Baltic Committee **ICES CM 1999/H:6**

REPORT OF THE

SECOND SCALE-READING WORKSHOP ON BALTIC SALMON

Helsinki, Finland
16–18 November 1998

International Council for the Exploration of the Sea

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See Appendix 1 for addresses of the participants.

2 Terms of Reference

The Second Scale Reading Workshop on Baltic Salmon (SSRWBS) under the Chairship of Mr E. Ikonen, Finland was held in Helsinki, Finland from 16-18 November, 1998 (C.Res./1997/2:43) to:

a) compare the scale structure of wild salmon originating in rivers from different parts of the Baltic;
b) compare the scale structure of reared salmon originating in different stocks and rearing practices; examine how sea growth influences the scale patterns of salmon originating in different parts of the Baltic;
c) prepare an evaluation of the accuracy and precision in the reading of scales of different origins;

SSRWBS will report to the meetings of the Baltic Salmon and Trout Assessment Working Group and the Baltic Committee.

RA (IBSFC 100%)

Justification:

At present there are often significant differences in the interpretation of scales of Baltic salmon among persons from different countries and laboratories. Scale readers need background knowledge of the life history of salmon to interpret the scales. Normally scale readers manage quite well in distinguishing wild and reared salmon when dealing with their national or local stocks. The aim of this workshop is to gather scientists who are familiar with the life history and scale pattern of their “own” salmon. They will become acquainted with the peculiarities of scales from other areas and of different origin (wild or reared). It is expected that the precision of ageing and other aspects of scale reading will increase among participants at the workshop. In order to test this assumption the workshop will prepare an international test on the accuracy and precision in scale reading.

3 Background and techniques of scale reading and interpretation

Scale sampling is essential when collecting biological data on Baltic salmon. Scale sampling has continuously been carried out in almost all countries producing and/or harvesting the Baltic salmon. On the basis of the scale reading, traditionally age and growth have been determined as well as the year class to which the salmon belong.

Since the 1950s the number of salmon of wild origin has decreased, but in the mid-1990s a slight increase took place. At the same time hatchery-reared smolt production has increased from a very low level to about 5 million annually and at present is still increasing.

On the basis of smolt production estimates, the share of wild salmon is about 10 % of the total production. When the status of most wild stocks is still weak, it has been shown that it would be beneficial to direct harvesting away from these wild salmon. However, outside the home river, the fishery nowadays exploits more or less a mixture of wild and reared salmon and there have been few opportunities to distinguish between the two. Although opportunities to direct the present salmon fishery towards the reared stock component are limited, these could still be utilised if the share of wild salmon were separated in catches.

The rearing of salmon smolt in hatcheries results in some habitus features, which normally differ, from those in wild salmon. The most common is deformation of fins; especially the dorsal fin of reared salmon, which is often curved, or even missing. Salmon smolt reared in a hatchery often differ from wild smolt in age, growth pattern and size. These factors can mostly be detected in scale pattern when comparing the scale patterns of wild fish. In the 1990s, all hatchery reared smolt have been one or two years old, while in the natural environment, the smolt age varies between one and four years depending on the latitude and nature of the home river. Hatchery-reared smolt has been predominantly larger than the wild, which is also detectable on the basis of scale measurements. Different growing conditions in hatcheries can be seen in the growth pattern of the scale. The winter and summer bands of hatchery-reared salmon are less pronounced than those of wild salmon, at least when they come from northern areas. Often ageing of hatchery-reared smolt is difficult or even impossible, while the age of wild fish is relatively easy to determine.

The method of determining the origin of salmon (i.e., wild or reared) has been described by Antere & Ikonen in 1983. The method was applied in different laboratories but because of difficulties and uncertainties in stock discrimination it was proposed that under the ICES umbrella, a workshop to co-ordinate scale interpretation for Baltic salmon be organised. The Baltic salmon scale reading workshop met in Utsjoki, Finland in 1991. The workshop concluded that northern wild salmon can be fairly accurately separated from those reared both visually (Antere & Ikonen 1983) and by the discriminate function method where the width between the circuli of the first annual zone, the number of circuli in the first annual zone and the mean number of circuli per annual zone in the fresh water phase were used. However, when approaching more southerly areas, it was observed that difference in scale pattern between wild and hatchery-reared salmon decreased. Discriminate analysis derived from the Finnish material was observed to be too narrow and should be broadened to include the southern stocks or then a separate function should be developed for them.

The workshop also recommended that the amount of misclassification should be investigated before putting scale-based stock discrimination into practice in the Baltic Sea. The test was planned and the test material included scales from salmon of known origin and known age, from both north and south. The blindfold test was initiated in 1992 with participating laboratories in Estonia, Finland, Poland, Russia and Sweden. The results of the test were reported in 1994 (Ikonen et al., 1994) recognising wild fish to be particularly difficult with a classification efficiency ranging from 19% to 79%. The results also suggested that the ageing of salmon is more difficult than previously thought. The correct determination percentages for sea aged ranged from 41% to 77% for the fish of a known age. The Baltic Salmon and Trout Assessment Working Group recommended the test and when results became available, the WG stated that for Baltic salmon stock assessment purposes, the levels of misclassification and misageing were too high.

Hiilivirta et al. (1998) compared the visual method (Antere & Ikonen, 1983) to the method based on discriminate function analysis. The discriminate function was based on variables; the width of the first freshwater annual zone; the maximum number of circuli per year in the freshwater zone; and the mean distance between circuli in the freshwater zone. These measurements were carried out with a computer-aided scale reading system. The visual method resulted in a 100% correct classification while the discriminate function analysis results suggested that it is possible to derive a discriminate function, which distinguishes between wild and hatchery-reared salmon originating in northern stocks almost as accurately (92.6%) as the visual method. However, the visual method is subjective and the correct classification is greatly dependent on the experience of the scale reader. The accuracy of the discriminant function method may be increased to the level where its applicability may even exceed that of the visual method, at least in situations where scale readers of limited experience must be employed.

A computer aided scale reading and age determination system for Atlantic salmon (SUOMUI) was developed for Finnish Game and Fisheries Research Institute (FGFRI) between the years 1986 and 1989 in co-operation with the Departments of Applied Mathematics and Applied Physics at the University of Kuopio. SUOMU I am used to read both the juvenile and adult growth phase in two separate images with different magnifications. The ageing and measurement results of both images are combined at the end of the analysis. SUOMU I is based on a proprietary and now obsolete video frame grabber. Image processing was designed for 1980s processor technology and the software works in a text-based environment. The deficiencies of the system are obvious in light of the modern computing environment, but it is still operational and will be used until the new system is ready.

SUOMU II - a new version of the computer aided scale reading system has been a two year project (funded by the Technology Development Centre of Finland (TEKES), the Regional Council of Lapland and FGFRI) and ended in 1998. It has been a technology project in which new image processing techniques, neural networks and multimedia hardware applied to scale reading in a graphical environment has been studied.

The goals of this project have included the use of a standard software layer for video capture (API) to reduce the cost of equipment and allow the replacement of obsolete components without reprogramming. The new multimedia hardware results in better image resolution and ergonomics, and reduces eye strain due to the superior picture quality of the computer monitor as compared to that of a TV-monitor. Another goal has been to develop detection methods, which would reduce the necessity for manual verification of circuli. Artificial neural networks have been tested on the classification of escaped/farmed and wild origin Atlantic salmon with some promising results.

Most of the technical difficulties have been solved and most of the original goals have been achieved. Further studies with neural networks and different data sets need to be done to complete the SUOMU II system which would allow successful identification of the origin of any given Atlantic salmon caught in the Teno River. SUOMU II is expected to be fully operational by the end of 1999.

This development work in the computer-aided scale reading techniques has been primarily carried out in Utsjoki in northern Finland and test material has been taken from the Teno River, which flows, into the Barents Sea. Hatchery origin fish met there have all been escapees from the net pen farming of salmon in the sea. In spite of the fact that discrimination between farmed and wild fish might be easier than in the Baltic Sea, the development of the computer aided scale reading system surely will increase stock identification possibilities in the Baltic Sea as well. In recent years, development in this field has been rapid especially along the Pacific Ocean coast with Pacific salmon.

Concerning the correct ageing of salmon (sea age) the guidelines will be found in the reports of the two Atlantic salmon scale-reading workshops held in 1984 and 1988 under the auspices of the ICES. These workshops produced the Atlantic salmon scale reading instructions (Shearer, ed. 1992). However, they were produced mostly for the scale interpretation of salmon in the Atlantic area. When Baltic salmon scales were subjected to these guidelines, the scale pattern was so different in most cases that they were rejected for application to Baltic salmon. However, the report is of great help in gaining experience in scale interpretation.

4 National reports on the smolt production and life histories of salmon in countries surrounding the baltic sea

Smolt production and life histories of salmon in Denmark

Frank Ivan Hansen

Smolt production

There is no wild salmon smolt production in Denmark.

