Pilot study smolt tagging 2006

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1 Introduction

With the purpose of reintroduction of Atlantic salmon (*Salmo salar*) in the river Rhine, smolts are released every year in the tributaries of the river by the "*Landesanstalt für Ökologie, Bodenordnung und Forsten NRW (LÖBF)*", in the framework of the Migratory fish programme of Northrhine-Westfalia. These smolts are introduced in the rivers shortly before their seaward migration. During their stay in the rivers, the smolts are imprinted by the characteristics of these so called home-waters and will return as adult salmon after having spend 1 to 3 years at sea. The first results of these stocking operations show that the return rate of adult salmon is relatively low, compared to other salmon rivers and reintroduction programmes. It is possible that the return rate eventually is too low to establish a sustainable salmon population. Several cause for the low return rate are currently discussed:

- Loss of downstream migrating smolts;
- High mortality in the marine phase of salmon, due to over fishing on the feeding grounds;
- High mortality of returning adult salmon, caused by a high level of by-catches in commercial fisheries in the coastal area, Rhine delta and rivers.

With regard to the loss of downstream migrating smolts, there is evidence that these fish are caught by professional fishermen in Lake IJsselmeer (Hartgers & Van Willigen, 2000). Also post-smolts are caught in the months May and June in the coastal waters near Haringvliet (Vriese & Wiegerinck, 1991). There is, however, no real insight in the downstream migration routes of smolts, the amount of losses during the downstream migration and the number of smolts that succeed in reaching the sea. To accomplish this, a large scale telemetry study on smolts is planned by LÖBF together with RWS-RIZA and Sportvisserij Nederland, using the NEDAP TRAIL system® in 2007. To test the feasibility of such a study, a pilot project on the tagging of smolts was performed in 2006 of which this report gives the results. The pilot project was also done with the aforementioned partners, of which RWS-RIZA took the initiative together with NEDAP, to develop the newest generation of small transponders.

2 Material and methods

In this project the NEDAP TRAIL System® was used. This system is based on the inductive coupling between an antenna loop and ferrite rod antenna within transponders. The system consists of detection stations on strategically chosen locations along the river Rhine (and Meuse) and its tributaries and implantable transponders. When a fish with a transponder passes a detection station its unique ID-number (among other information) is logged unto a data storage system. More information on the system can be found in Breukelaar *et al.* (1998) and Vriese *et al.* (2006).

With regard to the smolt project there were questions about the possibilities of tagging smolts with the rather large transponders (in relation to the size of the smolts). Although there has been quite an evolution in the size and weight of the transponders from the first version used with the NEDAP TRAIL system® (see figure 1, on the next page), the latest model transponder is still thought to be pushing the limits of what is possible.

The transponder used in this experiment has a length of 3.8 cm, a diameter of 13 mm, and a weight in air of 11,5 g. As can bee seen in figure 1, the casing of the transponder is no longer surgical glass but HDPE (High Density PolyEthelene), which reduces the weight of the transponder considerably. The smolts used are 2 year old fish with a minimum weight of 150 g. The transponder weight in water versus body weight of smolts ratio is 7⅔ % which is quite larger than the 2% rule commonly assumed as save. Nevertheless, the 2% rule is rather dated and recent research gives rise to other guidelines. For instance, Lacroix *et al.* (2004) states that transponder length should be less than 16% of the fish length and transponder weight should be less than 8% of the fish weight in order to maximize the chance of success in telemetry studies with juvenile Atlantic salmon. In our case, the smallest fish used in the project had a body length of 24 cm (T.L.) the length ratio being almost 15%. Weight and length ratios are within the boundaries of Lacroix *et al.* (2004) guidelines.

Figure 1. Different sizes of transponders used with the NEDAP TRAIL system®

The Atlantic salmon smolts used (Ätran 2+), were reared at the "*Lachscentrum Hasper Talsperre*" in Hagen-Haspe and graded at the beginning of the project to obtain fish of more or less similar size range (24-29 cm; 150-236 g). In total 10 smolts were used for this pilot study. A crew from VisAdvies and Sportvisserij Nederland performed the surgery on 2 May 2006 at the "*Lachscentrum*".

