative features that are typical in each area or river, including the description of the typical types of salmon scales in different areas around the Baltic Sea, maybe also elsewhere.

4 SGSAD in the future

4.1 Age determination of salmon from ocean waters to SGSAD?

The Study Group proposed that the SGSAD could be extended from the Baltic Sea to the whole distribution area of Atlantic salmon. In the Atlantic area, the last meeting concerning salmon age determination was in 1988. Thus there is need for effort on a meeting on age determination issues as well. A joined meeting could consist of parts that are common to all irrespective of the sea area and parts in subgroups (e.g. North Atlantic and Baltic areas). This is also a possibility to spread techniques and methods from area to another.

4.2 The selection of a new Chair to SGSAD

As Jari Raitaniemi will not continue as the Chair of SGSAD, the selection of a new Chair was discussed. The new Chair was not selected on this occasion, instead it was decided that Jari Raitaniemi will contact Ted Potter so that the selection of the Chair would be discussed in a wider group of salmon researchers.

4.3 The next meeting of SGSAD

It was suggested that the next meeting could take place in winter of the year 2010, if decisions are made in the ICES in autumn of 2009. The SGSAD suggested following TOR's to be included in the next meeting:

a) Identification of spawning marks: which are real spawning marks, which otherwise eroded zones, does spawning always leave a mark?
- At least some specimens have been tagged in different areas in the connection of spawning; with specimens that are known to have spawned, it is possible to examine the spawning marks
- A collection of about 20 pictures of the scales of a) typical spawned salmon and b) salmon, which have got other erosion marks in their scales

b) The status of the preparation of a description of salmon life cycle (blue book of IBSFC)

- Related to the salmon life cycles in the Baltic, different populations and the interpretation of scales
- Quantitative features that are typical in each area or river, i.e. description of the typical types of salmon scales in different areas around the Baltic Sea, maybe also elsewhere

c) The status of the investigation on possibilities to assess post-smolt survival rate on the basis of scale growth pattern

- 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
- The assessing will be done in cooperation between Finland (Irmeli Torvi) and Sweden
- In the Baltic this has been found difficult so far; how is it with the experience from cases outside of the Baltic Sea?

d) The status of the examination of thin slice from salmon pelvic fin ray

e) Number and width of striae in the annual growth zones

- Possibilities to use as an aid with difficult scales (Maria Dolgikh)
- Published papers, other documents, or experience from earlier studies

f) The status of the knowledge of wild populations particularly in the southern parts of the Baltic Sea

g) The status of strontium-calcium relationship studies from otoliths

- South-Swedish rivers, elsewhere?

Annex 1: List of the participants

Name	Address	Phone/Fax	E-mail
Maria Dolgikh	Russian Federal Research Institute of Fisheries and Oceanography. 107140 V.Krasnoselskaya st.17 Moscow Russia	Tel: +7 (499) 264 8892	dolgikh@vniro.ru
Irmeli Torvi	Finnish Game and Fisheries Research Institute, Viikinkaari 4 00791 Helsinki Finland	Tel: (+358) 0205751313	irmeli.torvi@rktl.fi
Gennady Ustyuzhinskiy	SevPINRO Uritskiy str.17 Arkhangelsk 163002 Russia	Tel: +7 (8182) 66 16 46	gena@sevpinro.ru
Dmitry Chupov	SevPINRO Uritskiy str.17 Arkhangelsk 163002 Russia	Tel: +7 (8182) 66 16 46	chupov@sevpinro.ru
Martin Kesler	Estonian Marine Institute Mäealuse 10a Tallinn, Estonia	Tel: (+372) 56 278 606	martin.kesler@ut.ee
Kestutis Skrupskelis	Institute of Ecology of Vilnius University Akademijos 2 Vilnius LT-08412 Latvia	Tel: (+370) 682 45622	kskrupskelis@gmail.com
Dmitry Sendek	State Research Institute on Lake and River Fisheries (GosNIORKh) St.-Petersburg 199053 Russia	Tel: +7 (812) 323 7724	sendek@mail.ru
Rita Barabanova	State Research Institute on Lake and River Fisheries (GosNIORKh) ~ St.-Petersburg 199053 Russia	Tel: +7 (812) 323 7724	rita-neusik@rambler.ru
Sergey Titov	State Research Institute on Lake and River Fisheries (GosNIORKh) St.-Petersburg 199053 Russia	Tel: +7 (812) 323 7724	sergtitov_54@mail.ru