In 1998 the following numbers of hatchery-reared smolts were released:

Sub-division	ICES square	No. of smoltsX1000	Mean length cm	Mean weight g	Releasing technique
24	39G4	60	22	120	delayed release
24	38G2	60	27.25	170	delayed release
25	39G5	30	17.55	52.3	normal

Life histories

Because of no wild salmon rivers and due to the fact that all hatchery-reared smolt have been released straight to the sea there has been no smolt run or spawning run detected. However, some tag recoveries have been obtained from rivers in

the Baltic Sea as well as outside. Most of tag recoveries have been reported in Sub-divisions 24-28. There are also recoveries in Sub-divisions 21-23 as well as outside the Baltic Sea.

Smolt production and life histories of salmon in Estonia
Tiit Paaver

Smolt production

Wild smolt production exists in the Gulf of Finland, ICES Sub-division 32 in the following rivers: Kunda, Loobu, Keila, and Vasalemma. Total annual production has been estimated at 5 000-7 000 smolts (M.Kangur, on the basis of electrofishing surveys). In the Gulf of Riga, ICES Sub-division 28, the Pärnu River production has been estimated at 2 000 smolts annually.

Hatchery-reared and released smolts and parr
Number of fish:

1996	31 800	one-year-old parr (Aravuse hatchery, Neva strain)
1997	11 800	one-year-old parr (Aravuse hatchery, Neva strain)
1997	29 000	two-year-old smolt (Põlula hatchery, Neva strain)
1998	51 000	one-summer-old parr (Põlula hatchery, Neva strain)
1998	90 000	two-year-old smolt (Põlula hatchery, Neva strain)

All the hatchery fish were released into rivers flowing into the Gulf of Finland (ICES Sub-division 32) less than 20 km from the river mouth. The fish were reared in the concrete basins or plastic tanks of the hatchery in fresh water and fed intensively. They were released in spring (April-June) as two-year-old smolts and one-year-old parr or in October as two-summer-old parr.

Life histories

One-year-old parr may be 8-10.5 cm and 3-5 g, two-summer-old parr 12-17 cm 20-50 g, and the two-year-old smolts are probably similar to two-summer-old parr. The smolt run takes place from April-May. Almost all smolts are two years old; few one or three years old. In many rivers the proportion of precocious male parr is significant (sometimes 70-80% of males) and they stay in the river for a third summer. It is not known whether they leave for the sea later. The size of reared juveniles varies significantly between years and fish farms, depending on the rearing conditions or that year's weather. The reared two-year-old smolts have been 40-140 g, the average total weight being 200 g in some exceptional groups in 1998. All the released hatchery fish are tagged by clipping of adipose fin (since 1997), while 4800 fish have been tagged with Carlin tags (EST TLN MEI) from 1997-1998. The hatchery-reared fish have been released only into the rivers where wild salmon reproduction has ceased or is very rare and irregular (Valgejõgi, Selja, Jägala, Pirita and Narva/Narova Rivers).

Migration in the sea has been little studied. Tagged salmon, which were released into Estonian rivers from 1997-1998, were recaptured near the release sites in the first few months, and later near the northern coast of the Gulf of Finland. In autumn, they were caught again near the release site at the mouth of the Selja River. The rate of straying of returning spawners can be significant, as shown in a few examples. In the Selja River salmon juveniles were absent for 20 years, but when the water quality improved, the salmon returned and spawned from 1995-1996. One tagged male salmon, released into the Valgejõgi, was caught at the mouth of the Selja in October. The age structure of spawners has not been studied between the 1950s and 1998. The male salmon released in spring 1998 returned as 1-1.2 kg grilse that autumn. In the 1940s, the males returned after one or two winters at the sea, the females after two or three, and very rarely four winters. After two summers at sea the total weight of salmon released as 70-80 g smolts is 3-5 kg.

As the spawning grounds are situated very near to the river mouths of relatively small rivers, while upstream migration is blocked by weirs or waterfalls situated 1-14 km away from the river mouths, the spawning migration is short (except in the large Narva/Narova River) in time and distance. Most likely, there are no spawners ascending the river in winter before the year of spawning. In some years, the salmon may go up into the Narva/Narova River in July-August, and into the other rivers in October-November.

The proportion of salmon/trout hybrids can be relatively high and have been found in almost all the rivers where the spawning of both species takes place.

Smolt production and life histories of salmon in Finland

Erkki Ikonen

Smolt production

Wild smolt production in Finland exists mainly in the Rivers Tornionjoki and Simojoki. In these rivers original stock still exists but both stocks have been supported by the annual release of hatchery-reared parr and smolt. In addition, natural reproduction has started again in some rivers where continuous releases, mainly smolt releases, have been carried out for many years, as in the Kymijoki River in the Gulf of Finland and the Kiiminkijoki River in the Gulf of Bothnia. The original stocks have become extinct in these rivers, so the Neva and Iijoki stocks have been used respectively, in releases. The Kiiminkijoki, Pyhäjoki and Kuivajoki Rivers are at the moment the former salmon rivers where the largest reproduction areas are still available. These rivers have thus been chosen to be included in the Salmon Action Plan programme of the IBSFC, whose target is to rebuild the salmon stocks of former salmon rivers. The number of smolts originating in natural reproduction will increase if the development of rebuilding is successful.

Rivers where natural reproduction occurs (1996-1998 average)

Sub-division	River	No smolts	Smolt age	Comments
31	Tornionjoki	75 000	3 (2-4) years	Parr+smolt releases
31	Simojoki	3000	2-3 (2-4) years	Parr+smolt releases
31	Kiiminkijoki	Some	2-4 years	Parr+smolt releases
32	Kymijoki	4 000	2 (1-3) years	Smolt releases

Production of hatchery-reared smolts

Sub-division	River or Site	No smolts	Age years	Strain	Comments
31	Kemijoki	615 000	2	Tornionj.+Iijoki	Compensatory rel.
31	Kuivajoki	20 000	2	Simojoki	Rehabilitation
31	Simojoki	80 000	2	Simojoki	Enhancement
31	Iijoki	310 000	2	Iijoki	Compensatory
31	Kiiminkijoki	29 000	2	Iijoki	Rehabilitation
31	Oulujoki	200 000	2	Oulujoki	Compensatory
31	Pyhäjoki	100 000	2	Tornionjoki	Rehabilitation
30	Merikarvianjoki	25 000	2	Neva	
30	Kokemäenjoki	150 000	2	Neva	
29	Åland	200 000	1+ and 2	Neva (Åland)	1+=delayed rel.
32	Vantaanjoki	60 000	1 and 2	Neva	
32	Kymijoki	270 000	1 and 2	Neva	Compens. partly

When released at the age of two, hatchery-reared smolts have normally been 170-220 mm long. When released at the age of one they have been 130-170 mm long. In delayed releases, smolt size has been 220-250 mm.

The great majority of hatchery-reared smolt originates from the brood stocks reared in hatcheries. These brood stocks are continually partly renewed by the offspring of sea run spawners. Smolt rearing takes place by using conventional rearing techniques. Only a small fraction of hatchery production has been reared a full year in the hatchery and the second summer in net cages from which they have been released (delayed release).

Smolts were released into the river, the river mouth or straight into the sea in spring from May-June. Only those fish released from net pens (delayed release) were released later in the summer or autumn.

Life histories

Wild smolts migrate into the sea from May-June. Hatchery-reared smolts are released in May or early June excluding those reared a second summer in net cages and released later in the summer or autumn.

