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Effect of stocking time on yield and location of recapture in two forms of brown trout (*Salmo trutta*) when stocked in respect to migration activity

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Abstract

Tagged 2-year-old trout smolts, *Salmo trutta*, were stocked into River Isojoki in 1996, 1997 and 1998 (a sea trout strain), and Lake Konnevesi in 1997 and 1998 (a brown trout strain) in April, May or June–July. Stocking dates were determined in respect to the migration activity of 100 PIT-tagged fish held in the laboratory. Migration activity was relatively similar in both trout forms each year. In April, movement activity was low; in May, movement activity of the PIT-tagged fish increased and in June–July, movement had ceased. There was a general tendency for lower migration activity in maturing males than for immature fish, but differences were not statistically significant every year. In sea trout, yield varied widely between years within a stocking time and between stocking times, being least in June–July (54.3 kg/1000 fish) and 77.3 and 86.3 kg/1000 fish in April and May, respectively. Brown trout yield was higher from stockings in June–July (181 and 312 kg/1000 fish) than from those in April or May (between 87 and 117 kg/1000 fish). Brown trout stocked in April or May tended to migrate downstream from the Lake Konnevesi more than did trout stocked in June–July.

Keywords: *Salmo trutta*; Smolt migration; Sexual maturation; Tagging; Stocking; Recapture

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1. Introduction

Two migrating forms of *Salmo trutta* exist in Finland: freshwater resident (brown trout) and anadromous (sea trout). Brown trout is freshwater resident which may migrate several hundred kilometres within lake systems (Valkeajärvi, 1993a). Usually, short rivers between the lakes function as spawning grounds and nursery habitat for them. Sea trout smolts migrate from several Finnish coastal streams to the brackish (3–6 ppt) Baltic sea. Man has destroyed most of the natural habitats and spawning grounds of brown and sea trout in Southern and Central Finland. Because of the drastic decrease in natural production of trout, Finnish brown trout and sea trout fisheries are dependent mainly upon fish released from hatcheries. Annually about 1.5 million brown trout and 2.1 million sea trout parr and smolts are released, as well as 3.4 million newly hatched brown trout fry (Finnish Game and Fisheries Research Institute, 1999).

Stocking results vary widely and often profitability is low; the weight (kg) of trout released may be greater than the yield and the fish often leave the stocking place and never return. This failure to return may be partly due to inappropriate timing of release with respect to imprinting. The critical period for imprinting is a short interval during which two interdependent characteristics are optimal: (1) a high ability for learning discrete environmental cues and (2) a capacity to retain this information in long-term memory. As the time for optimal olfactory imprinting is probably less than 10 days, as found for Atlantic salmon *S. salar* in laboratory tests (Morin et al., 1989), trout stocked at a wrong time might lack the ability for accurate homing. Tests on coho salmon (*Oncorhynchus mykiss*) confirm the importance of the parr–smolt transformation as a sensitive period for olfactory imprinting (Dittman et al., 1996). As homing of salmon may be based on sequential learning of cues encountered by smolts during seaward migration (Hansen and Jonsson, 1994), the location of stocking may be important in determining optimum return for exploitation. Stocking sea trout early in the spring (March–April) into River Aurajoki (SW Finland) gave higher yield than stocking during May, when sea trout and brown trout are usually released; trout stocked in early spring also had high homing behaviour (Juha Kääriä, personal communication).

The success of stocking is determined also by factors other than imprinting. At the time of sea entrance, the smolt has to be able to hypo-osmoregulate to survive in the saline environment. However, capability for osmoregulation in seawater is not a problem for fish entering the sea at the Finnish coast because salinity is usually between 0 and 7 ppt in the Gulf of Finland and Gulf of Bothnia. Also, smolts are sensitive to handling stress (Carey and McCormick, 1998), so fish transported and stocked as smolts may suffer higher stress-related mortality than fish stocked before or after smolting.

In a previous experiment (Pirhonen et al., 1998), *S. trutta* started “migrating” downstream in an annular tank after the first week of May and continued migrating for about 4 weeks after which the migration almost totally ended. In view of these results, it was hypothesised that (i) if trout were stocked before the beginning of smolt migration, they would imprint and home successfully as adults; (ii) if stocked during smolt migration imprinting would be compromised and homing would be less successful and (iii) if stocked after smolting, the trout would not migrate but stay around the stocking area.

