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Study on five different (non native) Atlantic salmon strains in first and second part of a salmon rehabilitation project in River Gudenå - Denmark.

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Abstract.

To reestablish a new salmon stock in River Gudenå 5 different Atlantic salmon strains have been released in the river since 1990. Two strains originating from Sweden: River Ätran and River Lagan, two from Ireland: Corrib and Burrishoole and one from Scotland: River Conon.

The preliminary results show a difference between the strains. In the seaward migration both in the river and in the brackish fjord the Swedish strains Ätran and Lagan show a higher preference to the main current. In migration velocity and timing the three strains Ätran, Lagan and Corrib are faster and earlier migrating than Burrishoole and Conon.

The return to homewater is also different among the strains, but there is no connection to the seaward smolt migration performance since the strains Burrishoole, Conon and Ätran have a higher return success compared to that of Lagan and Corrib.

From these preliminary results it is still too early to choose or disqualify a strain as the future Gudenå stock.

Keywords: atlantic salmon strains, migrating timing, migrating velocity, homewater return.

Introduction.

The original population of salmon in River Gudenå - the longest river of Denmark (158 kilometres) - became extinct in the 1920'ies when a hydroelectric power station was established in the lower part of the river. In 1987 it was decided to reestablish a new salmon population in River Gudenå. A 3-phased salmon rehabilitation project was initiated in 1988.

1st phase: gene-introduction. 5 - 6 years of annual importation of eggs and semen from salmon from rivers comparable with the River Gudenå. Production and release of a large number of smolts in order to build a cohort of brood fish as soon as possible.

2nd phase: gene-establishment. The establishment of a salmon trap for the catching of brood fish in order to continue the production of release fish. For 5 to 10 years a broad genetic population is being ensured, until we have obtained a natural reproduction in River Gudenå.

3rd phase: gene-stability. When the natural reproduction is stable and a new Gudenå river stock has been developed we have to decide whether the hatchery supply must stop or whether there is a need for continued releases.

To ensure the greatest possible genetic variation eggs and semen from 5 different salmon strains were selected. Two strains came from Sweden: River Ätran and river Lagan and two strains came from Ireland: Burrishoole and Corrib and one from Scotland: River Conon. By genetic DNA analyses (Nielsen, Hansen & Loeschcke, 1996) it came through that the 5 strains are genetically different. All 5 strains are bred under the same conditions in a recycled rearing plant. The first smolts were released in 1990. The establishment and running of the salmon trap has been very problematic and has thus prolonged phase 1 and we do not expect the salmon traps to be able to catch the 100 brood fish from each strain which are needed according to the genetic concept until 1996/97.

This salmon project in River Gudenå has given Denmark the possibility of carrying through investigations of salmon which have never been made before. By introducing 5 different strains to a former salmon river we have the unic possibility of studying these strains under the same conditions and without competition from an original strain. To have a general understanding of the Atlantic salmon biology it is important to involve the various differences in the strains. By using 5 strains it will also be easier to focus on the important problems of the stream which necessarily must be solved in order to re-establish a self-producing salmon population. A number of investigations concerning differences in strains are being carried out while a few have already been made. In the present paper we add up the preliminary results achieved so far.

Experiments.

Smolt Migration in the Brackish Fjord - Randers Fjord.

With the purpose of investigating the return succes among the different strains carlin tagged smolt were released in 1991, 92 and 93. The smolts were released on various locations in the lower part of the River Gudenå and in the brachish fjord - Randers Fjord. The large number of pound net in Randers Fjord are placed close to the channel with a net fence of 80 - 120 metres towards the bank. Thus the channel represents the only free strait through the Fjord. Two contemporary investigations from 1991 and 92 in Randers Fjord (Rasmussen, 1992; Rasmussen and Dieperink, 1994) into pound net fishing found a relatively large number of the carlin tagged smolt in the pound net. On going over the catch results from these investigations, we found a great difference between the strains in their catchability in the pound net (Table 1).