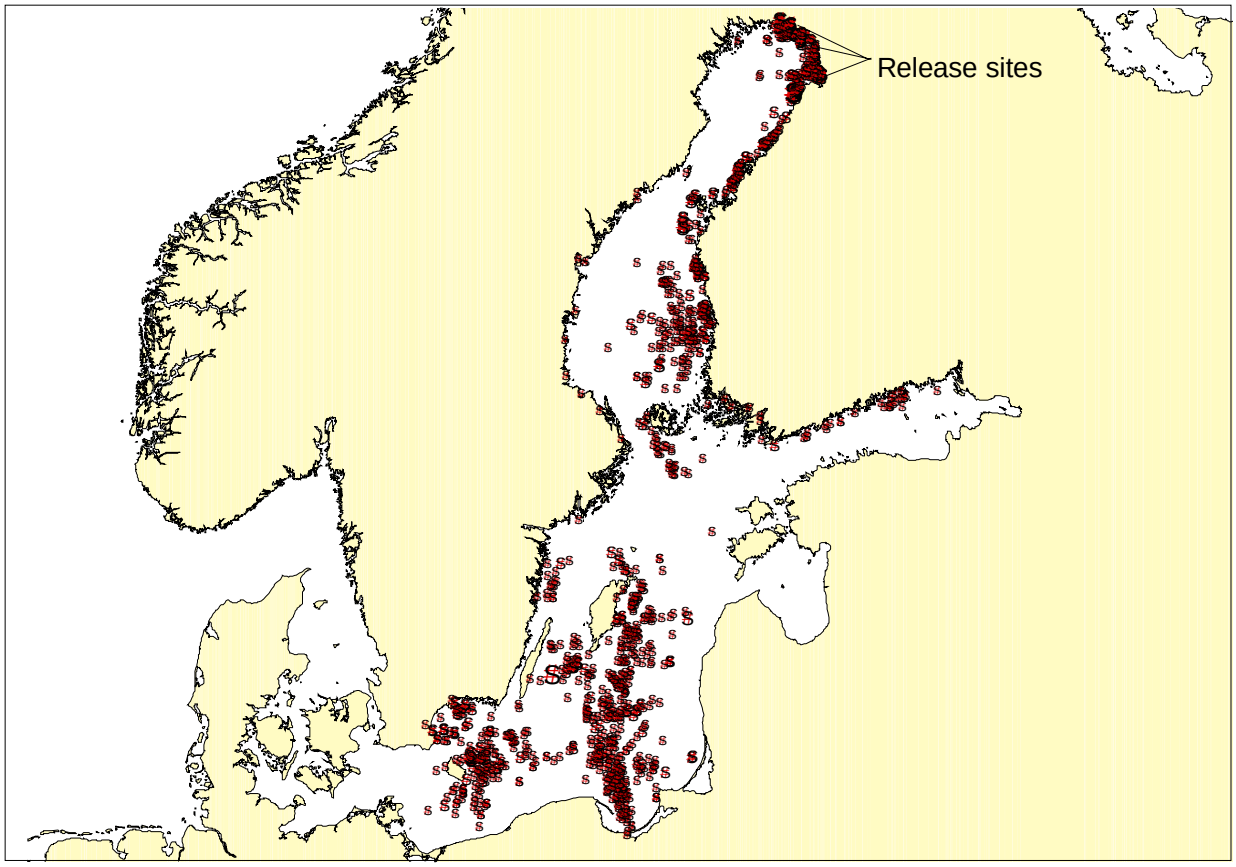

Figure A. Distribution of the tag recoveries of salmon originating from the smolt releases into the Kemijoki, Iijoki and Oulujoki Rivers.

Salmon originating in the Bothnian Bay rivers or releases (Sub-division 31) migrate to the feeding areas in the Baltic Main Basin where the main feeding areas are located in the surroundings of the greatest deeps, the Gotland Deep, Bornholm Deep and Gdansk Deep. However, the variable share of post-smolt stop for feeding in the Bothnian Sea area (Sub-division 30) every year. The share of feeding fish in the Bothnia Sea area probably depends on the availability of food. The strong herring year classes in the Bothnian Sea seem to correlate positively with numerous feeding salmon during the second year when those fish enter the offshore fishery (Ikonen and Parmanne, 1992).

The spawning run one to three years later will be detected in coastal areas from June-July. The main migration route, on the basis of tag recoveries, occurs along the west coast of Åland and along the Finnish coast to the home river. There are some recoveries from the Swedish coast of the Gulf of Bothnia as well and even some in the Gulf of Finland. The tag recoveries of smolt taggings in the Kemijoki, Iijoki and Oulujoki Rivers are presented in Figure A.

Tag recoveries of Neva salmon releases in the Bothnia Sea area reveal that the great majority of these fish migrate only in the Bothnian Sea area (Figure B). There are very few recoveries outside of the Bothnian Sea where these fish have been released. Neva salmon enter the coastal fishery in late June-July, later than northern stocks passing that area.

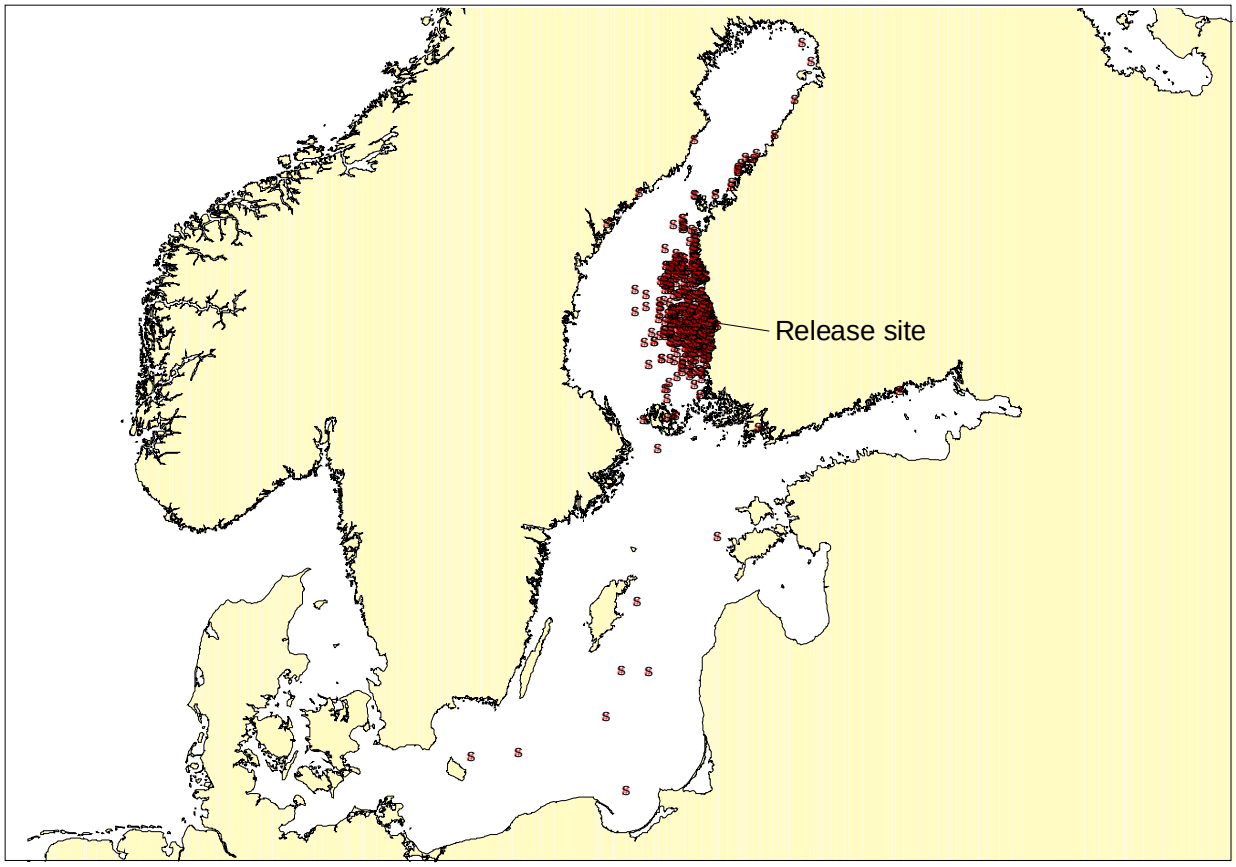

Figure B. Distribution of the tag recoveries of salmon originating from the smolt releases into the Kokemäenjoki River.

Tag recoveries of Neva salmon released into the Gulf of Finland suggest that the majority of fish will be caught in the gulf. However, there are more recoveries in the Main Basin area compared to the Bothnian Sea releases. On this basis, a great part of these fish feed in the Gulf of Finland but part in the Main Basin as well. There are also some recoveries in the Gulf of Bothnia (Figure C). In the Gulf of Finland, during the spawning run, Neva salmon also enter the coastal fishery in late June-July.

In all areas, the most common age group in the spawning population is normally A.2+. A strong grilse run suggests good post-smolt survival, an increased number of released smolt or a good year class of wild populations.