2. Materials and methods

Experiments to test these hypotheses were made in 1996, 1997 and 1998 with sea trout and in 1997 and 1998 with brown trout. Both trout forms were 2 years old at tagging and stocking (weight at release provided in Table 1). Sea trout originated from hatchery-reared parents of an anadromous strain from River Isojoki. Brown trout were offspring from hatchery-reared parents of a migrating, but freshwater resident, Rautalampi strain. Each year, 3000 sea trout (total 9000), in 1997 2400 and in 1998, 3600 brown trout (total 6000) were tagged with Carlin tags and weighed during January and February. After tagging, sea trout were kept separately in groups of 1000 fish, brown trout in groups of 800 and 1200 in 1997 and 1998, respectively. Tanks were annular in shape and 7 m in diameter and water depth was about 30 cm. The access to the centre of the tank was prevented by plastic covered metal netting (the width of the tank on one side was about 3 m, while on the other side only 30 cm). In one tank for each strain, there were also 100 trout, which were PIT-tagged behind the dorsal fin serving as indicator fish for estimating migration tendency. In the narrowest part of this tank, “migrating” fish had to swim through an acrylic tube (50 cm long, 20 cm in diameter) with two PIT-tag detectors (this tank was described in detail

Table 1
Numbers, percentages, percentages of males and movement activity of PIT-tagged sea trout and brown trout by sex and maturity status in experimental flumes between 1996 and 1998

Year		Sea trout			Brown trout		
		Mature males	Immature males	Females	Mature males	Immature males	Females
1996	*n*	32	13	22	–	–	–
	%	47.8	19.4	32.8	–	–	–
	% of males	71.1	28.9		–	–	
	antennae passages day^{-1}						
	May–June	35 (8.0)[b]	128 (13)[a]	51 (9.7)[b]	–	–	–
	October	50 (14)[b]	0.6 (0.5)[a]	0.04 (0.04)[a]	–	–	–
1997	*n*	50	8	31	39	3	43
	%	54.9	8.8	36.2	45.9	3.5	50.6
	% of males	86.2	13.8		92.9	7.1	
	antennae passages day^{-1}						
	May–June	98 (12)[b]	290 (53)[a]	223 (26)[a]	102 (13)[a]	273 (5.9)[b]	140 (11)[c]
	October	6.7 (2.7)[a]	0.4 (0.3)[a]	4.0 (1.2)[a]	22 (4.0)[a]	12 (6.3)[a]	16 (1.7)[a]
1998	*n*	32	10	50	30	21	39
	%	34.8	10.9	54.3	33.3	23.3	43.3
	% of males	76.2	23.8		58.8	41.2	
	antennae passages day^{-1}						
	May–June	137 (22)[a]	236 (40)[a]	216 (24)[a]	37 (4.6)[a]	55 (11)[a]	42 (4.0)[a]
	October	–	–	–	–	–	–

Movement activity is expressed as mean (S.E.) individual daily number of antennae passages during the smolt migration (May–June) and in October. Values denoted by different superscripts within a trout strain on the same row are significantly different. When recordings were not made, it is denoted by a dash.

in Pirhonen et al., 1998). Data were expressed as antennae passages per day, which equalled to the rounds (ca. 20 m) swam around the tank. The fish were held under natural photoperiod (62°27′N), temperature regime and fed a commercial dry feed with automated feeders 24 h/day. Water flow was about 20 cm s^{-1}.

The stocking dates were decided according to the movement activity of the PIT-tagged fish. The first batch was stocked in early April when the activity was usually low. The second batch was stocked when the movement activity was beginning to increase, usually right after the first week of May. The third batch (with the PIT-tagged fish) was kept in the hatchery until movement had ceased at the end of June or the start of July. One to seven days before stocking the third batch, the PIT-tagged individuals were separated from the Carlin-tagged fish by lowering the water level, netted out of the tank, anaesthetised with buffered tricainemethanesulfonate (MS-222) and weighed. After releasing the third groups in 1996 and 1997, PIT-tagged fish were pooled, and returned into the tank with the PIT-tag detectors. Their movements were monitored until late October, when the fish were killed, sexed and maturity for each individual was recorded. In 1998, PIT-tagged fish were held in a 4-m^2 tank (water depth 40 cm) from the last release until October for checking the sex and maturity.