Table 1. Catch af smolts in pound nets in Randers Fjord 1991 and 1992.

strain	number released	number caught	catch procent
Lagan	3995	64	1,60
Ätran	2445	44	1,80
Corrib	3497	141	4,03
Conon	1982	107	5,40

Differences between the strains in their catchability in the pound net indicate different migration routes in the Fjord. Thus the Swedish strains Ätran and Lagan seem to have a more direct migration in the channel compared to the strains Corrib and Conon.

Smolt Migration in the River Gudenå.

With the purpose of quantifying the total migration of trout and salmon smolt to Lake Tange a large smolt trap was placed in the main reach of the River Gudenå at the inlet of the lake - Kongensbro in spring 1996. The smolt trap barred appr. 2/3 of the width of the river but due to its placing in a small turn, appr. 85% of the water of the river traversed the trap. 4 kilometres and 10 kilometres respectively, upstream the trap salmon smolt from each of the five strains were released. The smolts were marked according to strain and place of release.

The number of smolts caught from each strain varied, Table 2.

Table 2. Catch of released smolts in smolt trap at the lake inlet Kongensbro.

strain	number released 10 km	4 km	caught in procent 10 km	4 km	all
Ätran	2490	1036	55.6	45.8	52.7
Lagan	2176	917	54.4	52.8	53.9
Corrib	2486	1044	40.1	40.1	40.1
Burrishoole	2536	1050	40.7	37.1	39.7
Conon	2510	1047	45.1	33.0	41.6

More smolts from the Swedish strains Ätran and Lagan than from the Irish Corrib and Borrishole and the Scottish Canon were caught due to the fact that the Swedish strains mainly prefer the main current traversing the trap. This indicates a different migration pattern of the strains in their freshwater migration.

Smolt Migration Timing.

The strains arrive at Kongensbro at different times, Figure 1. The whole migration is divided into 3 periods, each of a duration of 9 - 10 days. The 3 strains Corrib, Ätran and Lagan had their primary arrival in period 1 while the 2 strains Burrishoole and Conon arrived primarily in period 3, Table 3.

Table 3. Average time of arrival for smolts to Kongensbro after their release at Svostrup 10 kilometres upstream.

	Ätran		Lagan		Corrib		Burrishoole		Conon	
	avg. time	no.	avg. time	no.	avg. time	no.	avg. time	no.	avg. time	no.
	days	%	days	%	days	%	days	%	days	%
1. period 18-26 april	5.46	81	5.02	86	3.61	76	7.01	13	7.02	10
3. period 7-15 may	22.4	5	21.7	3	22.9	12	24.4	61	24.1	66
50 % passed	6		5		4		22		22	

The smoltifying level of the fish was examined by a single point test of Na+, K+-ATPase activity. There was no significant difference in activity among the strains. It appears that the difference in migration pattern of the strains was not due to difference in smoltification level.

The five strains may be divided into two types with a different migration timing. The strains Ätran, Lagan and Corrib has an

early timing with 75% of the strain migrating in period one. Burrishoole and Conon has a later timing with more than 60% of their migration in period 3.

Smolt Migration Velocity in Lake Tange.

In 1996 two smolt traps were placed at the outlet from Lake Tange one immediately below the power station and one in the fish ladder beside the power station. As observed at Kongensbro the strains shows similar periodic variation in migration timing at the outlet from the lake, Figure 2. The velocity of smolt migration in lakes can then be calculated in each period, Table 4.

Table 4. Migration velocity Lake Tange - 12 km.

	Ätran		Lagan		Corrib		Burrishoole		Conon	
	km/ day	no. %	km/ day	no. %	km/ day	no. %	km/ day	no. %	km/ day	no. %
1. period	3.63	39	4.01	57	2.26	41	0.77	7	0.58	22
3. period	0.73	36	0.72	21	0.75	30	0.88	66	0.85	63

The average migration velocity of smolt in period 1. (caught within the first 8 days after their first registration) is considerably higher for the strains Ätran, Lagan and Corrib than for Burrishole and Conon. In period 3 the migration is dominated by Burrishoole and Conon whose migration velocity is also higher.