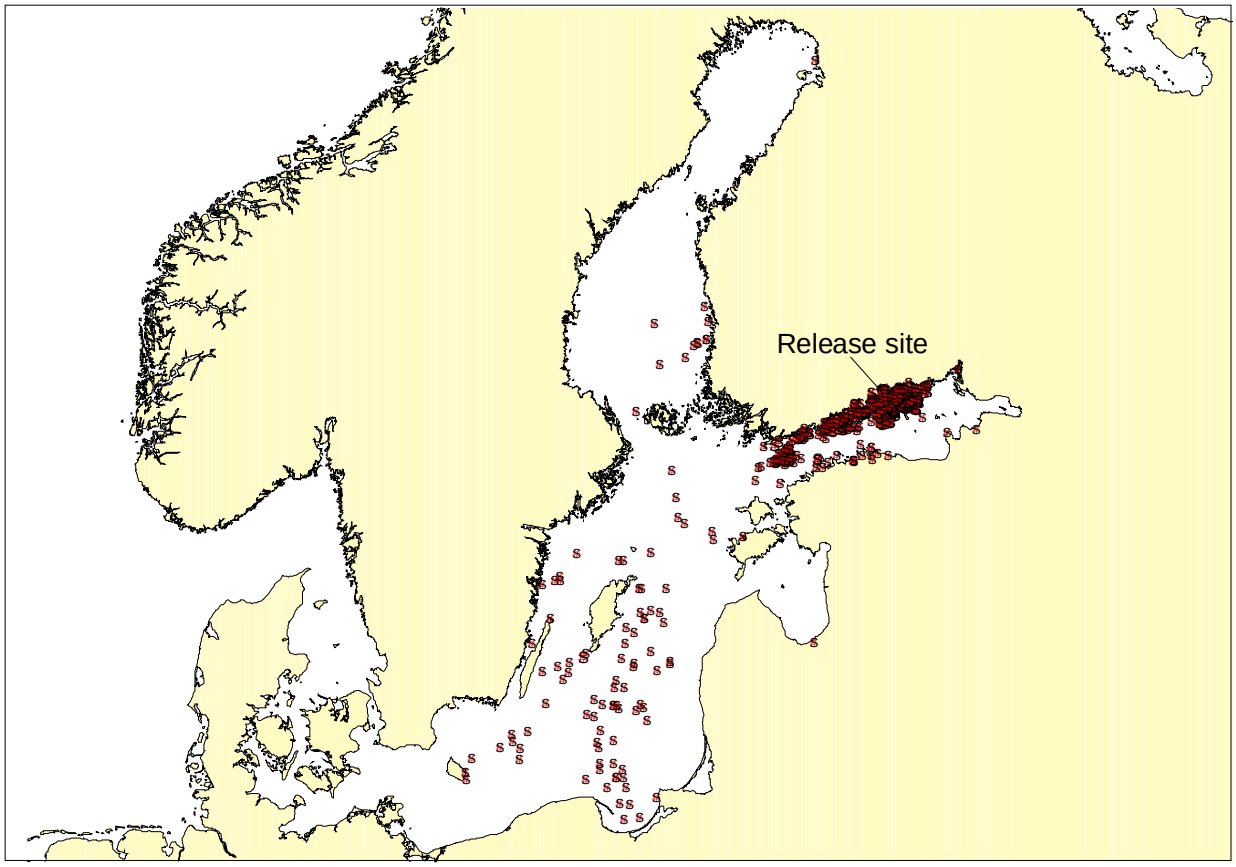

Figure C. Distribution of the tag recoveries of salmon originating from the smolt releases in the Kymijoki River.

Smolt production and life histories of salmon in Latvia

Andis Mitans

Smolt production

Wild smolt production

There are 10 rivers in Latvia having wild salmon smolt production. The total production is about 80 000 wild smolts. All rivers supporting wild stocks empty into Sub-division 28.

River	No of wild smolts x 1000
Salaca	25
Vitrupe	4
Peterupe	4
Gauja	13
Daugava	5
Irbe	7
Venta	12
Saka	7
Uzava	2
Barta	1
Total	80

Hatchery-reared smolt production

There are six salmon hatcheries in Latvia. Five of them use tanks for salmon rearing, but one of them (Pelchi) has ponds. Latvian hatcheries produce one and two-year-old smolts.

There are three salmon hatcheries in the Daugava River: Tome, Kegums and Dole. The Salaca hatchery also uses the Daugava broodstock and releases smolts into the Daugava river mouth. The total releases of salmon into the mouth of the Daugava river amounted to 600 000 smolts annually, mainly one-year-olds.

The Karli hatchery is situated in the basin of the Gauja River and produces about 120 000 one-year-old and 40 000 two-year-old smolts.

The Pelchi hatchery releases 40 000-50 000 smolts annually into the Venta River. The total number of hatchery-reared salmon smolts is about 800 000 - 900 000 smolts annually.

Hatchery-reared smolt production in 1997:

River Basin	Hatchery	Age	No.x1000	Mean weight g
Daugava	Tome	1 yr.	377	28.9
Daugava	Kegums	1 yr.	90	36.0
Daugava	Dole	1 yr.	85	22.5
Daugava	Salaca	1 yr.	168	24.9
Gauja	Karli	1 yr.	163	19.1
Gauja	Karli	2 yr.	9	57.1
Venta	Pelchi	1 yr.	50	14.8

Life histories

In Latvia, smolt descent takes place in May with mode in the first decade. The age structure of wild smolts consists of 30 to 40 per cent one-year-old smolts; the rest are two-year-olds and three is rare. Most of the reared smolts are also released in May, using only the normal releasing technique. Smolts are usually released in the lower section of the rivers and at the river mouth.

Latvian salmon migrate all around the Baltic Sea including the Gulf of Finland. However, the main feeding ground seems to be in the north-eastern part of the Baltic Proper.

Latvian salmon return as spawners mainly from the ages of 1+ to 4+. The spawning run begins in June and goes until November.

In Latvia, artificial reproduction is based on sea-run wild and hatchery origin salmon broodstock. The broodstock fishery is carried out near the mouth of the main salmon rivers in October-November.

Smolt production and life histories of salmon in Lithuania
Antanas Kontautas

Smolt production

Lithuanian rivers sustain mainly wild smolt production. There were no salmon juvenile, parr or smolt releases in Lithuanian rivers from 1997 to 1998.

Wild smolt production exists in the following rivers (ICES Sub-division 26):

River	Sub-division	No. of smolts	Age of smolts	Comments
Neris	26	14 000	1-2 years	no releases
Sventoji	26	1 500	1-2 years	no releases
Zeimena	26	4 500	1-2 years	no releases
Minija	26	-	-	no releases

The estimation of smolt production was based mainly on electrofishing data and the number of spawners at the mouth of the Nemunas. The smolt trapping data is sparse.

Life histories

The spawning migration to the Nemunas River starts in July, and in the Kuronian lagoon there is a maximum intensity from the middle of August to the end of September. In the spawning rivers (the migration distance is from 270 to 450 km) salmon appear from October to the first part of November when spawning takes place (Neris, Sventoji, Zeimena Rivers). Mainly A.1 to A.4-year-old fishes migrate, some of them 18-26 kg in weight. The 0+ parr are 9-14 cm long and 9 -14 g in weight. The 1+ parr density in the rivers is much less compared to 0+ and is 15-17 cm long and 25-40 g in weight. Precocious males stay for a third summer in rivers. The smolt run takes place from April to the first part of May. There is no data on migration into the sea. The data on of salmon/sea trout hybrids is absent, but, concerning electrofishing data, the salmon and sea trout parrs have separate nursery areas (data from the Neris and Zeimena Rivers).

Smolt production and life histories of salmon in Poland
Ryszard Bartel

Smolt production

Wild smolt production
The last salmon population became extinct in the mid-1980s. No natural smolt production yet exists. As a result of salmon restoration, salmon nests were observed in the Drawa River in autumn 1997 and kelts in the Parseta and in Drweca Rivers.

Hatchery-reared smolt production
Salmon restoration was initiated in Poland in 1985, when 50 000-eyed salmon eggs from the Daugava River were imported. In the following years, the Daugava salmon eggs were imported including 150 000 Daugava salmon fingerlings in autumn 1996.

Salmon spawners were reared in net cages in the Gulf of Gdansk until 1996. Since 1995, some smolts have been chosen for the rearing of salmon spawners in fresh water, in concrete basins at the Miastko hatchery. From these, 700 000 and 800 000 eggs, respectively, were spawned in 1997 and 1998.

Since 1994 smolts have been released into the Wieprza, Slupia, Rega and Drawa Rivers, as well as into the Vistula River and its tributary the Drweca River.

Releases of one and two-year-old smolts:

Year	No. of smolts
1994	22 647
1995	209 481
1996	116 783
1997	320 173
1998	535 457

The minimum length of smolts is 14.5 cm. Among smolts released, the dominant fish were a length of 17-22 cm. The largest smolts released reached the length of 28-29 cm and mean length varied from15 to 20 cm.

Salmon eggs are incubated in hatcheries at a normal water temperature, though sometimes in a recirculated system in warm water. Salmon smolts are reared in five hatcheries in earth ponds and concrete basins.

Salmon smolts can only be released into rivers or river mouths during the period of 1 March-15 May.

Life histories

Smolts released migrated very quickly to the sea northwards and were caught as far north as the Gulfs of Finland and Bothnia. In autumn 1997 and 1998, salmon spawners were mainly caught in the Wieprza and Drweca Rivers. Spawners varied in size from 77 cm to 105 cm in 1997, while in 1998 they were bigger and reached 120 cm. The age of the spawners caught in 1997 was A.2+ and A.3+.