The fish were transported to stocking places in three white insulated 1-m^3 fish transport tanks supplied with oxygen in 1996 and 1997, but also aerated in 1998. In 1996, sea trout were stocked in River Isojoki in two spots, about 5 km apart, 60–70 km from the river mouth. As fishing pressure that year, even on undersized trout (below the legal limit of 40 cm), was heavy in the river, in 1997 and 1998, the fish were released about 10 km from the sea (62°15′N, 21°30′E). In 1996, the first batch was released below the ice. Brown trout were released in an oligothophic Lake Konnevesi (188 km^2; 62°37′N, 26°35′E): the first batch below the ice, the second in the 2–3 m of clear water along the shore, and the third from the shore when all the ice had melted.

All calculations were based on tags voluntarily returned by fishermen. Unreturned or lost tags may have exceeded 70% (Valkeajärvi, 1993a), but it was assumed that the proportion of unreturned tags was similar in each stocking group.

Statistical comparisons for tag recoveries and yields between release times were made with Kruskall–Wallis ANOVA. Movement activities between sexes were compared, after testing for the homogeneity of variances, by ANOVA and possible post hoc comparisons of the means were performed by LSD test. Fish weights were compared with ANOVA or Mann–Whitney *U*-test.

3. Results

3.1. Movements, sexual maturation and weight of the PIT-tagged fish

There were clear changes in the movement behaviour of sea trout (Fig. 1) and brown trout (Fig. 2) during the spring and early summer. Downstream migration of sea trout was estimated to have started on May 13 in 1996 and 1997 and on May 8 in 1998. Onset of downstream migration of brown trout occurred on May 6 and 8 in 1997 and 1998, respectively. Water temperatures ranged during those days between 3.7 and 4.4 °C. In