The registration of the arrival of smolts in the traps and the calculations of their migration velocity clearly divides the 5 strains into 2 categories. Ätran, Lagan and Corrib are "quick" types which migrate early and with a high migration velocity. Burrishoole and Conon are slow types whose relatively slow migration is not initiated until after some time.

Return Success.

A number of catches from the releases in 1991, 92 and 93 of the carlin tagged salmon smolt has been reported on. The return of the marks has up till May 1996 been 0,71%. The low return rate is probably due to local conditions such as the reluctance from local anglers and the fishing trade to send in the tags. From the tag returns we are still able to picture a difference in return success among the strains. The home water return rate of the strains Ätran and Conon is greater with 0,63% and 0,67% respectively and lower for the strains Corrib and Lagan with 0,30% and 0,33% respectively.

From the catch of brood fish in 1994 and 95 a similar tendency in the return success of the different strains released as smolts in 1993 was found. Table 5.

Table 5. Catch of brood fish

Strain	release	1. SW		2. SW		all
	1993	no	CPT	no	CPT	CPT
Ätran	25600	35	1.37	7	0.27	1.6
Lagan	35300	21	0.59	7	0.20	0.8
Burrishoole	35100	77	2.19	4	0.11	2.3
Conon	30700	37	1.21	0	-	1.2

The brood fish are caught in salmon traps throughout autumn and in trammel net (87%) immediately before the spawning time.

Fishing with trammel net is selective according to size, that means a possible shortage of the large multi sea winter salmon (Koed, Rasmussen, Holdensgaard and Pedersen 1996). It is unlikely though, that this will affect the picture of difference between the strains.

The total result of both return registrations shows that the strain Burrishoole takes the lead with the highest return rate. The strains Conon and Ätran come in second and Corrib and Lagan take third place.

Discussion.

In the present project we have chosen a number of experiments which serve as guide line to the development of the project.

During the smolt migration in rivers as well as in the fjord the strains Ätran and Lagen are different from the others in preferring migration in the main current whereas the strains Corrib, Burrishoole and Conon prefer migrations in more shallow waters. The timing and the migration velocity of the strains is divided into 2 categories; Ätran, Lagan and Corrib are relatively early and quick types and Burrishoole and Conon are late and relatively slow types. Probably different temperatures and/or the length of the day start migration and influences the 2 types different. Obviously the ruturn success is independant of both migration pattern and migration velocity in fresh water since the return success rate of Ätran, Burrishoole and Conon is higher than that of of Lagan and Corrib.

The strains have different characteristics and on the basis of the preliminary results it is not possible to decide which of the

strains is most suitable as future strain in the river Gudenå. This calls for continued investigations of differences between the strains.

In working with 5 strains at the same time the arguments are stronger when it comes to focusing on the important problems outside the range of fishing biology, namely river conditions. In the heavily culture influenced river Gudenå considerable changes have happened. The greatest problem is that of passage and damming of the river where once in the 1920'ies a hydroelectric power station was placed. Despite the establishment of a fishing passage at the power station conditions are still inadequate (Koed, Rasmussen, Holdensgaard and Pedersen 1996). Where the river originally had a considerable spawning and feeding area (Jensen 1982) the dammed reservoir Lake Tange today causes a considerable mortality of smolt (Rasmussen, Aarestrup and Jepsen 1996).

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Figure 1.