Smolt production and life histories of salmon in Russia
Oleg Christoforov and Irene Murza

Smolt production

There are three rivers (Neva, Luga, Narva/Narova) inhabited by salmon and about 20 small rivers and brooks inhabited by sea trout along the Russian coast of the Gulf of Finland (ICES Sub-division 32). There were 5 000 to 20 000 salmon spawners entering each of the salmon rivers annually at the end of the 19th century, but the number of individuals underwent a significant reduction later owing to habitat deterioration. To support the Baltic salmon populations, re-stocking was started. Over the period from 1874 to 1915 the Nikolsky hatchery and its branches performed all releases of young salmon. Then, the Nevsky, Narvsky and Luzhsky salmon hatcheries were built and put into operation in 1921, 1957 and 1989, respectively. The outputs designed for the Narvsky and Luzhsky hatcheries are 100 000 and 300 000 smolts a year. The new Nevsky hatchery, designed for an output of 100 000 smolts, began its activity in 1998.

At present, the regular commercial fishing of salmon in the rivers of this region is absent. A restriction on catching salmon spawners for the purpose of artificial propagation takes place just before the spawning season. The fish are captured by net (Neva River, Narva/Narova River), or by trap net (Luga River). The research of entire batches of caught adult fish as well as the sampling of young fish from natural conditions provide the basis for the modern salmon and trout population-monitoring programme. This programme was developed and is being carried out by the scientific group of the St. Petersburg State University. The Committee of Fisheries of the Russian Federation co-ordinates it.

An extensive bank of biological and statistical data covering the period of hatchery activity was created. It is supplemented annually by information on the number, size and age of released young fish and caught adult salmon. A sex ratio and quota of previously matured individuals among spawners as well as the quality of eggs and milt are analysed. As well, a percentage of reared and wild fish is estimated by means of a combined method based on the external body morphology and scale patterns. The reading of scale structure is very useful in recognising of the species, sex and life history of fish, including age at release and the biotechnology of rearing. Fin clipping has been discontinued, but regular scale sampling before young fish are released is now carried out. Monitoring data allows the estimation of dynamic trends in each population and the effect of re-stocking measures in each river can be checked. This information is applied to calculate the rates at which salmon return to the river (or, actually, rates of adult fish recapture in the river after release of each hatchery generation) and to predict the number of spawners that will enter the river the next year.

Selected data concerning the Neva, Narva/Narova and Luga salmon populations as well as hatchery salmon rearing are presented below.

It is important to note in general that the present-day abundance and structure of the above populations are very labile and depend on the dynamics of young fish released during the previous five to six years. Differences between the populations in age-composition, fish body size, egg size and fecundity are found. Under hatchery conditions, about 40-50 % of males mature as parr at the age of 1+. Mature parr males may undergo smolting at the age of 2, 3 or 4 years old. Some of fish spend their first year of sea life near the river estuary and then migrate to the Main Basin of the Baltic.

Neva River is 74 km long. The entire length of this river is accessible for upstream salmon migration. The number of adult salmon caught in the Neva River in the early-to-mid 1970s reached 1 500 to 2 600 individuals a year. Destruction of the main spawning grounds (the Ivanovsky rapids) from 1975-1978, the subsequent deepening of the river bed as well as dam building across the Neva Bay in 1986 and an increase in water pollution has resulted in a decrease in salmon abundance since 1976. The number of Neva salmon spawners caught over the last two decades has not exceeded several hundred individuals per year. It is known from historical data that a portion of hatchery (fin-clipped) fish in the Neva salmon population grew rapidly, from 22% to 89%, between 1960 and the 1970s (Persov, 1971; Melnikova et al., 1980; Kazakov, 1990). According to the results of adult fish scale reading, the percentage of likely wild spawners did not exceed 1-2 % from 1990 to 1994, and such individuals were not found later (Murza, Christoforov, 1992; our unpublished data). On the contrary, we were able to reveal examples of scales with the features characteristic of wild salmon in a series of screenings of sets of Neva salmon scales collected since 1958.

Under Neva hatchery conditions, young fish are held in fibreglass tanks. The two-year-old smolts are released in May, whereas parr of different ages are released throughout spring, summer and autumn. The site of the young fish release is the river near the hatchery. The number of salmon released since 1990 is presented in Table 1.

The present-day rates for salmon return to the river from hatchery release of 2, 1-1+ and 0+ year old young fish are 2-3.3%, 0.2% and 0.1%, correspondingly (Christoforov, Murza, 1998).

Table 1. Number of young salmon released by the Neva hatchery and number of salmon spawners caught in the Neva River from 1990 to 1998.

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998
Release of young fish, Thousands individuals	0+	126	-	-	-	-	-	30	-	22.3
	1; 1+	33.1	-	-	-	-	-	8.9	10.8	13.4
	2	4.6	-	-	9.2	6.6	10	10.5	6.2	12
Catch of spawners, individuals		224	140	71	107	128	150	127	136	109

Under Narva/Narova hatchery conditions, young fish are held in fibreglass tanks and sometimes in river net pens. The one and two-year-old salmon are released in May, whereas salmon of 0+ and 1+ years old are released throughout spring, summer and autumn. The site of young salmon released is the river downstream from the hatchery. The number of fish released since 1990 is presented in Table 2.

The rates of return to the river after release from 1980 to 1984 of one-year-old "heated" salmon smolts were up to 2.3-4.2 % (Kazakov et al., 1988), but later decreased sharply from 1.8-1.9 % to 0.1-0.7 % (Christoforov, Murza, 1998). It is assumed that changes in offshore fishing might be responsible for this phenomenon.

Table 2. Number of young salmon released by the Narva/Narova hatchery and number of salmon spawners caught in the Narva/Narova River from 1990 to 1998.

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998
Release of young fish, Thousands of individuals	0+	-	-	-	-	-	-	-	-	43
	1; 1+	77.5*)	101 *)	11.5*)	108 *)	78.5*)	116	92.6	129	80
	2	-	-	-	-	13.5	-	7.5	-	-
Catch of spawners, individuals**)		945	455	54	163	139	124	164	263	514

*) These generations of fish were reared by use of warm wastewater ("heated").
**) There are Narva/Narova salmon catches by Russian fishermen only presented here.

The information on Estonian annual catches of Narva/Narova salmon is unavailable.

Under the Luga River hatchery conditions, young fish are kept in fibreglass tanks. As well, summer rearing in net pens was carried out from 1994 to 1996. The captive brood stock of salmon was then formed (Murza et al., 1997). The one and two-year-old fish are released from April-May, whereas 0+ and 1+ year old fish are released throughout spring, summer and autumn. The sites of the young salmon release are the River Luga and its tributaries. Number of fish released since 1990 is presented in Table 3.

Table 3. Number of young salmon released by the Luga hatchery and number of salmon spawners caught in the Luga hatchery from 1990 to 1998*).

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998
Release of young salmon, Thousands individuals	0+	2.9	-	-	40	-	-	-	-	8.1
	1; 1+	-	0.8	1.2	20.3	-	5.7	16.1	40	59.4
	2	-	-	-	-	1.8	-	-	-	-
Catch of spawners, individuals		-	-	-	12	3	46	34	2	59

*) The information concerning sea trout is not presented in Table 3. The number of trout spawners caught by the hatchery range from 61 to 157 individuals annually. The percentage of wild fish among of them is 54-70 %. The number of immature trout registered by trap net is up to 164 individuals a year.

Life histories

Young salmon spend two to four years in the Neva River. The proportions of two, three and four-year-old smolts may range from 31.3 to 84.1%, from 10 to 64.9% and from 0 to 11% correspondingly. Descriptions of the biological features of wild Neva salmon smolts are sparse. N.I. Jandovskaya (1941) noted that hatchery and wild two-year-old smolts caught in May-June near the Neva hatchery were characterised by a fork length of 16-17.5 cm and body weight of 41-53 g, whereas three-year-old smolts were 17.5-20.0 cm and 66 g or more. According to A. .A. Svetovidova (1941) fork length and weight of smolts caught in the Neva River from 1924-1937 were 13.4-15.6 cm and 30.3-37 g, whereas the range of smolt fork length back calculated from adult fish scales was from 12.7 to 19.2 cm. According to our data, the range in smolt length back calculated from the scales of adult fish caught over the last decade was 12-24 cm (13.5-19.7 cm in 90 % of individuals).

During their sea life Neva salmon migrate across the Gulf of Finland and Main Basin of the Baltic Sea, but they have not been found in the Gulf of Riga nor in the north part of the Gulf of Bothnia (Melnikova, Persov, 1968; Kazakov, 1990).