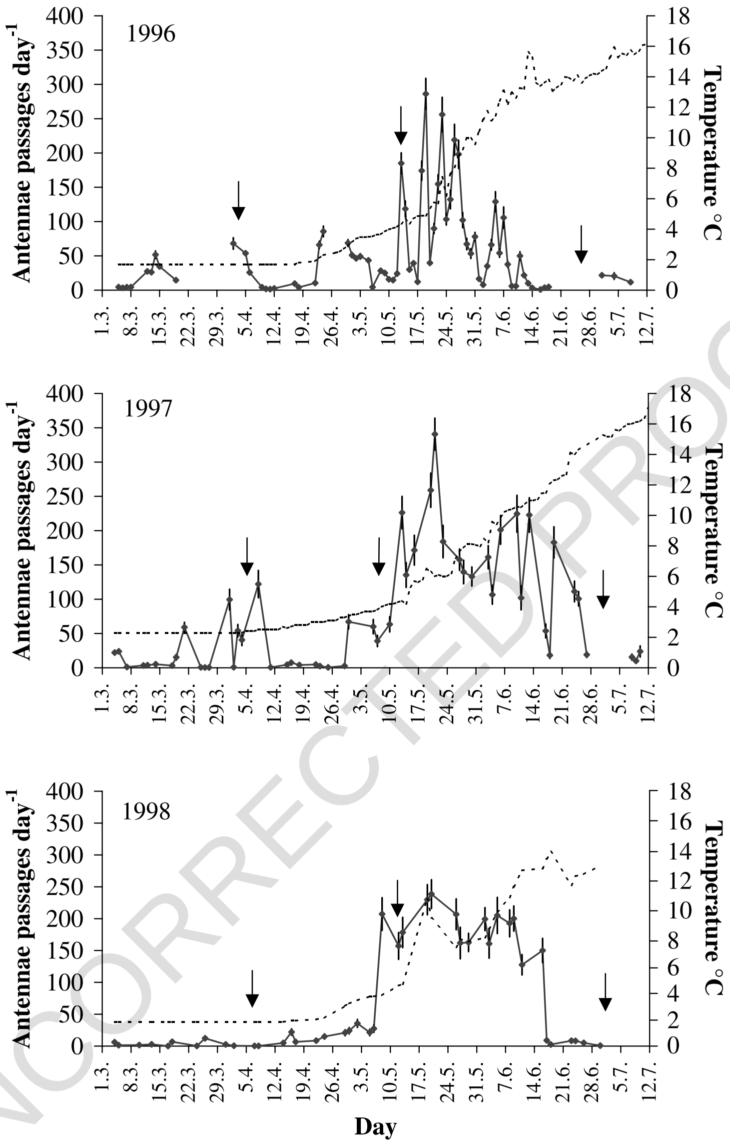

Fig. 1. Average movement activities (± S.E., $n \approx 100$) of the PIT-tagged sea trout in the annular experimental tank expressed as daily number of passages through PIT-tag detection antennae in 1996–1998. Arrows indicate stocking times for the Carlin-tagged trout, broken line is for temperature (right *y*-axis).

1996, migration activity in sea trout varied widely between days during the period regarded as smolt migration (Fig. 1). In 1997, an increase in downstream migration of brown trout could be detected (Fig. 2), but it was not as clear as with sea trout or brown trout in 1998. Also, in 1997, brown trout showed relatively high activities on several days throughout the late summer and autumn (data not shown). In 1998, the migration period in

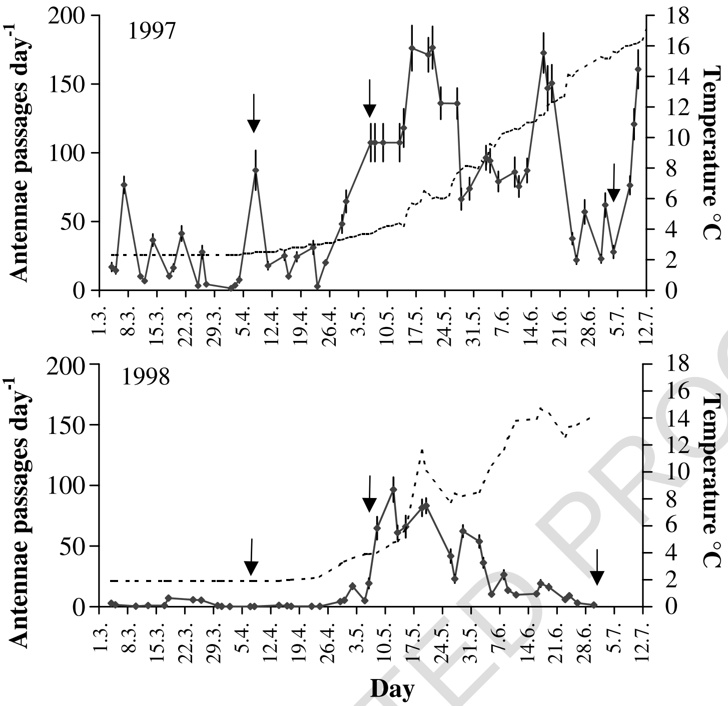

Fig. 2. Average movement activities (± S.E., $n \approx 100$) of the PIT-tagged brown trout in the annular experimental tank expressed as daily number of passages through PIT-tag detection antennae in 1997 and 1998. Arrows indicate stocking times for the Carlin-tagged trout, broken line is for temperature (right y-axis).

both trout forms was very clear (Figs. 1 and 2) and that year, the second clear peak in the migration occurred concomitantly with the peak in temperature.

Most of the males (sea trout: 71.1.–86.2%, brown trout: 58.8–92.9%) were maturing sexually at age 2+ (Table 1). In each year during the migration period in May–June, maturing males tended to migrate less than did immature males or females, but differences were not statistically significant in 1998 (Table 1). Also, every year, immature males made more antennae passages during the migration period (May–June) than did females, but significantly so only twice (1996, sea trout: $p < 0.001$; 1997, brown trout $p < 0.001$). On the other hand, in October 1996, mature males showed higher movement activities than immature males or females ($p < 0.01$; Table 1).

Fish weight varied significantly between years ($p < 0.000$ in April for both forms of trout). Based on the weight of the PIT-tagged fish, Carlin-tagged fish which were released in June–July were significantly heavier ($p < 0.05$) than the fish released earlier (Table 2).