Name	Address	Phone/Fax	E-mail
Nina Shindavina	Russian Federal Selection genetic Center of Fish Husbandry Strelninskoe shosse 4. Ropsha, Leningradsk. obl. 188514 Russia	Tel: +7 (812) 422 7995	ropshatrout@mail.ru
Eva Bergstrand	Swedish Board of Fisheries Institute of Freshwater Research Drottningholm SE 17893 Drottningholm Sweden	+ 46 8 6990609 + 46 8 6990650	eva.bergstrand@fiskeriverket.se
Lars Karlsson	Swedish Board of Fisheries Institute of Freshwater Research Brobacken SE-814 94 Älvkarleby Sweden	Tel: +46(0)2682503 Fax:+46(0)2682515	lars.karlsson@fiskeriverket.se
Jari Raitaniemi **(Chair)**	Finnish Game and Fisheries Research Institute Turku Game and Fisheries Research Itäinen Pitkäkatu 3 20520 Turku, Finland	Tel:+358 205751685 +358 40 7308079	jari.raitaniemi@rktl.fi

Annex 2: Agenda

Tuesday 11 November

10:00 Start of the meeting

Introduction of participants, who is who

View on the schedule, proceeding and tasks of the meeting.

a) The status of the examination of thin slice from salmon pelvic fin ray
b) The status of analysis of Baltic salmon otoliths

   a. *is it possible to improve neutral red staining of salmon otoliths or make the annual rings clearer?*

   b. *grinding instead of sawing? Could that make the annuli clearer in salmon?*

   microstructures – another staining method or different preparation methods? - Russia: test with similar method as what are used with Pacific salmon species

   c. *wild fish – what do the river years look like, can wild fish be separated from reared fish*

   d. *Strontium-Calcium relationship? South-Swedish rivers*

      i. *How about elsewhere? Is there early emigration behaviour of fry (even May) from rivers to the sea? Soon after hatching*

c) The status of the investigation on possibilities to assess post-smolt survival rate on the basis of scale growth pattern

   a. *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*

   b. *The assessing will be done as cooperation between Finland (Irmeli Torvi) and Sweden*

d) the results of the scale reading blind test with scales from each part of the Baltic Sea

   Three scale samples of nearly 50 specimens of salmon per area (Bothnian Sea, Gulf of Finland, the main basin of the Baltic Sea) were circulated in different laboratories. The results of 4 readers are presented.

Wednesday 12 November

e) The status of the reference collection of scales as photographic images
f) The status of the preparation of a description of salmon life cycle (blue book of IBSFC)

SGSAD in the future:

The selection of a new Chair to SGSAD

The next meeting of SGSAD

TOR's for the next meeting

16:00 Closing of the meeting

Annex 3: ToRs for the next meeting

The **Study Group on Salmon Age Determination [SGSAD]** (Chair to be decided) will meet in (venue to be decided) the winter period of 2010 to:

a) evaluate the status of examination of thin slice from salmon pelvic fin ray;
b) evaluate the possibility to differentiate real spawning marks from other erosion marks;
c) evaluate the status of the preparation of a description of salmon life cycle (blue book of IBSFC);
d) evaluate the status of the investigations on possibilities to assess post-smolt survival rate on the basis of scale growth pattern;
e) evaluate the possibilities to use the number and width of striae as an aid in the interpretation of difficult scales;
f) evaluate the experiences from the use of strontium-calcium relationship in the research on e.g. early emigration behaviour of fry.

SGSAD will report by 1 June 2010 or 2011 (depending on the date of SGSAD meeting) for the attention of Transition Group on the Science Requirements to Support Conservation, Restoration and Management of Diadromous Species (TGRECORDS) and SCICOM.

Supporting Information

Priority:	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.
Scientific justification and relation to action plan:	In the age determination of fish, quality assurance is a vital part to ensure the reliability of age determinations. 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. In addition to age determination, SGSAD contributes the use of scientific methods that utilize calcified structures, especially scales and otoliths. Stock assessment of salmon and other research on salmon are benefitted from the work of SGSAD.
Resource requirements:	
Participants:	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities:	None.
Financial:	BSRP has supported the work of SGSAD by means of travelling expenses of the participants from countries that get funding from BSRP.
Linkages to advisory committees:	There are linkages with Transition Group on the Science Requirements to Support Conservation, Restoration and Management of Diadromous Species; Baltic Committee; and Baltic Salmon and Trout Working Group.
Linkages to other committees or groups:	There is a very close working relationship with all the groups under WGFAST/WGFTFB. It also is of close relevance to the Working Group on Ecosystem Effects of Fisheries.

Linkages to other organizations:	By contributing the efforts to increase the validity of salmon age determination, SGSAD supports the objectives of the EU Data Collection Programme.