Adult fish ascend the river from May to October (predominantly from August-September) and become mature from mid-October to early November. The range in the total age of spawners is 3+ to 9+. The duration of sea life before the first return to the river may be from 1+ to 4+ in males and from 2+ to 4+ in females. Over the last decade the predominant age groups of males have been 2.1+; 3.1+; 2.2+; 3.2+ and for females, 2.2+; 2.3+; 3.2+; 3.3+. The one SW (sea winter) individuals make up 25-84 (mean 55.3)% of the total number of males. The female/male ratio varies from 1-0.8 to 1-3.4 (mean 1-1.6). The percentage of previously matured fish stayed high over the whole period of hatchery activity (9-37%).

The Narva/Narova River is 77 km long. Only 20 km in its lower part is accessible for upstream salmon migration. The dam building in 1953-1955 resulted in the loss of spawning grounds and a rapid depletion of the native Narva/Narova salmon population (Barannikova, 1962). From 0 to 12 wild salmon individuals a year were captured from 1958-1966. A new population was created by the Narva/Narova hatchery from 1969-1974 on the basis of eggs and/or young fish introduced from the Neva, Gauja and Luga populations (Kazakov, 1990) as well as from the Dauguva population. An application of intensive biotechnology for young fish winter rearing (pen-cages in warm wastewater) over the period 1980-1994 has provided an annual release of about 100 000 one-year-old smolts, resulting in significant growth of the Narva/Narova salmon population. From 945 to 2 200 spawners have been caught each year from 1984-1990. The subsequent cessation of the use of intensive biotechnology by the Narva/Narova hatchery led to rapid changes in the age composition of the population. A percentage of “heated” fish among salmon spawners stayed high until 1998. The percentage of fish migrating from the river as one-year-old smolts among the Narva/Narova salmon spawners has decreased from 70–90% in 1980s to 42% in 1996 and to 2.3% in 1997 (Christoforov, Murza, 1998). The present-day low percentage of fish smolting at one year resembles the 1970s (4-12%). The scale structure of “heated” one-year-old fish is characterised by the presence of additional bands composed of wide-spaced and narrow-spaced circuli. Formal reading of such scales may lead to the wrong age determination (Kazakov et al., 1988). Wild individuals of salmon were not found in the Narva/Narova population over the last three decades. The number of spawners caught since 1990 is presented in Table 2.

Young fish spend one to three (males up to four) years in the river. The downstream migration of smolts takes place in April-May. The range of the smolt fork length back calculated from the scales of adult fish caught from 1993-1997 was 12.8-25.6 cm (14.3-18.0 cm in 90% of individuals). The length of hatchery smolts caught in late May-early June 1998 in the Narva/Narova Bay varied from 12.5 to 15 cm.

During their sea life, Narva/Narova salmon migrate across the Gulf of Finland and Main Basin of the Baltic Sea, but are rarely found in the Gulf of Bothnia and were completely absent in the Gulf of Riga (Kazakov et al., 1992).

Adult fish ascend the river from May–June to October (predominantly from August-September) and become mature during mid or late October. The range in the total age of spawners is 2+ to 7+. The duration of sea life before the first return to the river may be from 0+ to 4+ in males and from 2+ to 4+ in females. Over the last decade, the predominant age groups of males were 1.1+; 2.1+; 3.1+ and for females 1.2+; 2.2+; 1.3+; 2.3+. The one SW individuals make up more than 90 % of the total number of males. The female to male ratio varies from 1: 0.5 to 1: 3.3 (mean 1: 2.4). The percentage of previously matured fish is 0–2.5% (mean 2.1%).

The Luga River is 353 km long. The whole length of this river is accessible for upstream salmon migration now, but extinction of the native Luga salmon population took place many years ago owing to rafting and dam building. The main spawning grounds in the rapids of the Luga and its tributaries (Oredezh and Saba) were unattainable for salmon from the 1930s-1950s. The last time young wild salmon were registered in this river was 1934 (Kutchina, 1939) and the final known instances of wild salmon spawners caught were dated 1964 and 1969 (6 and 2 individuals). A new salmon population is now being created by the Luzhsky hatchery on the basis of eggs and/or fry introduced from the Neva,

Narova and Daugava populations. Limited river net fishing was performed from 1993-1994 and trap nets were used from 1995-98. The number of salmon spawners caught is presented in Table 3. Scale reading shows that all of these fish as well as all of the salmon parr sampled by our group in the Luga River were hatchery reared.

It is known from historical and modern sources that the migration of Luga salmon smolt takes place in May. More than 90% of the smolts are two years old, whereas three-year-old fish are rare (Kutchina, 1939; our unpublished data). The range in smolt fork length back calculated is 12-18.8 (13.5-17.8 in 90% of individuals).

Salmon spawners ascend the river from May to October and become mature in mid to late October. The range in the total age of spawners is 3+ to 7+. The duration of sea life before the first return to the river may be from 1+ to 4+ in males and from 2+ to 4+ in females. Over the period 1994-1998, the predominant age groups for males were 2.1+; 2.2+ and for females 2.2+; 2.3+. The one SW individuals make up more than 90 % of the total number of males. The female/male ratio varies from 1: 0.3 to 1: 3.5. The percentage of previously matured fish is low. Wild individuals were not found in the present-day Luga salmon population.

The data on the routes of sea migrations and on the rates of return to the river are fragmentary at the moment.

The results of monitoring being performed by the university scientific group show that hatchery propagation is the main method for the conservation and rebuilding of Russian Baltic salmon stocks (Barannikova et al., 1994; Christoforov, Murza, 1998). Features of salmon river water quality improvement and water ecosystem restoration were revealed during the last three to four years (including rehabilitation of Crustaceans and rheophilic Mollusca). This provides a significant reason for optimism.

Chair's comment:

In the Russian national report there is no information on the salmon situation in the Russian area in Sub-division 26. However, it has been suggested (Michelson, pers. comm.) that there are neither salmon rivers nor salmon smolt production in that area. Only sea trout exist in these rivers.

Additional information to the Russian national report has been presented by Serguei Michelson (Appendix 2), suggesting that in the Gulf of Finland in the Neva, Luga, Sista, Voronka and Kovashi Rivers wild smolt production could occur. The WGBAST report (Anon.1998) also states that wild salmon smolt production could occur in the Neva, Luga, Sista, Voronka, Kovashi and Koporka Rivers. However, neither Michelson nor the WGBAST report provides any information on how this wild production has been detected and what methods were used when these wild smolt production estimates were done. Therefore, the report by Christoforov and Murza will be taken as the Russian national report and contradictory information presented by Michelson as well as information in the WGBAST report will be discussed later when background information on these wild smolt production estimates has been shown.

Smolt production and life histories of salmon in Sweden
Lars Karlsson

Smolt production

Wild salmon rivers
There are 14 so-called wild salmon rivers; see table below.

Sub-division	River	No smolts [1]	Smolt age	Comments
31	Torne älv	75 000	2-4 years	Release of smolts
31	Kalix älv	60 000	2-4 years	
31	Råne älv	1 000	2-4 years	
31	Pite älv	4 000	2-4 years	
31	Åby älv	4 000	2-4 years	
31	Byske älv	35 000	2-4 years	
31	Rickleån	1 000	2-4 years	
31	Sävarån	1 000	2-4 years	
31	Ume älv/Vindelälven	17 000	2-4 years	Release of smolts
31	Öre älv	1 000	2-4 years	
31	Lögde älv	2 000	2-4 years	
30	Ljungan	7 000	?	Release of smolts
27	Emån	4 000	1-3 years	
25	Mörrumsån	50 000	1-3 years	

1. Average level from 1996-98.

Enhancement of the wild populations through the release of reared parr, fry or salmon eggs occurs in several of the rivers. It is anticipated that the releases will be phased out when production levels in the rivers have increased somewhat. Reared smolts that are released in these rivers are adipose fin clipped.

Production of reared smolts

Regular releases of reared smolts takes place in the following nine rivers. In two of these rivers wild smolt production occurs.

Sub-division	River	No smolts	Age (years)	Comments
31	Lule älv	550 000	2	
31	Skellefte älv	120 000	2	
31	Ume älv	100 000	2	Wild prod. in tributary Vindelälven
30	Gide älv	6 000	2	
30	Ångermanälven	210 000	2	
30	Indalsälven	320 000	2	
30	Ljungan	30 000	2	Wild prod.
30	Ljusnan	185 000	2, small part 1 y.	
30	Dalälven	190 000	2, small part 1 y.	

In total there are regular releases of about 1.7 million smolts. In addition to these regular compensatory releases smaller irregular releases occur in some other rivers in Sub-divisions 30-31. There are also normally less than 0.05 million reared smolts released in Sub-divisions 29-25.