3.2. Carlin-tagged fish

Out of 9000 Carlin-tagged sea trout, 1005 tags (11.2%) were returned by May 2001. In brown trout, 827 tags were returned out of 6000 tagged fish (13.8%). Sea trout which were

Table 2
Release data (date, weight and number of released individuals) and recovery data (number of recovered individuals, % of recovered individuals and yield) for sea trout and brown trout

Release data				Recovery data		
Year	Date	Weight (g)	*n*	*n*	%	kg/1000 smolts
Sea trout						
1996	3 April	196.8 (6.3)[a]	1000	159	15.9	89
1997	7 April	144.8 (5.9)[a]	1000	17	1.7	17
1998	6 April	163.8 (4.3)[a]	1000	66	6.6	126
Average	April	168.5 (15.2)	1000	80.7 (41.6)	8.1 (4.2)	77.3 (32.0)
1996	13 May	204.5 (9.9)[a]	1000	239	23.9	74
1997	7 May	160.7 (8.2)[a]	1000	49	4.9	74
1998	12 May	196.7 (6.5)[b]	1000	67	6.7	111
Average	May	187.3 (13.6)	1000	118.3 (60.6)	11.8 (6.1)	86.3 (12.3)
1996	26 June	220.0 (12.4)[b]	1000	252	25.2	73
1997	1 July	214.8 (7.4)[b]	1000	107	10.7	45
1998	1 July	242.8 (5.4)[c]	1000	32	3.2	45
Average	June–July	225.9 (8.6)	1000	130.3 (64.6)	13.0 (6.5)	54.3 (9.3)
Brown trout						
1997	8 April	148.3 (4.0)[a]	800	95	11.9	117
1998	8 April	180.7 (4.0)[a]	1200	104	8.7	87
Average	April	164.5 (16.2)	1000	99.5 (4.5)	10.3 (1.6)	102.0 (15.0)
1997	6 May	158.1 (4.5)[a]	800	89	11.1	89
1998	7 May	214.4 (6.8)[b]	1200	107	8.9	90
Average	May	186.3 (28.2)	1000	98 (9.0)	10.0 (1.1)	89.5 (0.5)
1997	4 July	221.0 (5.1)[b]	800	126	15.8	181
1998	30 June	256.2 (5.8)[c]	1200	283	23.6	312
Average	June–July	238.6 (17.6)	1000	204.5 (78.5)	19.7 (3.9)	246.5 (65.5)

S.E. in parenthesis. Values for weight are based on PIT-tagged fish held among the Carlin-tagged fish. Within the trout form, values for weight at release that are denoted by different superscripts within the same year are significantly different from each other.

caught in the river (716 individuals) were caught almost exclusively with lures and flies (in those cases when the fishing gear was reported), but those caught from the sea (289 individuals) were mainly caught with gill nets. About 80% of brown trout were caught with gill nets in lakes.

Tag recoveries in sea trout varied widely between years from different stocking times (Table 2), highest recoveries being from the 1996 stocking. In 1996, 65–87% of the returned tags were returned during the first year (Fig. 3A). In 1997 and 1998, most tags were returned during the second year after stocking, with the exception of the June–July group in 1997, where 88% were returned during the first year (Fig. 3A).

Stocking time had an influence on tag recoveries of brown trout even though differences were not statistically significant. In groups which were released in April or May, about 10% of the tags were returned with only slight variation between years, but 20% were returned from those groups released in June–July (Table 2). On average, 49% and 51% of the tags which were recovered from April and May stockings were returned during the first year, while the respective value for June–July stocking was 34%. The highest