The surgical procedure followed was described by Vriese (1995) and originally developed for implantations of transponders on larger salmonids. Some of the surgery equipment used (V-shaped trough, tubes etc.) had to be downsize because of the size of the smolts. Fish had not been fed for 24 hours before surgery. All smolts were individually anaesthetized, using a 40 mg/l benzocaïn solution to obtain a stage 3 level of anaesthesia (i.e., total loss of equilibrium and swimming motion, absence of reactivity and reflexes, and no opercular motion). Induction time was 5-7 min. Total length and weight were measured first. The fish was then placed ventral side up into a V-shaped operating trough, which is part of a live support system. One end of the V-shaped trough and the head of the fish are immersed in a small tank filled with a 20 mg/l aerated benzocaïn solution. A small flexible tube, within a facial mask that covers the front end of the head, is induced in the mouth of the fish and the benzocaïn solution is pumped through gills of the smolt to ensure proper aeration during the surgical procedure. All surgical equipment and the transponders were cold sterilized by a minimum 15-min. immersion in a benzalkonium chloride solution and rinsed in sterile saline. Also sterile surgical gloves and towels were used. A small mid-ventral incision was made, starting about 1 cm anterior to the pelvic girdle with a curved-point, number 22 sterile scalpel blade, extending for 2,5 cm. The disinfected tag was positioned in the peritoneal cavity, directly under the incision. The incision was then closed with three simple, interrupted stitches that were tied with surgeons' knots, using Vicryl® 3/0 FS-1 Ethicon. After surgery fish were held shortly for observation in a small recovery tank. When the smolt was reacting normally in terms of breathing, equilibrium and swimming motion, it was placed in a larger holding tank. The next Friday (5th of May 2006) fish were released into the Sieg system, tributary of the river Rhine.

Figure 2*. Anaesthetized smolt

Figure 3*. Making the incision

Figure 4. Recovering smolt

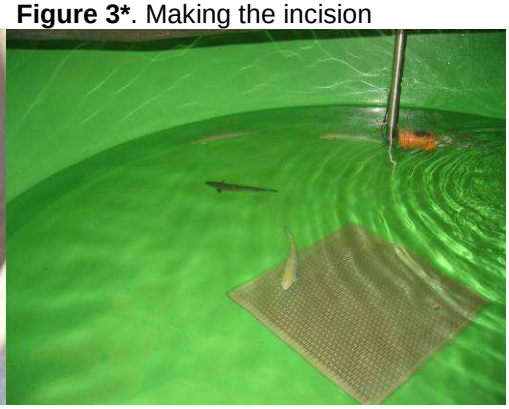

Figure 5*. After the procedure

(*: Photo's 2, 3 and 5 by G. Feldhaus, LÖBF.)

3 Results

3.1 Tagging

In the following table the tagging data are given (table 1).

Table 1. Tagging data of salmon smolts (2 May 2006)

Fish number	Transponder number	Weight	Length	Species	Origin
1	6001	171	26	Salmon smolt	Hasper Talsperre
2	6002	236	29	Salmon smolt	Hasper Talsperre
3	6003	160	25	Salmon smolt	Hasper Talsperre
4	6004	156	25	Salmon smolt	Hasper Talsperre
5	6005	155	24	Salmon smolt	Hasper Talsperre
6	6006	155	25	Salmon smolt	Hasper Talsperre
7	6007	155	25	Salmon smolt	Hasper Talsperre
8	6008	155	25	Salmon smolt	Hasper Talsperre
9	6010	150	24	Salmon smolt	Hasper Talsperre
10	6011	151	25	Salmon smolt	Hasper Talsperre

As can been seen from the table the tagged salmon smolts vary in length from 24 to 29 cm and in weight from 150 to 236 g. The tagging of the larger smolts was easier compared to the smaller fish. With the smallest fish it was sometimes more difficult to close the incision tight enough to bring opposing tissue surfaces together along the total length of the incision. The volume of the tag turns out to be rather large for the relatively small body cavity of the smallest fish. Nevertheless, all fish survived the surgical procedures. When the fish were returned to the holding tank it took several hours before normal behaviour was displayed. In the beginning they rested on the bottom of the holding tank and did not move very much. Later on they resumed normal swimming behaviour and feeding. On Friday, 5th of May 2006, fish were released into the Sieg system.

3.2 Smolt migration

Table 2 (on the next page) gives the registrations of the salmon smolts on the NEDAP TRAIL system®. In total 5 out of 10 tagged smolts were detected on the system (50%). Two of these smolts (transponder numbers 6008 and 6011) were detected in the evening/night of the day of release on the station Sieg_Menden and thus started their downstream migration very shortly after being released. Two other fish (transponder numbers 6001 and 6006) followed the next day (6th of May 2006) and the last fish (transponder number 6002) started to migrate on the 10th of May (5 days after being released).