Life histories

All smolts are reared in land-based hatcheries and are normally released into the rivers in April-May as two-year-old smolts. The fish normally have a total length of 140-210 mm at release, the mean being about 180 mm. One-year-old fish are smaller, about 140 mm. In some of the hatcheries in the southern part of the Gulf of Bothnia, parr are graded in the autumn to find fish that are of sufficient size to be released as one-year-old smolt the following year. In addition, there are normally releases of about 0.5-0.8 million reared parr and about 0.5 million eggs in rivers in the Gulf of Bothnia and the Main Basin. From1999 and onwards all reared smolts will probably be adipose fin clipped. Delayed release as a technique may be used on a small scale, but large scale delayed releases will not occur.

Migration

The smolt run occurs in May-June in the Gulf of Bothnia and in April in the Main Basin.Wild smolts in the Main Basin are smaller than those in the Gulf of Bothnia, 110-150 mm as compared to 140-190 mm.

A great majority of all salmon from Swedish populations in the Gulf of Bothnia migrate to the Main Basin for feeding. There is a slight tendency for two populations to differ from the others. The reared fish from the Ume älv River migrate further to the south in the Main Basin than other examined populations and the reared fish from the Dalälven River in the southernmost part of the Gulf of Bothnia stay to a slightly larger extent in the Gulf of Bothnia. Most fish from the northern populations as well as fish from the Emån and Mörrumsån Rivers stay to feed in the southern part of the Main Basin in Sub-divisions 25-28. After one to four years the fish migrate to spawn. Salmon from the Emån and Mörrumsån normally ascend the rivers early in the summer. The salmon spawners originating in the Gulf of Bothnia enter the gulf in late May-August. The more northerly of these populations often migrate northwards along the Finnish coast, while those from the southern populations in Sub-division 30 to some extent migrate directly to their home rivers. The fish enter the rivers from June-September. Wild salmon is normally one to three weeks earlier than reared fish. The spawning takes place in October in northern Sweden and somewhat later in southern Sweden.

Synthesis of the national reports

Sub-division	Number of wild smolts	Age	Number of reared smolts	Age	Main migration area	Comments
24	0		120 000	?	24-28	Denmark
25	0		30 000	?	24-28	Denmark
25	50 000	1-3	0		24-28	Sweden
25-26	0		540 000	1-2	24-29	Poland
26	20 000	1-2	0		?	Lithuania
27	4 000	1-3			?	Sweden
28	2 000	1-3			?	Estonia
28	80 000	1-3	850 000	1-2	25-29,32	Latvia
29	0		200 000	1+-2	29-30	Finland
30	0		175 000	1-2	30	Finland
30	7 000	?	941 000	2 (1)	24-30	Sweden
31	28 000	2-4	1 354 000	2	24-31	Finland
31	176 000	2-4	770 000	2	24-31	Sweden
32	7 000	2	90 000	1-2	32 ?	Estonia
32	4 000	1-3	330 000	1-2	28-29,32	Finland
32	0 ?		164 000	1-2	28-29,32	Russia

5 Scale pattern of the wild and hatchery-reared salmon originating from different rivers, different stocks or rearing practices in the Sub-divisions

In the following is the collection of scale pictures showing mostly the known origin and known age of salmon originating in different Sub-divisions (Figures 1.-65.). The main aim of this workshop was to combine information on the salmon river life, rearing practices as well as migration at sea and analyse how the origin and life history of salmon affect the scale pattern. However, taking into account the quality of scale material provided and in many cases the restricted experience in scale reading and interpretation by the participants, the workshop was not able to fulfil this aim.

Fig. 1. A wild salmon smolt from the Tornionjoki River (Sub-division 31), age 4+. Thickening of the circuli is clear and all freshwater annual zones distinct.

Fig. 2. A wild salmon smolt from the Tornionjoki River (Sub-division 31), age 3+. All freshwater annual zones are distinct.

Fig. 3. A wild salmon smolt from the Tornionjoki River (Sub-division 31), age 2+. Both freshwater annual zones are distinct. New growth clearly seen.

Fig. 4. A wild salmon smolt from the Tornionjoki River (Sub-division 31), age 4+. Thickening of the circuli of the first three years is relatively poor but the annuli are quite easy to localise. The growth of the fourth year is strong.

Fig. 5. A hatchery-reared smolt with two freshwater years (released in Sub-division 31). The growth of the second year is strong with several widely spaced circuli. The circuli at the margins of the annual zones do not form thickenings.

Fig. 6a, b. A spawner from the Tornionjoki River (Sub-division 31), age 4.3+, interpreted as wild by the visual method.

Fig. 7a, b. A spawner from the Tornionjoki River (Sub-division 31), age 3.3+G1, interpreted as wild by the visual method. In this case it is difficult to say whether the narrow spaced circuli outside the third annual zone form a fourth freshwater zone or only a run-out band.

Fig. 8a, b. A wild salmon from the Simojoki River (Sub-division 31) tagged as a smolt in 1991. The age is 2.2+.

Fig. 9a, b. A wild salmon from the Simojoki River (Sub-division 31) tagged as a smolt in 1991. The age is 3.2+.

Fig. 10a, b. A hatchery-reared salmon released as a one-year-old parr in the Simojoki River (Sub-division 31). The fin clipping combination “adipose + right pelvic fin clipped” refers to releases in the spring of even numbered years (-92, -94 etc.). Because the fish obviously has two sea years it most probably has two freshwater years. The age is thus 2.2+. After the release this fish spent one year in the river. Distinguishing this example from a wild fish is difficult.

Fig. 11a, b. A hatchery-reared salmon released as a one-year-old parr in the Simojoki River (Sub-division 31). This fish has the same kind of fin clipping combination as the previous one but because it has only one sea year it must have three freshwater years. Thus the age is 3.1+. Distinguishing this fish from a wild fish is difficult.

Fig. 12a, b. A hatchery-reared salmon released as a one-year-old parr in the Simojoki River (Sub-division 31). The fin clipping combination refers to the age 2.2+. In this case, however, the hatchery origin is obvious. The first annual zone is so broad and irregular with no thickening of the circuli that the centre of the freshwater zone refers to the hatchery origin.

Fig. 13a, b. A. hatchery-reared, tagged salmon, age A.1+ (released in Sub-division 31). Smolt age two years. Both freshwater zones are broad and the first one in particular has no thickening at the end of the zone.

Fig. 14a, b. A. hatchery-reared, tagged salmon, age A.1+ (released in Sub-division 31). Smolt age two years. The first freshwater annual zone is small. The circuli do not thicken towards the end of the second zone and the "clear" band typical for reared salmon is visible.

Fig. 15a, b. A. hatchery-reared, tagged salmon, age A.1+ (released in Sub-division 32). Smolt age one year. Although the known age at release is one year this fish could be interpreted as having two freshwater years because the centre of the scale has several closely spaced circuli. After the last freshwater year there is a narrow run-out band formed of about eight-nine circuli.

Fig. 16a, b. A. hatchery-reared, tagged salmon, age A.2+ (released in Sub-division 30). Smolt age one year.

Fig. 17. A. hatchery-reared, tagged salmon, age A.1 (released in Sub-division 30). Smolt age two years. A large smolt, 318 mm. The interpretation is quite easy although the freshwater area is relatively large.

Fig. 18a, b. A. hatchery-reared, tagged salmon, age A.1+ (released in Sub-division 31). Smolt age three years. The first freshwater year is difficult to localise and the scale could be interpreted as having only two freshwater years. Misclassification as wild is not possible.

Fig. 19. A. hatchery-reared, tagged salmon, age A.1+ (released in Sub-division 31). Smolt age four years. Misclassification as wild is not possible.

Fig. 20a, b. A. hatchery-reared, tagged salmon, age A.2+ (released in Sub-division 30). Smolt age two years. The smolt age and the location of annuli are difficult to determine.

Fig. 21. A. hatchery-reared, tagged salmon, age A.2 (released in Sub-division 31). Smolt age two years. In the second annual zone, a check occurs. The salmon could be interpreted as wild but the margin of the freshwater zone with no thickening of circuli reveals the origin as hatchery-reared.

Fig. 22a, b. A wild salmon from the Simojoki River (Sub-division 31) tagged as a smolt in 1991, age 3.2+. After the last freshwater year there is a narrow run-out band formed of about seven circuli.

Fig. 23. A wild salmon from the Simojoki River (Sub-division 31) tagged as a smolt in 1991, age 3.2+. Poor growth for almost the whole first sea year shown by the closely spaced circuli.

Fig. 24. A hatchery-reared, tagged salmon, age A.2+ (released in Sub-division 32). Growth has started immediately after release with no run-out.

Fig. 25. A hatchery-reared, tagged salmon, age A.2+ (released in Sub-division 31). The first sea year (1993) with less than 20 circuli.

Fig. 26. A. hatchery-reared, tagged salmon, age A.1+ (released in Sub-division 31). The exact location of the first sea annulus is difficult to determine because the growth seems to have continued throughout the winter. The position of the annulus is assessed by counting the circuli.