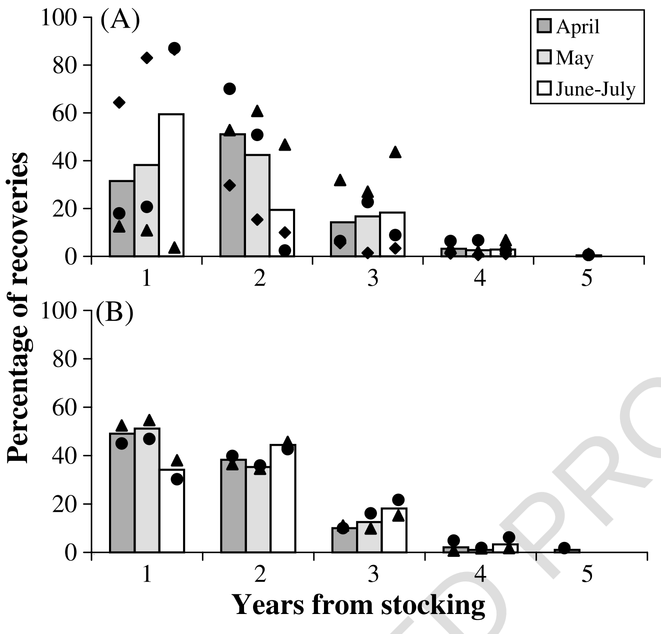

Fig. 3. Share of Carlin tag recoveries in different years after stocking for sea trout (A) and brown trout (B) stocked either in April, May, or June–July. Average shown with the bar, share for each year above the bar shown separately (1996 diamond, 1997 circle and 1998 triangle). No data available for the fifth year for the fish stocked in 1998. Year 1 refers to the calendar year of stocking and so on.

proportion of the fish of the June–July group (44%) was caught during the second year (Fig. 3B).

Total yield varied widely in sea trout, especially in the April stocking (from <20 to >120 kg/1000 smolts released in 1997 and 1998, respectively) (Table 2). There were no statistical differences in yield between different stocking times. In brown trout, the highest yield (247 kg/1000 smolts) was obtained in both years from stockings made in June–July. Yields from April (102 kg) and May (90 kg) stockings were much lower, but probably because of the small sample size ($n=2$). The differences were not statistically significant.

Sea trout caught in the river (303 g; S.E. 14.7, $n=541$) were significantly smaller than fish caught in the sea (1589 g, S.E. 83.4, $n=216$: $p<0.001$), and the overall mean weight was 670 g. Mean weight for brown trout was 1174 g (S.E. 36.8, $n=666$).

Recapture sites of sea trout varied widely between years. In 1996 when the trout were stocked higher up the river, 80–99% were caught in the river (Fig. 4A). In 1997 and 1998, most of the tags were recovered from the sea, except from the June–July group in 1997 (Fig. 4A). In brown trout (Fig. 4B), always more than 60% in each stocking group were caught in Lake Konnevesi, but the highest proportion of postulated nonmigrants (95.5%, i.e. fish which were caught in Lake Konnevesi) was in the groups stocked in June–July (Fig. 4B).

Few sea trout returned to the River Isojoki to spawn. From the 1996 stocking, only 11 tags were returned from fish >40 cm caught in the river. All these individuals were

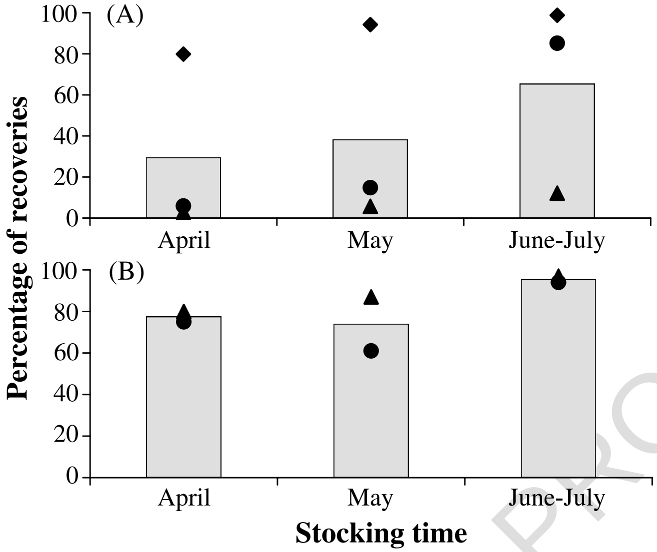

Fig. 4. Percentage of Carlin tag recoveries (A) from the River Isojoki itself for sea trout and (B) from the basin of Lake Konnevesi for brown trout for the groups stocked in April, May, or June–July. Remaining tags were returned from the sea (A) and watercourses below Lake Konnevesi (B). The bar represents mean percentage, percentages for each year above the bar shown separately (1996 diamond, 1997 circle and 1998 triangle).