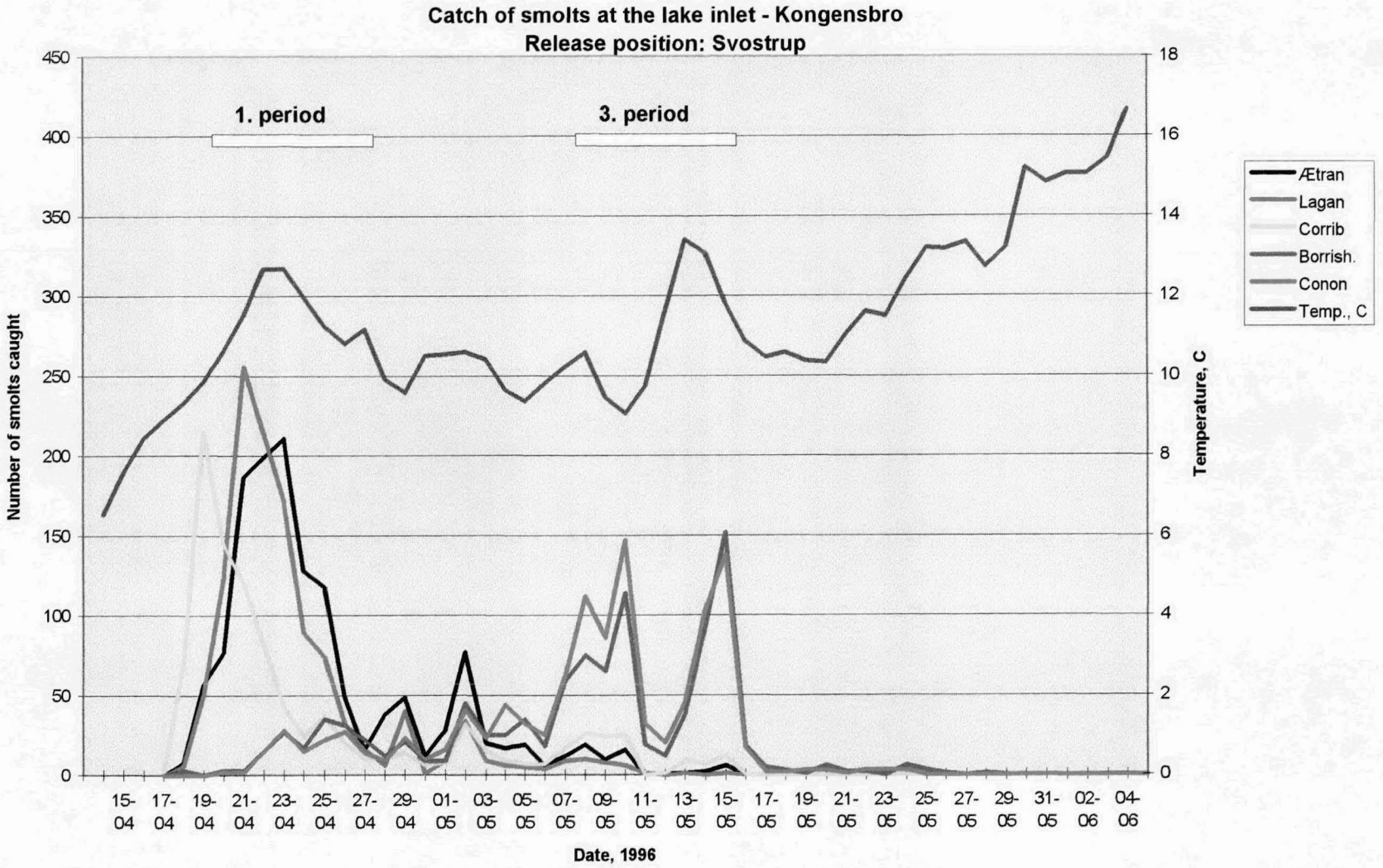
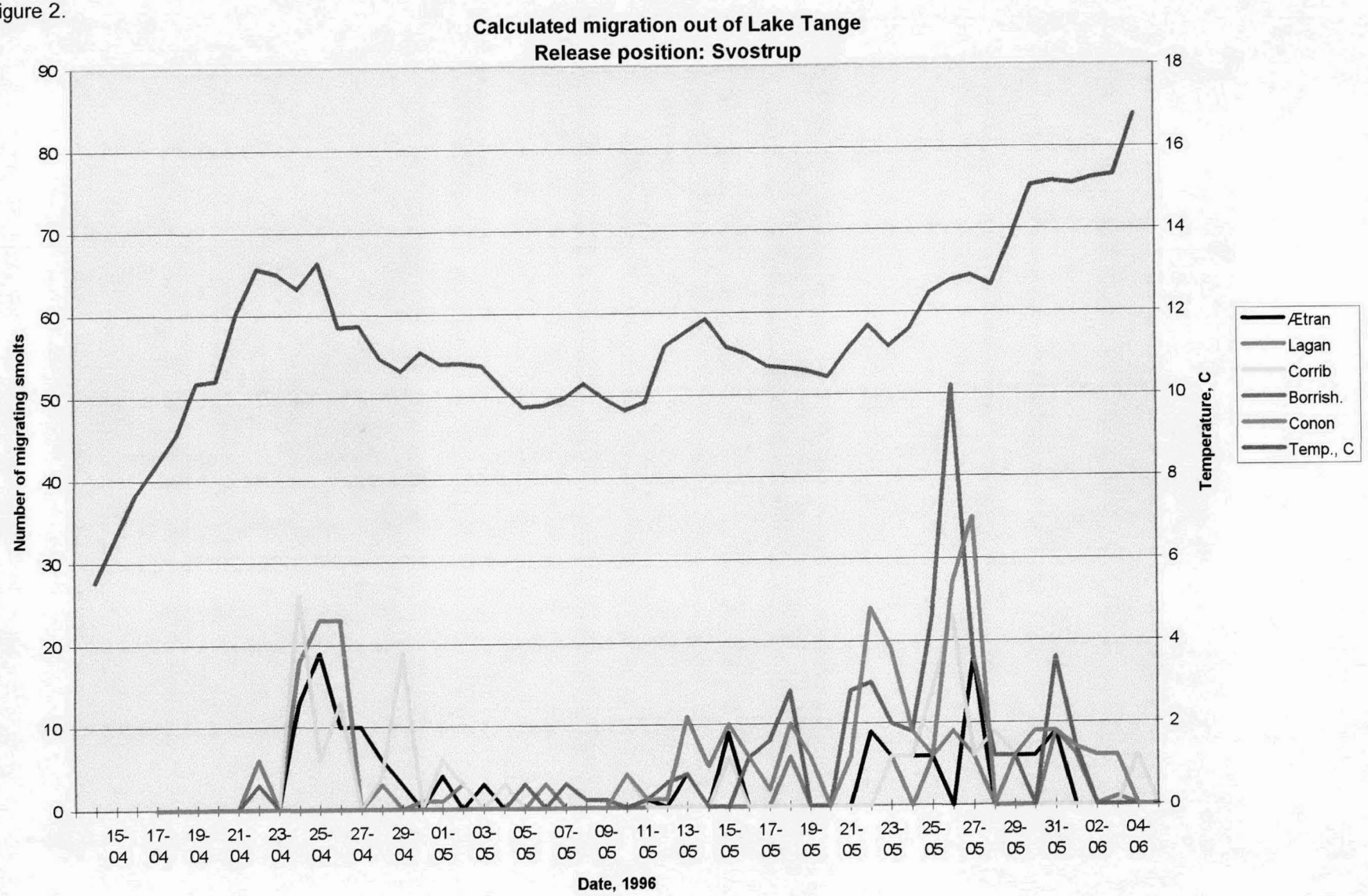

Catch of smolts at the lake inlet - Kongensbro
Release position: Svostrup
1. period
3. period
Number of smolts caught
Temperature, C
Date, 1996
Ætran
Lagan
Corrib
Borrish.
Conon
Temp., C
0
50
100
150
200
250
300
350
400
450
0
2
4
6
8
10
12
14
16
18
15-04
17-04
19-04
21-04
23-04
25-04
27-04
29-04
01-05
03-05
05-05
07-05
09-05
11-05
13-05
15-05
17-05
19-05
21-05
23-05
25-05
27-05
29-05
31-05
02-06
04-06

Figure 2.


Calculated migration out of Lake Tange
Release position: Svostrup
Number of migrating smolts
Temperature, C
Date, 1996
Ætran
Lagan
Corrib
Borrish.
Conon
Temp., C
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16
18
15-04
17-04
19-04
21-04
23-04
25-04
27-04
29-04
01-05
03-05
05-05
07-05
09-05
11-05
13-05
15-05
17-05
19-05
21-05
23-05
25-05
27-05
29-05
31-05
02-06
04-06