Fig. 27. A. hatchery-reared, tagged salmon, age A.2+ (released in Sub-division 32). A check is formed in a region about ten circuli before the second sea annulus. It is better seen on the left side of the scale.

Fig. 28. A kelt from a catch sample (Sub-division 31), interpreted as wild by the visual method, age 4.2+G+.

Fig. 29. A spawning salmon caught from the Tornionjoki River (Sub-division 31), interpreted as wild by the visual method, age 3.2+G1.

Fig. 30a, b. A hatchery-reared salmon released in the Gulf of Bothnia (Sub-division 31) in September 1985. The salmon was kept in a cage for four months before it was released. The smolt age was two years. Age at capture A.2+.

Fig. 31a, b. A hatchery-reared salmon released in the Gulf of Bothnia (Sub-division 31) in September 1985. The salmon was kept in a cage for four months before it was released. The smolt age was two years. Age at capture A.1+.

Fig. 32a, b. A hatchery-reared salmon released in the Gulf of Bothnia (Sub-division 31) in September 1985. The salmon was kept in a cage for four months before it was released. The smolt age was two years. Age at capture A.2+.

Fig. 33a, b. A hatchery-reared salmon released in the Gulf of Bothnia (Sub-division 31) in June 1987. The salmon was kept in a cage for three weeks before it was released. The smolt age was two years. Age at capture A.2.

Fig. 34a, b. A hatchery-reared salmon released in the Gulf of Bothnia (Sub-division 31) in June 1987. The salmon was kept in a cage for three weeks before it was released. The smolt age was two years. Age at capture A.1+.

Fig. 35a, b. A hatchery-reared salmon released in the Gotland area (Sub-division 27) in July 1987. The salmon was kept in a cage for eight weeks before it was released. The smolt age was one year. Age at capture A.1+.

Fig. 36a, b. A hatchery-reared salmon released in the Dalälven River (Sub-division 30) in April 1990. The smolt age was two years. Age at capture A.1+.

Fig. 37a, b. A hatchery-reared salmon released in the Dalälven River (Sub-division 30) in April 1990. The smolt age was two years. Age at capture A.1+.

Fig. 38a, b. A hatchery-reared salmon released in the Dalälven River (Sub-division 30) in April 1990. The smolt age was two years. Age at capture A.3.

Fig. 39. A wild salmon parr caught from the Mörrum River (Sub-division 25) 9.9.96. Early maturing male, age 1+.

Fig. 40a, b. A salmon tagged as a wild smolt from the Mörrum River (Sub-division 25). Age 2.2+.

Fig. 41a, b. A salmon tagged as a wild smolt from the Mörrum River (Sub-division 25). Age 2.2+.

Fig. 42a, b. A salmon tagged as a wild smolt from the Mörrum River (Sub-division 25). Age 2.2.

Fig. 43a, b. A salmon tagged as a wild smolt from the Mörrum River (Sub-division 25). Age 2(1?).1+.

Fig. 44a, b. A salmon tagged as a wild smolt from the Mörrum River (Sub-division 25). Age 2.2+.

Fig. 45a, b. A salmon tagged as a wild smolt from the Mörrum River (Sub-division 25). Age 2.1+.

Fig. 46a, b. A hatchery-reared salmon caught from the Narova River (Sub-division 32), age 2.3+. Age at release was one year.

Fig. 47a, b. A hatchery-reared salmon caught from the Narova River (Sub-division 32), age 2.1+. Age at release was one year.

Fig. 48a, b. A hatchery-reared salmon caught from the Luga River (Sub-division 32), age 2.3+G+1+. Age at release was 0+.

Fig. 49a, b. A hatchery-reared salmon caught from the Luga River (Sub-division 32), age 2.3+. Age at release was one year.

Fig. 50a, b. A hatchery-reared salmon caught from the Luga River (Sub-division 32), age 2.1+. Age at release was one year.

Fig. 51a, b. A hatchery-reared salmon caught from the Luga River (Sub-division 32), age 2.2+. Age at release was one year.

Fig. 52a, b. A hatchery-reared salmon caught from the Neva River (Sub-division 32), age 2.4+. Age at release was 0+.

Fig. 53a, b. A hatchery-reared salmon caught from the Neva River (Sub-division 32), age 2.1+. Age at release was two years.

Fig. 54a, b. A hatchery-reared salmon caught from the Neva River (Sub-division 32), age 3.2+. Age at release was two years.

Fig. 55. A wild salmon parr caught from the Keila River (Sub-division 32). Early maturing male, age 2+.

Fig. 56. A hatchery-reared salmon caught from the Selja River (Sub-division 32). Age 2.+.

Fig. 57. A hatchery-reared salmon caught from the Selja River (Sub-division 32). Age 2+.+.

Fig. 58. A hatchery-reared salmon caught from the Selja River (Sub-division 32). Age 2.+.

Fig. 59. A wild salmon smolt from the Salatsa River (Sub-division 28), age 1(+).

Fig. 60. A wild salmon smolt from the Salatsa River (Sub-division 28), age two years.

Fig. 61. A hatchery-reared salmon smolt from the Salatsa hatchery (Latvia, Sub-division 28), age two years.

Fig. 62. A hatchery-reared salmon smolt from the Tome hatchery (Latvia, Sub-division 28), age one year.

Fig. 63a, b. A hatchery-reared salmon tagged as a smolt in the Daugava River mouth (Sub-division 28), age 1.1+

Fig. 64a, b. A hatchery-reared salmon tagged as a smolt in the Daugava River mouth (Sub-division 28), age 1.2+

Fig. 65a, b. A hatchery-reared salmon tagged as a smolt in the Daugava River mouth (Sub-division 28), age 1.2+

6 Evaluation of the accuracy and precision in scale reading

The workshop unanimously stated that the situation in which to prepare an evaluation of the accuracy and precision in scale reading of salmon of different origin is premature because there have been recent changes in scale readers in different laboratories and in some laboratories new scale readers have just been appointed. The evaluation will be carried out when the new scale readers have gathered more experience in scale interpretation.

The computer-aided scale reading technique would be helpful, especially in stock discrimination. However, this experience is needed in scale pattern analyses before this technique can be effectively utilised. At the moment this computer-aided scale reading technique is only available in Finland among the laboratories working with Baltic salmon.

7 Recommendations

1) The Workshop recommends that the scale readers working with Baltic Salmon should meet in Helsinki, Finland from 22-24 March 1999 to learn more about the scale structure of salmon from different parts of the Baltic Sea. At the end of this meeting there will be a small test to evaluate the accuracy and homogeneity of the results of scale reading.

2) Because of the problems in ageing and stock discrimination in scale reading pointed out in this report, the Workshop recommends that an international project should be established with Erkki Ikonen as co-ordinator to:

    a) improve the accuracy of the scale reading

    b) promote the development of scale reading methodology in the Baltic Sea region

    c) prepare an evaluation of the accuracy in scale reading

3) The Workshop recommends that institutes continue and intensify their efforts to collect scale samples of salmon with a known origin, particularly in the eastern and southern parts of the Baltic Sea region.

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Appendix 2

Additional report by Serguei Michelson (Russia)

Smolt production in ICES Sub-division 32
Wild smolts
Rivers with Present Production of Wild Salmon

River	Wild smolt production, *1000
Luga (with tributaries)	11
Neva	20
Sista	1.5
Voronka	1.5
Kovash	1.0

Hatchery reared (released) in 1998

River	Number of fish, *1000	Age	Weight, g	Rearing techniques	Releasing techniques
Neva	12 13.5 22.3	2-y smolt 2-s parr 1-s parr	23.8 20.0 2.9	tanks in the hatchery	normal
Narva	24.0 80.0 43.0	2-s smolt 1-y smolt 1-s parr	21.7 24.1 3.5	tanks in the hatchery	normal
Luga	0.3 4.8 10.2 43.4 0.7 8.1	2-s smolt 1-y smolt 1-y smolt 1-y parr 1-y parr 1-s parr	100.0 21.4 20.0 20.0 8.8 2.7	tanks in the hatchery	normal

Life history

Narva/Narova River
Migration in the sea

Migration routes lay mostly to the west along the coast of Gulf of Finland, and then pass along the mouth of the Neva River to the east along the coast of Finland to the main basin of the Baltic Sea.

The main places for catching (according to the results of tag returning) are the Squares 49, 51, 52, 53, 54, 55, 58, 60, 61, 62, 63, 85, 86, 89, 90, 107, and 116.

Neva River

The main migration routes lay to the east along the coast of Finland to the main basin of the Baltic Sea.

The places for catching (according to the results of tag returning) are the Squares 54, 55, 57, 58, 59, 63, 75, 76, 86, 87, 107, 116, 133, and 134.

Luga River

The feeding range in the first year after the smolt run is located mostly around the area of the mouth of the Luga River.

A collection of scale prints with descriptions will be presented at the next workshop meeting at the end of March, 1999.