between 40 and 49 cm and weighed < 1.3 kg, which may indicate that these fish had remained resident in the river. From the 1997 stocking, only one tag was returned from a large river-caught sea trout (2.8 kg and 63 cm, released in June–July). From the 1998 stocking, there were four recoveries (59–71 cm; 2.9–4.8 kg) from sea trout on the spawning migration, three from April stocking and one from May. In Lake Konnevesi, it was impossible to estimate which brown trout had left the lake and were returning for spawning, especially when most of the fish seemed to be residents; no large individuals were caught from rivers during autumn.

Neither strain showed any differences in growth between release groups. Brown trout stocked in 1998 grew faster than those stocked in 1997 during the first 2 years. In general, fish weighed 2–2.5 kg 3 years after stocking and 2.8–3.8 kg after 4 years. At 4 years after stocking, brown trout were larger than sea trout, but the number of fish caught at that age was too low for statistical comparisons. The legal minimum of 40 cm was reached usually during the second year after stocking. In the 1996 sea trout stocking, the size of 40 cm was reached only during the third year; at that time, the fish in other groups were >50 cm.

4. Discussion

The PIT-tagged smolts began migrating within a period of 1 week in early May in both trout forms during the 3 years of experimentation. Migration started with these same trout strains at almost exactly the same time in other years, too (Pirhonen et al., 1998; Pirhonen and Forsman, 1999). The reason for higher activities in 1996 and 1997 before May is unknown, but it does not seem to be a systematic pattern, because of the absence of those peaks in the spring 1998.

The extent of movement behaviour in the tanks was much lower than reported previously (Pirhonen et al., 1998). The most likely reason for that difference was the number of fish in the tanks, ca. 180 in the earlier experiment but 1100 sea trout or 900 (1997) or 1300 (1998) brown trout in the present experiment. When the fish started migrating, there was considerable crowding in front of the detection tube, which did not occur in the less populated tank. Despite the crowding, clear changes in behaviour were recorded.

Up to 93% of males were maturing sexually at age 2+. The incidence of maturation in males was much higher than previously reported for Finnish *S. trutta* of similar age in a hatchery (Pirhonen et al., 1998; Pirhonen and Forsman, 1999), or for those caught in Lake Konnevesi in the 1980s (8.3%; Valkeajärvi, 1993b). The tendency for migration was lower for maturing males than for immature males, even though statistical difference was not detected every year. This result of depressed smolt migration of mature males is in accordance with earlier findings (Thorpe, 1987, 1994; Dellefors and Faremo, 1988; Hansen et al., 1989; Fängstam et al., 1993; Pirhonen et al., 1998). However, it seems that maturation and downstream migration are not totally exclusive processes, and that tendency for migration in mature males may depend on fish size (Fängstam et al., 1993; Pirhonen et al., 1998). The reason for the previously unreported tendency (in two out of five case the difference was significant) for immature males to migrate more than females during the spring is unknown. Mature males were consistently the most active fish, as estimated by antennae passages, during October, which is the natural spawning time for trout in Finland. Thorpe et al. (1988) have reported a similar result with Atlantic salmon, as did Pirhonen and Forsman (1999) with brown trout in an artificial stream. In addition, sexual maturation can also decrease significantly the recapture rates and yield of stocked fish; in Baltic salmon, recapture rates for releases of immature fish were seven to eight times higher than for previously mature males (Lundqvist et al., 1994). If that is the case with migrating forms of *S. trutta* as well, much higher recapture rates and yield could have been obtained if the proportion of mature or maturing males could have been decreased.

Because of seasonal growth, the fish stocked in April and May were smaller than those stocked in June–July. This size difference did not influence the recovery rates in sea trout and the average yield in earlier stockings was higher than in the last stocking group. However, in brown trout, the June–July stocking group gave higher yield, and the benefit of being slightly larger than the fish stocked in April and May can be a plausible explanation, because larger salmon smolts are known to have higher survival rate (Lundqvist et al., 1994). The yield of the June–July stocking was higher due to lower mortality and a higher proportion of the fish was caught during the second and third year after stocking.