Two fish (transponder number 6001 and 6006) were never seen again after being detected on the station Sieg_Menden. The smolt with transponder number 6008, after having passed station Sieg_Menden, was detected 4 days later on the station

Rijn_Xanten, which was also the last detection of this fish. The remaining two other fish were more successful in their downstream migration.

Table 2. Registration of smolts on the NEDAP TRAIL system® in 2006

Transponder number	Name of station	Time	Date
6001	Sieg_Menden	1:08	6-5-2006
6002	Rijn_Xanten	8:09	10-5-2006
6002	Waal_Vuren	7:46	11-5-2006
6002	DKil_s'Gravendeel	6:13	12-5-2006
6002	DKil_s'Gravendeel	10:41	12-5-2006
6002	DKil_s'Gravendeel	18:55	12-5-2006
6002	DKil_s'Gravendeel	20:48	12-5-2006
6002	DKil_s'Gravendeel	6:53	13-5-2006
6002	DKil_s'Gravendeel	10:08	13-5-2006
6006	Sieg_Menden	5:25	6-5-2006
6008	Sieg_Menden	23:42	5-5-2006
6008	Rijn_Xanten	5:24	9-5-2006
6011	Sieg_Menden	22:22	5-5-2006
6011	Waal_Vuren	17:47	7-5-2006
6011	BenMerwede_BHardinx	20:18	7-5-2006
6011	OudeMaas_Spijkenisse	7:32	8-5-2006

The fish with transponder number 6002 was not detected on station Sieg_Menden but was detected on station Rijn_Xanten on the 10th of May 2006. It travelled onwards in the direction of the river Waal, where it was detected almost 24 hours later on station Waal_Vuren. From there it travelled to the Hollands Diep and passed through de Dortse Kil where it was detected again almost 24 hours later (station DKil_s'Gravendeel, 12-5-2006). It seems that from then on the smolt is confused by the changing flow directions (due to the tide) in the Dortse Kil as it is detected passing this station several times within 2 days. After the last detection on this station the fish is probably swimming in the direction of Hollands Diep. As there were no detections on the stations on the Haringvliet dam this smolt probably did not reach the sea.

The fish with transponder number 6011 was detected on the station Sieg_Menden but not on station Rijn_Xanten. The next location of detection, after leaving the Sieg, was station Waal_Vuren, almost 44 hours later. In this 44 hours the fish travelled a distance of almost 300 km with an average speed of 1,84 m/s, which is well above average river flow (1 m/s). Of all the smolts detected, this fish has the highest migration speed. Almost three hours later this smolt is detected on the river Beneden Merwede near Boven Hardinxveld. The next day, in the morning, the fish is swimming along the Oude Maas which enters the Nieuwe Waterweg. It is very likely that this smolt has reached the North sea.

When looking at the migrating group of smolts it can be calculated that their average weight and length is larger than that of the group that does not migrate out of the Sieg (respectively 173,6 g versus 155,2 g and 26,0 cm versus 24,6 cm). However, with the small groups involved this difference is not statistically significant and the average of the migrating group is uplifted because of the presence of one exceptionally large fish with a length of 29 cm and a weight of 236 g. Also, the most

successful migrant (the smolt with transponder number 6011 that probably reached the North sea) was, in terms of weight, the one but lightest fish

4 Conclusions and discussion

- Survival rate after tagging 2+ Ätran smolts with the newest generation of NEDAP transponders was 100% until the day of release.
- Smolts started their downstream migration very shortly after being released (two on the same day, two on the next day and one 5 days later).
- After release, 5 out of 10 smolts (50%) were detected on the NEDAP TRAIL system®.
- Probably 5 smolts never left the Sieg; this number could be lower as the detection data show that at least one detected smolt passed the station Sieg_Menden undetected.
- In total 2 out of 5 migrating smolts reached the Netherlands.
- Probably one smolt reached the sea.
- The fastest migration speed observed is 1,84 m/s (travelling a distance of almost 300 km in under 44 hours).
- With the results observed, it can be concluded that the NEDAP TRAIL system® is a viable tool for studying downstream smolt migration.

As of yet there is no insight in the mortality rate of smolts tagged with the newest generation of NEDAP transponders. It is likely that the mortality of smolts is higher than the mortality of tagged adult salmon. The migration out of the Sieg is commencing in a few days and it cannot be excluded that 50% of the tagged smolts died in the Sieg. However, other (natural) cause could also be involved. This should be a point of attention is following studies.

Although there are no clear indications that larger smolts perform better when tagged, it is advisable to use the largest smolts available from the viewpoint of surgical procedures.

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