The present recapture results could be slightly skewed, by possible changes in the fishing intensity within the same period between years. An increase or decrease in yield from 1 year to another, or from one period to another in the same year might be an expression of increased fishing in the same period or year, and not an effect of stocking time. As no large changes in fishing effort were reported within these fishing areas, the differences in yield have been considered a result of stocking time.

On average, yield from April and May stockings of 2-year-old brown trout to Lake Konnevesi from 1965 to 1989 has been 85 kg/1000 fish (Valkeajärvi, 1993a), similar to stockings in April and May in this study. This supports the idea that the lake stockings of brown trout should be made after the migration period, if the goal is to maximise biomass production. These late stockings seem to ensure that the trout stay in the lake in which they were stocked, which is desirable from the point of view of the fishing district. However, during 1997 and especially 1998, vendace (an important prey species for brown trout) populations were strong in Lake Konnevesi (Valkeajärvi, unpublished), which may have partially decreased the inclination for migration. From brown trout stockings made between 1986 and 1988, about 38% of individuals have been caught downstream from Lake Konnevesi (Valkeajärvi, 1993a).

Even the best yields of sea trout stockings of the present experiment were quite low when compared with the previous results. The average yield of sea trout in the Bothnian sea has been 140 kg/1000 smolts between the years 1979 and 1989, but about 260 kg/1000 smolts in the Gulf of Finland (Ikonen and Lankinen, 1993). Koivurinta et al. (2001) reported that the average yield of sea trout (river Isojoki strain) in the eastern Gulf of Finland varied between 77 and 282 kg/1000 smolts in 11 different groups stocked at the coast in the vicinity of rivers between 1993 and 1996. Most of the tags of the 1996 stocking were returned already during the same year, which certainly has influenced the yield because the fish were recaptured when small. Proportionally more tags were returned during the second and third year after stocking from fish released in 1997 and 1998, but still the yield was low because the overall recapture rates were low, usually 2–7%, and most fish had been caught by the end of the second year after the release. In the 1980s, return rates of tagged sea trout on the Bothnian sea have been about 6% (Ikonen and Lankinen, 1993). Present results give only some support to the idea that sea trout stockings should be made in early spring (Koivurinta et al., 2001). Better average yield was obtained in April and May stockings than in those made in June–July, but variation between years was large in April. The present results do not indicate a best strategy for increasing the profitability of sea trout stockings in River Isojoki. However, it would be advisable not to stock them in the upper reaches of the river to avoid fishing pressure on undersized fish and to guide fishermen not to keep undersized fish. Also, it seems that a big proportion of sea trout stocked in the upper part of the river in 1996 was not inclined to emigrate at all. That can be explained partly by the high incidence of sexual maturation of males.

Because only five large fish returning to the River Isojoki were recovered out of 9000 stocked smolts, no conclusion can be made about the effect of stocking time on homing behaviour of the test fish. Because there were no disadvantages of early stockings in River Isojoki, sea trout could be stocked there before smolt migration as suggested for other areas along the Finnish coast (Koivurinta et al., 2001; J. Kääriä, personal communication). However, present fishing pressure for smolts in the river and for immature or maturing fish in the sea is so intense, that attempts to rehabilitate the natural life cycle of sea trout by stocking seem impractical in this area.

In conclusion, tests of the two hypotheses about the effect of stocking time on imprinting and homing were inconclusive. In brown trout, stocking after the smolting period would be more profitable in terms of yield and proportion of nonemigrating fish than in stockings made earlier in spring. No such clear effects of stocking time were observed in sea trout. However, stocking brown trout into lakes is possibly not enough to rehabilitate the natural life cycle, because imprinting to the rivers is questionable (Valkeajärvi, 1993b). Incidence of maturation of males during the year when they were expected to smolt was very high in fish, which were under hatchery conditions. Even though the effect of early sexual maturation on the stocking result is not known in the present experiment, it is likely that it had a negative effect on the yield. To inhibit maturation at age 2 and consequently increase the proportion of migrating fish, nutritional manipulation should be adopted (Rowe and Thorpe, 1990; Thorpe et al., 1990; Rowe et al., 1991; Thorpe and Metcalfe, 1998), if the trout are to be stocked at the smolt age.

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